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WESTINGHOUSE CLASS 3

WCAP-11420

WESTINGHOUSE SETPOINT METHODOLOGY FOR PROTECTION SYSTEMS BEAVER VALLEY UNIT 1

October, 1987

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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 statistical 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., [ ]$^{+a,c}$. This allows the use of a statistical summation of the various breakdown 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 normal, conservative approach, arithmetic summation, to form independent quantities, e.g., [ ]$^{+a,c}$. An explanation of the overall approach is provided in Section 2.0.

Section 3.0 provides a description, or definition, of each of the various components in the setpoint parameter breakdown, thus insuring a clear understanding of the breakdown. Also provided is a detailed example of each setpoint margin calculation demonstrating the technique and noting how each parameter value is derived. In nearly all cases, significant margin exists between the statistical summation and the total allowance.

Section 4.0 notes what the current standardized Technical Specifications use for setpoints and an explanation of the impact of the statistical 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 statistical approach.

2.0 COMBINATION OF ERROR COMPONENTS

2.1 METHODOLOGY

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

The methodology used for this combination is not new. Basically it is the "square root of the sum of the squares" which has been utilized in other Westinghouse reports. This technique, or other statistical approaches of a similar nature, have been used in WCAP-10395(1) and WCAP-8567(2). WCAP-8567 has been approved by the NRC Staff thus noting the acceptability of statistical techniques for the application requested. In addition, ANSI, the American Nuclear Society, and the Instrument Society of America approve of the use of probabilistic techniques in determining safety-related setpoints(3)(4). Thus it can be seen that the use of statistical approaches in analysis techniques is now widespread. The methodology used for this report is essentially the same as that used for V. C. Summer which was approved by the NRC in NUREG-0717, Supplement No. 4(5)

(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 the Operation of Virgil C. Summer Nuclear Station, Unit No. 1," Docket No. 50-395, August, 1982.

The relationship between the error components and the total statistical error allowance for a channel is,

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

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
STE	=	Sensor Temperature Effects
SPE	=	Sensor Pressure Effects
RCA	=	Rack Calibration Accuracy
RCSA	=	Rack Comparator Setting Accuracy
RMTE	=	Rack Measurement and Test Equipment Accuracy
RD	=	Rack Drift
RTE	=	Rack Temperature Effects
EA	=	Environmental Allowance

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

The Westinghouse setpoint methodology results in a value with a 95 percent probability with a high confidence level. With the exception of Process Measurement Accuracy, Rack Drift, and Sensor Drift, all uncertainties assumed are the extremes of the ranges of the various parameters, i.e., are better than 2σ values. Rack Drift and Sensor Drift are assumed, based on a survey of reported plant LERs, and with Process Measurement Accuracy are considered as conservative values.

2.2 SENSOR ALLOWANCES

Four parameters are considered to be sensor allowances, SCA, SD, STE, and SPE (see Table 3-17). Of these four parameters, two are considered to be statistically independent, STE and SPE, and two are considered interactive SD and SCA. STE and SPE are considered to be independent due to the manner in which the instrumentation is checked, i.e., the instrumentation is calibrated and drift determined under conditions in which pressure and temperature are assumed constant. An example of this would be as follows; assume a sensor is placed in some position in the containment during a refueling outage. After placement, an instrument technician calibrates the sensor. This calibration is performed at ambient pressure and temperature conditions. Some time later with the plant shutdown, an instrument technician checks for sensor drift. Using the same technique as for calibrating the sensor, the technician determines if the sensor has drifted or not. The conditions under which this determination is made are again at ambient pressure and temperature conditions. Thus the temperature and pressure have no impact on the drift determination and are, therefore, independent of the drift allowance.

SD and SCA 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 representing accurately the input. The same is done for a determination of the sensor drift. Thus 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, SD and SCA have been added to form an independent group which is then factored into Equation 2.1. An example of the impact of this treatment is; for Pressurizer Water Level-High (sensor parameters only):

[ ]$^{+a,c}$

using Equation 2.1 as written gives a total of;

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

[ ]$^{+a,c}$= 1.66 percent

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

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

[ ]$^{+a,c}$ = 1.32 percent

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

Four parameters, as noted by Table 3-17, are considered to be rack allowances, RCA, RCSA, RTE, and RD. Three of these parameters are considered to be interactive (for much the same reason outlined for sensors in 2.2), RCA, RCSA, and RD. When calibrating or determining drift in the racks for a specific channel, the processes are performed at essentially constant temperature, i.e., ambient temperature. Because of this, the RTE parameter is considered to be independent of any factors for calibration or drift. However, the same cannot be said for the other rack parameters. As noted in 2.2, when calibrating or determining drift for a channel, the same end result is desired, that is, at what point does the bistable change state. After initial calibration it is not possible to distinguish the difference between a calibration error, rack drift or a comparator setting error. Based on this logic, these three 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 same channel using the same approach outlined in Equations 2.1 and 2.2 the following results are reached:

[ ]+a,c

using Equation 2.1 the result is;

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

[ ]+a,c = 1.82 percent

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

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

$$[\qquad\qquad]^{+a,c} = 1.25 \text{ percent}$$

Thus the impact of the use of Equation 2.1 is even greater in the area of rack effects than for the sensor. Therefore, accounting for interactive effects in the statistical treatment of these allowances insures a conservative result.

2.4 PROCESS ALLOWANCES

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

2.5 MEASUREMENT AND TEST EQUIPMENT ACCURACY

Westinghouse was informed by Duquesne Light Company that the equipment used for calibration and functional testing of the transmitters and racks does not meet the SAMA standard(1) requirement of test equipment accuracy being 10% or less of the calibration accuracy (referenced in 3.2.6.a or 3.2.7.a.). The measurement and test equipment accuracies are identified in this report for each instrument channel.

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

3.0 PROTECTION SYSTEM SETPOINT METHODOLOGY

3.1 MARGIN CALCULATION

As noted in Section One, Westinghouse utilizes a statistical summation of the various components of the channel breakdown. This approach is valid where no dependency is present. An arithmetic summation is required where an interaction between two parameters exists, Section Two provides a more detailed explanation of this approach. The equation used to determine the margin, and thus the acceptability of the parameter values used, is:

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

where:

TA = Total Allowance, and
all other parameters are as defined for Equation 2.1.

Tables 3-1 through 3-16 and 3-22 provide individual channel breakdown and channel statistical allowance calculations for all protection functions utilizing 7100 process rack equipment. Table 3-17 provides a summary of the previous 17 tables and includes analysis and technical specification values, total allowance and margin. The amount of margin allowed is based on a subjective engineering judgement.

3.2 DEFINITIONS FOR PROTECTION SYSTEM SETPOINT TOLERANCES

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

1. Trip Accuracy

The tolerance band containing the highest expected value of the difference between (a) the desired trip point value of a process variable and (b) the actual value at which a comparator trips (and thus actuates some desired result). This is the tolerance band, in percent of span, within which the complete channel must perform its intended trip function. It includes comparator setting accuracy, channel accuracy (including the sensor) for each input, and environmental effects on the rack-mounted electronics. It comprises all instrumentation errors; however, it does not include process measurement accuracy.

2. Process Measurement Accuracy

Includes plant variable measurement errors up to but not including the sensor. Examples are the effect of fluid stratification on temperature measurements and the effect of changing fluid density on level measurements.

3. Actuation Accuracy

Synonymous with trip accuracy, but used where the word "trip" does not apply.

4. Indication Accuracy

The tolerance band containing the highest expected value of the difference between (a) the value of a process variable read on an indicator or recorder and (b) the actual value of that process variable. An indication must fall within this tolerance band. It includes channel accuracy, accuracy of readout devices, and rack environmental effects, but not process measurement accuracy (such as fluid stratification). It also assumes a controlled environment for the readout device. Although it is defined, indication accuracy is not used in this report.

5. Channel Accuracy

The accuracy of an analog channel which includes the accuracy of the primary element and/or transmitter and modules in the chain where calibration of modules intermediate in a chain is allowed to compensate for errors in other modules of the chain. Rack environmental effects are not included here to avoid duplication due to dual inputs, however, normal environmental effects on field mounted hardware is included.

6. Sensor Allowable Deviation

The accuracy that can be expected in the field. It includes drift, temperature effects, field calibration and for the case of d/p transmitters, an allowance for the effect of static pressure variations.

The tolerances are as follows:

a. Reference (calibration) accuracy - [ ]$^{+a,c}$ percent unless other data indicates more inaccuracy. This accuracy is the SAMA reference accuracy as defined in SAMA standard PMC 20.1-1973[1].

b. Temperature effect - [ ]$^{+a,c}$ percent based on a nominal temperature coefficient of [ ]$^{+a,c}$ percent/100°F and a maximum assumed change of 50°F.

c. Pressure effect - usually calibrated out because pressure is constant. If not constant, nominal [ ]$^{+a,c}$ percent is used. Present data indicates a static pressure effect of approximately [ ]$^{+a,c}$ percent/1000 psi.

d. Drift - change in input-output relationship over a period of time at reference conditions (e.g., constant temperature - [ ]$^{+a,c}$ percent of span).

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

7. Rack Allowable Deviation

The tolerances are as follows:

a. Rack Calibration Accuracy

The accuracy that can be expected during a calibration at reference conditions. This accuracy is the SAMA reference accuracy as defined in SAMA standard PMC 20.1-1973[1]. This includes all modules in a rack and is a total of [ ]$^{+a,c}$ percent of span assuming the chain of modules is tuned to this accuracy. All rack modules individually must have a reference accuracy within [ ]$^{+a,c}$ percent.

b. Rack Environmental Effects

Includes effects of temperature, humidity, voltage and frequency changes of which temperature is the most significant. An accuracy of [ ]$^{+a,c}$ percent is used which considers a nominal ambient temperature of 70°F with extremes to 40°F and 120°F for short periods of time.

c. Rack Drift (instrument channel drift) - change in input-output relationship over a period of time at reference conditions (e.g., constant temperature) - $\pm$1 percent of span.

d. Comparator Setting Accuracy

Assuming an exact electronic input, (note that the "channel accuracy" takes care of deviations from this ideal), the tolerance on the precision with which a comparator trip value

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

can be set, within such practical constraints as time and effort expended in making the setting.

The tolerances are as follows:

(a) Fixed setpoint with a single input - [ ]$^{+a,c}$ percent accuracy. This assumes that comparator nonlinearities are compensated by the setpoint.

(b) Dual input - an additional [ ]$^{+a,c}$ percent must be added for comparator nonlinearities between two inputs. Total [ ]$^{+a,c}$ percent accuracy.

Note: The following four definitions are currently used in the Standardized Technical Specifications (STS).

8. Nominal Safety System Setting

The desired setpoint for the variable. Initial calibration and subsequent recalibrations should be made at the nominal safety system setting ("Trip Setpoint" in STS).

9. Limiting Safety System Setting

A setting chosen to prevent exceeding a Safety Analysis Limit ("Allowable Values" in STS). Violation of this setting represents an STS violation.

10. Allowance for Instrument Channel Drift

The difference between (8) and (9) taken in the conservative direction.

11. Safety Analysis Limit

The setpoint value assumed in safety analyses.

3.3 STATISTICAL METHODOLOGY CONCLUSION

The Westinghouse setpoint methodology results in a value with a 95 percent probability with a high confidence level. With the exception of Process Measurement Accuracy, Rack Drift and Sensor Drift, all uncertainties assumed are the extremes of the ranges of the various parameters, i.e., are better than 2σ values. Rack Drift and Sensor Drift are assumed, based on a survey of reported plant LERs, and with Process Measurement Accuracy are considered as conservative values.

TABLE 3-1

POWER RANGE, NEUTRON FLUX - HIGH AND LOW SETPOINTS

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

* In percent span (120 percent Rated Thermal Power)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-2

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

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

* In percent span (120 percent Rated Thermal Power)

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 [ ]	
Measurement and Test Equipment Accuracy	
Sensor Pressure Effects	
Sensor Temperature Effects +a,c [ ]	
Sensor Drift +a,c [ ]	
Environmental Allowance	
Rack Calibration	
Rack Accuracy	
Measurement and Test Equipment Accuracy	
Comparator	
One input	
Rack Temperature Effects	
Rack Drift	
5 percent of Rated Thermal Power	

* In percent span (conservatively assumed to be 120 percent Rated Thermal Power)

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

* In percent span (1×10^6 counts per second)

Channel Statistical Allowance =

[ ] +a,c

TABLE 3-5

OVERTEMPERATURE ΔT

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

TABLE 3-5 (Continued)

OVERTEMPERATURE ΔT

Parameter	Allowance*
Total Rack Calibration Accuracy +a,c	+a,c
Comparator	
ΔT	
T_{avg}	
Rack Temperature Effects	
Rack Drift	
ΔT	
T_{avg}	

** In % ΔT span, ΔT - 101.1°F, T_{avg} - 100°F, Pressure 800 psi, Power - 150% RTP, ΔI - +30% ΔI

* See table 3-18 for gain 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	
Rack Calibration [ ]+a,c	
Measurement and Test Equipment [ ]+a,c	
Total Rack Calibration Accuracy [ ]+a,c	
Comparator ΔT T_{avg}	

TABLE 3-6 (Continued)

OVERPOWER ΔT

Parameter	Allowance*
Channel Temperature Effects	[ ]$^{+a,c}$
Rack Drift	
ΔT	
T_{avg}	

* In % ΔT span, ΔT = 101.1 °F, T_{avg} - 100°F, Power - 150% RTP
** See table 3-19 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 TRIPS

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

* In percent span (800 psi)

Channel Statistical Allowance =

Pressurizer Pressure - Low

[ ]+a,c

Pressurizer Pressure - High

[ ]+a,c

TABLE 3-8

PRESSURIZER WATER LEVEL - HIGH

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

* In percent span (100 percent 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 [ ]+a,c	
Sensor Pressure Effects [ ]+a,c	
Sensor Temperature Effects [ ]+a,c	
Sensor Drift [ ]+a,c	
Environmental Allowance	
Rack Calibration	
Rack Accuracy [ ]+a,c	
Measurement and Test Equipment Allowance [ ]+a,c	
Comparator	
One input [ ]+a,c	
Rack Temperature effects [ ]+a,c	
Rack Drift	
1.0 percent ΔP Span	

* In percent flow span (120 percent Thermal Design Flow)
** See Table 3-21 for explanation

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-10

STEAM GENERATOR WATER LEVEL - LOW AND LOW-LOW

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

* In percent span (100 percent span)

** See Table 3-20 for explanation

Channel Statistical Allowance (Low-Low Level) =

[ ]+a,c

Channel Statistical Allowance (Low Level) =

[ ]+a,c

TABLE 3-11

STEAM/FEEDWATER FLOW MISMATCH

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

* In percent flow span (120.0 percent steam flow); percent ΔP span converted to flow span via 3-21.8.

TABLE 3-11 (Continued)

STEAM/FEEDWATER FLOW MISMATCH

Parameter	Allowance*
Comparator Two Inputs	[ ]+a,c
Rack Temperature Effects	
Rack Drift Steam Flow Feed Flow Steam Pressure [ ]+a,c	

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-12

CONTAINMENT PRESSURE - HIGH, INTERMEDIATE HIGH-HIGH, HIGH-HIGH

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

* In percent span (65 psig)

Channel Statistical Allowance =

+a,c

TABLE 3-13

PRESSURIZER PRESSURE LOW, SAFETY INJECTION

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

* In percent span (800 psi)

Channel Statistical Allowance =

+a,c

TABLE 3-14

STEAMLINE PRESSURE - LOW

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

* In percent span (1400 psig)

Channel Statistical Allowance =

+a,c

TABLE 3-15

NEGATIVE STEAMLINE PRESSURE RATE - HIGH

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

* In percent span (1400 psig)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-16

STEAM GENERATOR WATER LEVEL - HIGH-HIGH

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

* In percent span (100 percent span)

** See Table 3-20 for explanation

Channel Statistical Allowance =

[ ]+a,c

NOTES FOR

1. ALL VALUES IN PERCENT SPAN.
2. AS NOTED IN TABLE 14D-3 OF FSAR
3. AS NOTED IN TABLES 2.2-1 AND 3.3-4 OF PLANT TECHNICAL SPECIFICATIONS.
4. [ ]a,c
5. NOT USED IN SAFETY ANALYSIS
6. AS NOTED IN FIGURE 14D-1 OF FSAR
7. AS NOTED IN TABLE 2.2-1 NOTE 1 OF PLANT TECHNICAL SPECIFICATIONS
8. AS NOTED IN TABLE 2.2-1 NOTE 2 OF PLANT TECHNICAL SPECIFICATIONS
9. NOT NOTED IN TABLE 14D-3 OF FSAR BUT USED IN SAFETY ANALYSIS
10. INCLUDES ALLOWANCE FOR MEASUREMENT TEST EQUIPMENT UNCERTAINTIES
11. [ ]a,c
12. [
13.]a,c
14. [ ]a,c
15. [ ]a,c
16. INCORE/EXCORE f(ΔI) COMPARISON AS NOTED IN TABLE 4.3-1 OF PLANT TECHNICAL SPECIFICATIONS
17. [ ]a,c

REACTOR PROTECTION SY
ACTUATION SYSTEM
BEAVE

	PROTECTION CHANNEL	1 PROCESS MEASUREMENT ACCURACY (1)	2 PRIMARY ELEMENT ACCURACY (1)	SENSOR 3 CALIBRATION ACCURACY (1)	4 PRESSURE EFFECTS (1)	5 TEMPERATURE EFFECTS (1)	6 DRIF (1)
1	POWER RANGE, NEUTRON FLUX - HIGH SETPOINT						
2	POWER RANGE, NEUTRON FLUX - LOW SETPOINT						
3	POWER RANGE, NEUTRON FLUX - HIGH POSITIVE RATE						
4	POWER RANGE, NEUTRON FLUX - HIGH NEGATIVE RATE						
5	INTERMEDIATE RANGE, NEUTRON FLUX						
6	SOURCE RANGE, NEUTRON FLUX						
7	OVERTEMPERATURE ΔT ΔT CHANNEL (ROSEMOUNT)						
8	TAVG CHANNEL (ROSEMOUNT)						
9							
10	PRESSURIZER PRESSURE CHANNEL						
11	f(ΔI) CHANNEL						
12	OVERPOWER ΔT ΔT CHANNEL (ROSEMOUNT)						
13							
14	TAVG CHANNEL (ROSEMOUNT)						
15	PRESSURIZER PRESSURE - LOW, REACTOR TRIP (BARTON XMITTER)						
16	PRESSURIZER PRESSURE - HIGH (BARTON XMITTER)						
17	PRESSURIZER WATER LEVEL - HIGH (BARTON XMITTER)						
18	LOSS OF FLOW (FISCHER PORTER XMITTER)						
19	STEAM GENERATOR WATER LEVEL - LOW-LOW (BARTON XMITTER)						
20	STEAM GENERATOR WATER LEVEL - LOW (BARTON XMITTER)						
21	STEAM FLOW - FEED FLOW MISMATCH STEAM FLOW (BARTON XMITTER)						
22	STEAM PRESSURE (BARTON XMITTER)						
23	FEED FLOW (FISCHER PORTER XMITTER)						
24	UNDERVOLTAGE - RCP (I.T.E. 47H RELAY-BUS 1A, GE CFV12A RELAY-BUS 1B, 1C)						
25	UNDERFREQUENCY - RCP (HATHAWAY RELAY SFR-59-1A)						
26	PRESSURIZER PRESSURE LOW - SI (BARTON XMITTER)						
27	STEAMLINE PRESSURE-LOW (BARTON XMITTER)						
28	CONTAINMENT PRESSURE HIGH (BARTON XMITTER)						
29	CONTAINMENT PRESSURE HIGH-HIGH (BARTON XMITTER)						
30	CONTAINMENT PRESSURE INTERMEDIATE HIGH-HIGH (BARTON XMITTER)						
31	NEGATIVE STEAM PRESSURE RATE - HIGH (BARTON XMITTER)						
32	STEAM GENERATOR WATER LEVEL HIGH - HIGH (BARTON XMITTER)						
33	RWST LEVEL - LOW (FISCHER PORTER XMITTER)						
34	RWST LEVEL-AUTO QS FLOW REDUCTION (FISCHER PORTER XMITTER)						
35	4.16 KV EMERGENCY BUS UNDERVOLTAGE - TRIP FEED (I.T.E.-47H RELAY-BUS 1AE, 1DF)						
36	4.16 KV EMERGENCY BUS UNDERVOLTAGE - START DIESEL (I.T.E.-47H RELAY-BUS 1AE, 1DF						
37	4.16 KV EMERGENCY BUS UNDERVOLTAGE - DEGRADED VOLTAGE (I.T.E.-27H RELAY)						
38	480V EMERGENCY BUS UNDERVOLTAGE - DEGRADED VOLTAGE (I.T.E.-27H RELAY)						
39	AUX FEED TURBINE DRIVEN PUMP DISCHARGE PRESSURE - LOW (BARKSDALE XMITTER)						
40							

18.[ ]+a,c

19. PRECISION FLOW CALORIMETRIC UNCERTAINTY ±2.0% FLOW.

]+a,c 20.[ ]+a,c

21.[ ]+a,c

22.[ ]+a,c

23.[ ]+a,c

24.[ ]+a,c

TABLE 3-17
STEM/ENGINEERED SAFETY FEATURES
CHANNEL ERROR ALLOWANCES
VALLEY UNIT 1

SI
APERTURE
CARD

Also Available On
Aperture Card

T	7 ENVIRONMENTAL ALLOWANCE (1)	8 CALIBRATION ACCURACY (1)	9 COMPARATOR SETTING ACCURACY (1)	10 TEMPERATURE EFFECTS (1)	11 DRIFT (1)	12 SAFETY ANALYSIS LIMIT (2)	13 STS ALLOWABLE VALUE (3)	14 STS TRIP SETPOINT (3)	15 TOTAL ALLOWANCE (1)	16 CHANNEL STATISTICAL ALLOWANCE (1)	17 MARGIN (1)	
		INSTRUMENT RACK										
					+a,c 1.0	118% RTP (2)	111.3% RTP	109% RTP				+a,c 1
					1.0	35% RTP (2)	27.3% RTP	25% RTP				2
					0.5	(5)	6.3% RTP	5.0% RTP				3
					0.5	6.9% RTP (9)	6.3% RTP	5.0% RTP				4
					4.2	(5)	31.1% RTP	25% RTP				5
					3.0	(5)	1.4E+05 CPS	1.0E+05 CPS				6
					1.0							7
					1.0							8
						function (6)	function (7) +3.4% ΔT span	function (7)				9
					---							10
					---							11
					1.0							12
						function (6)	function (8) +3.4% ΔT span	function (8)				13
					1.0							14
					1.0	1920 psig	1934 psig	1945 psig				15
					1.0	2436 psig	2394 psig	2385 psig				16
					1.0	(5)	93.9% span	92% span				17
					0.6	87.0% design (2)	89.2% design	90% design				18
					1.0	0% span (2)	10.7% span	12.0% span				19
					1.0	(5)	23.1% span	25.0% span				20
					1.0							21
					0.5	(5)	43.4% steam flow	40% steam flow				22
					1.0							23
					1.0	(12)	2687 volts	2750 volts				24
					1.0	57.0 Hz.	57.4 Hz.	57.5 Hz.				25
					1.0	1700.0 psig	1830 psig	1845 psig				26
					1.0	723.0 psig	488 psig	500 psig				27
					1.0	3.5 psig	2.4 psig	1.5 psig				28
					1.0	10.0 psig	6.9 psig	9.0 psig				29
					1.0	5.0 psig	7.9 psig	3.0 psig				30
					1.0	(5)	≤127 psi	≤100 psi				31
					1.0	80.0% span	76.9% span	75% span				32
					1.0	18 feet 9 inches	10 feet 9 inches	19 feet 2.5 inches				33
					1.0	(5)	10 feet 9 inches	11 feet 0 inches				34
					1.0	(5)	73% of BUS VOLTAGE	75% of BUS VOLTAGE				35
					1.0	(5)	81% of BUS VOLTAGE	83% of BUS VOLTAGE				36
					1.0	(5)	88% of BUS VOLTAGE	90% of BUS VOLTAGE				37
					1.0	(5)	88% of BUS VOLTAGE	90% of BUS VOLTAGE				38
					1.0	(5)	484 psig	468 psig				39
												40

8903200238-01

TABLE 3-18

OVERTEMPERATURE ΔT GAIN CALCULATIONS

The equation for Overtemperature ΔT is:

Overtemperature ΔT $\leq$

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

K_1 (max)	=	[ ]$^{+a,c}$
K_1 (nominal)	=	1.18 (Technical Specification Trip Setpoint)
K_2	=	0.01655/°F
K_3	=	0.000801/psi
Vessel T_H	=	609.9°F
Vessel T_C	=	542.5°F
Positive ΔI gain	=	1.91% FP ΔI/% ΔI

ΔT span = [
 =] +a,c

Process Measurement Accuracy

ΔT_{PMA} = [
 =
 =] +a,c

ΔI

PMA1 = [
 =
 =

PMA1 =
 =
 =] +a,c

TABLE 3-18 (Continued)

OVERTEMPERATURE ΔT GAIN CALCULATIONS

Pressure Channel Uncertainties

Pressure Gain = [ ] +a,c
=
=

SCA = [ ] +a,c
=
=

M&TE = [ ]
=

STE = [ ] +a,c
=
=

SD = [ ] +a,c
=
=

Total Allowance

TA = [ ] +a,c
=
=

TABLE 3-19

OVERPOWER ΔT GAIN CALCULATIONS

The equation for Overpower ΔT is:

Overpower ΔT $\leq$

$$\Delta T_0 \{ K_4 - K_5 (\frac{\tau_3 S}{1 + \tau_3 S}) T - K_6 [T - T"] - f_2 (\Delta I) \}$$

K_4 (max)	=	$[\quad]^{+a,c}$
K_4 (nominal)	=	1.07 (Technical Specification Trip Setpoint)
K_5	=	0.02/°F
K_6	=	0.00128
Vessel T_H	=	609.9°F
Vessel T_C	=	542.5°F

ΔT span = $[\quad$
= $\quad]^{+a,c}$

Process Measurement Accuracy

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

Total Allowance

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

TABLE 3-20

STEAM GENERATOR LEVEL DENSITY VARIATIONS

Because of density variations with load due to changes in recirculation, it is impossible without some form of compensation to have the same accuracy under all load conditions. In the past the recommended calibration has been at 50 percent power conditions. Approximate errors at 0 percent and 100 percent water level readings and also for nominal trip points of 10 percent and 70 percent level are listed below for a typical 50 percent power condition calibration. These errors are only from density changes and do not reflect channel accuracies, trip accuracies or indicated accuracies which has been defined as a ΔP measurement only.[1]

INDICATED LEVEL (50 Percent Power Calibration)

	0 percent	10 percent	70 percent	100 percent
Actual Level 0 Percent Power				
Actual Level 100 Percent Power				

+a,c

(1) Miller, R. B., "Accuracy Analysis for Protection/Safeguards and Selected Control Channels", WCAP-8108 (Proprietary), March 1973.

TABLE 3-21

ΔP MEASUREMENTS EXPRESSED IN FLOW UNITS

The ΔP accuracy expressed as percent of span of the transmitter applies throughout the measured span, i.e., $\pm$ 1.5 percent of 100 inches $\Delta P = \pm$ 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:

$$(F_N)^2 = \Delta P_N \qquad \text{where N = nominal flow}$$

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

$$\text{thus } \partial F_N = \frac{\partial(\Delta P_N)}{2(F_N)} \qquad \text{Eq. 3-21.1}$$

Error at a point (not in percent) is:

$$\frac{\partial(F_N)}{F_N} = \frac{\partial(\Delta P_N)}{2(F_N)^2} = \frac{\partial(\Delta P_N)}{2(\Delta P_N)} \qquad \text{Eq. 3-21.2}$$

and

$$\frac{\Delta P_N}{\Delta P_{max}} = \frac{(F_N)^2}{(F_{max})^2} \text{ where max = maximum flow} \qquad \text{Eq. 3-21.3}$$

and the transmitter ΔP error is:

$$\frac{\partial(\Delta P_N)}{\Delta P_{max}} \times 100 = \text{percent error (full scale } \Delta P) \qquad \text{Eq. 3-21.4}$$

$$\therefore \frac{\partial(F_N)}{F_N} = \frac{(\Delta P_{max})\left(\frac{\text{percent error (FS } \Delta P)}{100}\right)}{2(\Delta P_{max})\left(\frac{F_N}{F_{max}}\right)^2} = \left(\frac{\text{percent error (FS } \Delta P)}{2\text{x}100}\right)\left(\frac{F_{max}}{F_N}\right)^2$$

Eq. 3-21.5

Error in flow units is:

$$\partial(F_N) = (F_N)\left(\frac{\text{percent error (FS }\Delta P)}{2\times100}\right)\left(\frac{F_{max}}{F_N}\right)^2 \qquad \text{Eq. 3-21.6}$$

Error in percent nominal flow is:

$$\frac{\partial(F_N)}{F_N} \times 100 = \left(\frac{\text{percent error (FS }\Delta P)}{2}\right)\left(\frac{F_{max}}{F_N}\right)^2 \qquad \text{Eq. 3-21.7}$$

Error in percent full span is:

$$\frac{\partial(F_N)}{F_{max}} \times 100 = \frac{(F_N)(\text{percent error (FS }\Delta P))}{F_{max} \times 2 \times 100}\left(\frac{F_{max}}{F_N}\right)^2 \times 100$$

$$= \left(\frac{\text{percent error (FS }\Delta P)}{2}\right)\left(\frac{F_{max}}{F_N}\right) \qquad \text{Eq. 3-21.8}$$

Equation 3-21.8 is used to express errors in percent full span in this document.

TABLE 3-22

RWST LEVEL - LOW, AUTO QS FLOW REDUCTION

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

*In percent span (100 percent span)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-23

UNDERVOLTAGE - RCP

Parameter	Allowance*
	+a,c
Process Measurement Accuracy	
Primary Element Accuracy (transformer accuracy)	
Sensor Calibration	
Measurement and Test Equipment Accuracy	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance	
Rack Calibration	
Rack Accuracy	
Measurement and Test Equipment Accuracy	
Comparator	
One input	
Rack Temperature Effects	
Rack Drift	

* In percent span (1050 volts)

Channel Statistical Allowance =

+a,c

TABLE 3-24

UNDERFREQUENCY - RCP

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

* In percent span (8 Hertz)

Channel Statistical Allowance =

+a,c

TABLE 3-25

4.16 kV EMERGENCY BUS UNDERVOLTAGE - TRIP FEED,
START DIESEL, DEGRADED VOLTAGE

Parameter	Allowance*
Process Measurement Accuracy	+a,c
Primary Element Accuracy (transformer accuracy)	
Sensor Calibration Measurement and Test Equipment Accuracy	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance	
Rack Calibration Rack Accuracy Measurement and Test Equipment Accuracy	
Comparator One input	
Rack Temperature Effects	
Rack Drift	

* In percent span (1050 volts)

Channel Statistical Allowance =

+a,c

TABLE 3-26

480 VOLT EMERGENCY BUS UNDERVOLTAGE - DEGRADED VOLTAGE

Parameter	Allowance*
	+a,c
Process Measurement Accuracy	
Primary Element Accuracy (transformer accuracy)	
Sensor Calibration Measurement and Test Equipment Accuracy	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance	
Rack Calibration Rack Accuracy Measurement and Test Equipment Accuracy	
Comparator One input	
Rack Temperature Effects	
Rack Drift	

* In percent span (120 volts)

Channel Statistical Allowance =

+a,c

TABLE 3-27

AUXILIARY FEEDWATER TURBINE DRIVEN PUMP DISCHARGE PRESSURE - LOW

Parameter	Allowance*
	+a,c
Process Measurement Accuracy	
Primary Element Accuracy (transformer accuracy)	
Sensor Calibration Measurement and Test Equipment Accuracy	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance	
Rack Calibration Rack Accuracy Measurement and Test Equipment Accuracy	
Comparator One input	
Rack Temperature Effects	
Rack Drift	

* In percent span (200 psig)

Channel Statistical Allowance =

[ ] +a,c

4.0 TECHNICAL SPECIFICATION USAGE

4.1 CURRENT USE

The Standardized Technical Specifications (STS) as used for Westinghouse type plant designs (see NUREG-0452, Revision 4) utilizes a two column format for the RPS and ESF system. This format recognizes that the setpoint channel breakdown, as presented in Figure 4-1, allows for a certain amount of rack drift. The intent of this format is to reduce the number of Licensee Event Reports (LERs) in the area of instrumentation setpoint drift. It appears that this approach has been successful in achieving its goal. However, the approach utilized is fairly simplistic and does not recognize how setpoint calibrations and verifications are performed in the plant. In fact, this two column approach forces the plant to take a double penalty in the area of calibration error. As noted in Figure 4-1, the plant must allow for calibration error below the STS Trip Setpoint, in addition to the allowance assumed in the various accident analyses, if full utilization of the rack drift is wanted. This is due, as noted in 2.2, to the fact that calibration error cannot be distinguished from rack drift after an initial calibration. Thus, the plant is left with two choices; 1) to assume a rack drift value less than that allowed for in the analyses (actual RD = assumed RD-RCA) or, 2) penalize the operation of the plant (by increasing the possibility of a spurious trip) by lowering the nominal trip setpoint into the operating margin.

The use of the statistical summation technique described in Section 2 of this report allows for a natural extension of the two column approach. This extension recognizes the calibration/verification techniques used in the plants and allows for a more flexible approach in reporting LERs. Also of significant benefit to the plant is the incorporation of sensor drift parameters on an 18 month basis (or more often if necessary).

4.2 WESTINGHOUSE STATISTICAL SETPOINT METHODOLOGY FOR STS SETPOINTS

Recognizing that besides rack drift the plant also experiences sensor drift, a different approach to technical specification setpoints, that is somewhat more sophisticated, is used today. This methodology accounts for two additional factors seen in the plant during periodic surveillance, 1) interactive effects for both sensors and rack and, 2) sensor drift effects.

4.2.1 RACK ALLOWANCE

The first item that will be covered is the interactive effects. When an instrument technician looks for rack drift he is seeing more than that. This interaction has been noted several times and is handled in Equations 2.1 and 3.1 the arithmetic summation of rack drift, rack comparator setting accuracy, and rack calibration accuracy for rack effects and sensor drift and sensor calibration accuracy for sensor effects. To provide a conservative "trigger value", the difference between the STS trip setpoint and the STS allowable value is determined by two methods. The first is simply the values used in the statistical calculation, $T_1=(RD + RCA + RMTE + RCSA)$. The second extracts these values from the calculations and compares the remaining numbers statistically against the total allowance as follows:

$$T_2 = TA - \left([(A) + (S)^2]^{1/2} + EA \right) \qquad \text{(Eq. 4.1)}$$

where:

T_2 = Rack trigger value

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

S = (SCA + SMTE + SD)

EA, TA and all other parameters are as defined for Equations 2.1 and 3.1.

The smaller of the trigger values should be used for comparison with the "as measured" (RD + RCA + RMTE + RCSA) value. As long as the "as measured" value is smaller, the channel is well within the accuracy allowance. If the "as measured" value exceeds the "trigger value", the actual numbers should be used in the calculation described in Section 4.2.3.

This means that all the instrument technician has to do during the 31 day periodic surveillance is determine the value of the bistable trip setpoint, verify that it is less than the STS Allowable Value, and does not have to account for any additional effects. The same approach is used for the sensor, i.e., the "as measured" value is used when required. Tables 4-1 and 4-2 show the current STS setpoint philosophy (NUREG-0452, Revision 4) and the Westinghouse rack allowance (for use on 31 day surveillance only). A comparison of the two different Allowable Values will show the net gain of the Westinghouse version.

4.2.2 INCLUSION OF "AS MEASURED" SENSOR ALLOWANCE

If the approach used by Westinghouse was a straight arithmetic sum, sensor allowances for drift would also be straight forward, i.e., a three column setpoint methodology. However, the use of the statistical summation requires a somewhat more complicated approach. This methodology; as demonstrated in Section 4.2.3, Implementation, can be used quite readily by any operator whose plant's setpoints are based on statistical summation. The methodology is based on the use of the following equation.

$$(A)^{1/2} + R + S + EA \leq TA \qquad \text{(Eq. 4.2)}$$

where:

R = the "as measured rack value" (RD + RCA + RMTE + RCSA)

S = the "as measured sensor value" (SD + SCA + SMTE)

and all other parameters are as defined in Equation 4.1.

Equation 4.2 can be reduced further, for use in the STS to:

$$Z + R + S \leq TA \qquad \text{(Eq. 4.3)}$$

where:

$$Z = A^{1/2} + EA$$

Equation 4.3 would be used in two instances, 1) when the "as measured" rack setpoint value exceeds the rack "trigger value" as defined by the STS Allowable Value, and, 2) when determining that the "as measured" sensor value is within acceptable values as utilized in the various Safety Analyses and verified every 18 months.

4.2.3 IMPLEMENTATION OF THE WESTINGHOUSE SETPOINT METHODOLOGY

Implementation of this methodology is reasonably straight forward, Appendix A provides a text and tables for use in the Technical Specifications. An example of how the specification would be used for the Pressurizer Water Level - High reactor trip is as follows.

Every 31 days, as required by Table 4.3-1 of NUREG-0452, Revision 4, a functional test would be performed on the channels of this trip function. During this test the bistable trip setpoint would be determined for each channel. If the "as measured" bistable trip setpoint error was found to be less than or equal to that required by the Allowable Value, no action would be necessary by the plant staff. The Allowable Value is determined by Equation 4.1 as follows:

$$T = TA - \left([(A) + (S)^2]^{1/2} + EA \right)$$

where:

TA = 5 percent (an assumed value)

+a,c

A =

$(S)^2$ =

EA =

T =

=

=

=

However, since only 1.8 percent is assumed for T in the various analyses, that value will be used as the "trigger value". The lowest of two values is used for the "trigger value"; either the value for T assumed in the analyses or the value calculated by Equation 4.1.

Now assume that one bistable has "drifted" more than that allowed by the STS for 31 day surveillance. According to ACTION statement "A", the plant staff must verify that Equation 2.2-1 is met. Going to Table 2.2-1, the following values are noted: Z = 2.18 and the Total Allowance (TA) = 5.0 for the purpose of this example. Assume that the "as measured" rack setpoint value is 2.25 percent low and the "as measured" sensor value is 1.5 percent. Equation 2.2-1 looks like:

$$Z + R + S \leq TA$$

$$2.18 + 2.25 + 1.5 \leq 5.0$$
$$5.9 \leq 5.0$$

As can be seen, 5.9 percent is not less than 5.0 percent thus, the plant staff must follow ACTION statement "B" (declare channel inoperable and place in the "tripped" condition). It should be noted that if the plant staff had not measured the sensor drift, but instead used the value of S in Table 2.2-1 then the sum of Z + R + S would also be greater than 5.0 percent. In fact, almost anytime the "as measured" value for rack drift is greater than T (the "trigger value"), use of S in Table 2.2-1 will result in the sum of Z + R + S being greater than TA and requiring the reporting of the case to the NRC.

If the sum of R + S was about one percent less, e.g., R = 2.0 percent, S = 0.75 percent thus, R + S = 2.75 percent, then the sum of Z + R + S would be less than 5 percent. Under this condition, the plant staff would recalibrate the instrumentation, as good engineering practice suggests, but the incident is not reportable, even though the "trigger value" is exceeded, because Equation 2.2-1 was satisfied.

In the determination of T for a function with multiple channel inputs there is a slight disagreement between Westinghouse proposed methodology and NRC approved methodology. Westinghouse believes that T should be either:

$$T_{12} = (RCA_1 + RMTE_1 + RCSA_1 + RD_1) + (RCA_2 + RMTE_2 + RCSA_2 + RD_2) \qquad \text{(Eq. 4.4)}$$

$$T_{22} = TA - ((A + (S_1)^2 + (S_2)^2)^{1/2} + EA) \qquad \text{(Eq. 4.5)}$$

where the subscript 1 and 2 denote channels 1 and 2, and the value of T used is whichever is smaller.

The NRC in turn has approved a method of determining T for a multiple channel input function as follows, either:

$$T_3 = [(RCA_1 + RMTE_1 + RCSA_1 + RD_1)^2 + (RCA_2 + RMTE_2 + RCSA_2 + RD_2)^2]^{1/2}$$

or (Eq. 4.6)

Equation 4.5 as described above.

Again the value of T used is whichever is smaller. This method is described in NUREG-0717 Supplement 4, dated August 1982.

An example demonstrating all of the above noted equations for Overpower ΔT is provided below: (Numbers arbitrarily assumed for purposes of this example)

+a,c

TA =
A =
$(S_1)^2$ =
$(S_2)^2$ =

+a,c

$RCA_1 + RMTE_1 + RCSA_1 + RD_1$ =
$RCA_2 + RMTE_2 + RCSA_2 + RD_2$ =
$RCA_3 = 0.007$
EA =
Bias =

Using Equation 4.4;

$$T_{12} = \left[\quad \right]^{+a,c}$$

Using Equation 4.5;

$$T_{22} = \left[\quad \right]^{+a,c}$$

Using Equation 4.6;

$$T_3 = \left[\quad \right]^{+a,c}$$

The value of T used is from Equation 4.5. In this document Equations 4.5 and 4.6, whichever results in the smaller value is used for multiple channel input functions to remain consistent with current NRC approved methodologies. Table 4-3 notes the values of TA, A, S, T, and Z for all protection functions and is utilized in the determination of the Allowable Values noted in Appendix A.

Table 4.3-1 also requires that a calibration be performed every refueling (approximately 18 months). To satisfy this requirement, the plant staff would determine the bistable trip setpoint (thus, determining the "as measured" rack value at that time) and the sensor "as measured" value. Taking these two "as measured" values and using Equation 2.2-1 again the plant staff can determine that the tested channel is in fact within the Safety Analysis allowance.

4.3 CONCLUSION

Using the above methodology, the plant gains added operational flexibility and yet remains within the allowances accounted for in the various accident analyses. In addition, the methodology allows for a sensor drift factor and an increased rack drift factor. These two gains should significantly reduce the problems associated with channel drift and thus, decrease the number of LERs while allowing plant operation in a safe manner.

TABLE 4-1

EXAMPLES OF CURRENT STS SETPOINT PHILOSOPHY

	Power Range Neutron Flux - High	Pressurizer Pressure - High
Safety Analysis Limit	118 percent	2410 psig
STS Allowable Value	110 percent	2395 psig
STS Trip Setpoint	109 percent	2385 psig

TABLE 4-2

EXAMPLES OF WESTINGHOUSE STS RACK ALLOWANCE

	Power Range Neutron Flux - High	Pressurizer Pressure - High
Safety Analysis Limit	118 percent	2410 psig
STS Allowable Value (Trigger Value)	111.2 percent	2396 psig
STS Trip Setpoint	109 percent	2385 psig

Safety Analysis Limit

Process Measurement Accuracy

Primary Element Accuracy

Sensor Temperature Effects

Sensor Pressure Effects

Sensor Calibration Accuracy

Sensor Drift

Environmental Allowance

Rack Temperature Effects

Rack Comparator Setting Accuracy

Rack Calibration Accuracy

STS Allowable Value

Rack Drift

STS Trip Setpoint

Actual Calibration Setpoint

Figure 4-1 NUREG-0452 Rev. 4 Setpoint Error Breakdown

Safety Analysis Limit

Process Measurement Accuracy

Primary Element Accuracy

Sensor Temperature Effects

Sensor Pressure Effects

Sensor Calibration Accuracy

Sensor Drift

Environmental Allowance

Rack Temperature Effects

STS Allowable Value

Rack Comparator Setting Accuracy

Rack Calibration Accuracy

Rack Drift

STS Trip Setpoint

Figure 4-2 Westinghouse STS Setpoint Error Breakdown

WESTINGHOUSE PROTECTION SY

BEAVER

UNIT

TABLE 4-3

PROTECTION CHANNEL	TOTAL ALLOWANCE (TA) (9)	(A) (9) (1)	(S) (9) (2)	(T)
POWER RANGE, NEUTRON FLUX - HIGH SETPOINT	7.5	[ ]+a,c	0.0	
POWER RANGE, NEUTRON FLUX - LOW SETPOINT	8.3		0.0	
POWER RANGE, NEUTRON FLUX - HIGH POSITIVE RATE	1.6		0.0	
POWER RANGE, NEUTRON FLUX - HIGH NEGATIVE RATE	1.6		0.0	
INTERMEDIATE RANGE, NEUTRON FLUX	17.0		0.0	
SOURCE RANGE, NEUTRON FLUX	17.0		0.0	
OVERTEMPERATURE ΔT	8.0		1.40+0.69	
OVERPOWER ΔT	5.4		1.40	
PRESSURIZER PRESSURE-LOW REACTOR TRIP	3.1		1.62	
PRESSURIZER PRESSURE-HIGH	6.4		0.62	
PRESSURIZER WATER LEVEL-HIGH	8.0		1.62	
LOSS OF FLOW	2.5		0.60	
STEAM GENERATOR WATER LEVEL-LOW-LOW	12.0		1.62	
STEAM GENERATOR WATER LEVEL - LOW	25.0		1.62	
STEAM FLOW - FEED FLOW MISMATCH	20.0		1.00+0.81+1.00	
UNDERVOLTAGE - RCP	10.0		0.0	
UNDERFREQUENCY - RCP	6.2		0.0	
PRESSURIZER PRESSURE LOW - S.I.	18.1		1.62	
STEAMLINE PRESSURE - LOW	12.6		1.62	
CONTAINMENT PRESSURE HIGH	3.1		1.62	
CONTAINMENT PRESSURE HIGH - HIGH	3.1		1.62	
CONTAINMENT PRESSURE INTERMEDIATE HIGH - HIGH	3.1		1.62	
NEGATIVE STEAM PRESSURE RATE - HIGH	3.0		0.0	
STEAM GENERATOR WATER LEVEL HIGH - HIGH	5.0		1.62	
RWST LEVEL - LOW	3.7		1.62	
RWST LEVEL-AUTO QS FLOW REDUCTION	4.0		1.62	
4.16 KV EMERGENCY BUS UNDERVOLTAGE - TRIP FEED	15.0		0.0	
4.16 KV EMERGENCY BUS UNDERVOLTAGE - START DIESEL	15.0		0.0	
4.16 KV EMERGENCY BUS UNDERVOLTAGE - DEGRADED VOLTAGE	15.0		0.0	
480V EMERGENCY BUS UNDERVOLTAGE - DEGRADED VOLTAGE	15.0		0.0	
AUX FEED TURBINE DRIVEN PUMP DISCHARGE PRESSURE - LOW	5.0		0.0	

NOTES:

(1) [

(2)

(3)

(4)]+a,c

(5) TAVG - 100°F

ΔP - 800 PSI

φ - 120% RTP

ΔT - 101.1°F

ΔI - ±30% ΔI

(6) TAVG - 100°F

ΔP - 800 PSI

φ - 120% RTP

ΔT - 101.1°F

(7) [ ]+a,c

(8) AS NOTED IN NOTES 1.2 AND 3 OF TABLE 2.2-1 OF STS.

(9) ALL VALUES IN PERCENT SPAN

(10) [ ]+a,c

STEM STS SETPOINT INPUTS
/ALLEY
1

(9) (3)	(Z) (9) (4)	INSTRUMENT SPAN	STS TRIP SETPOINT	STS ALLOWABLE VALUE (10)	MAXIMUM VALUE (7)
.91	4.56	120% RTP	109% RTP	111.3% RTP	
.91	4.56	120% RTP	25% RTP	27.3% RTP	
.08	0.50	120% RTP	5.0% RTP	6.3% RTP	
.08	0.50	120% RTP	5.0% RTP	6.3% RTP	
.11	8.41	120% RTP	25% RTP	31.1% RTP	
.91	10.01	1.0E+06 CPS	1.0E+05 CPS	1.4E+05 CPS	
.38	4.34	(5).	FUNCTION (8)	FUNCTION (8)+3.4% ΔT SPAN	
.35	1.38	(6).	FUNCTION (8)	FUNCTION (8)+3.4% ΔT SPAN	
.36	0.71	800 PSIG	1945 PSIG	1934 PSIG	
.18	4.96	800 PSIG	2385 PSIG	2394 PSIG	
.91	2.18	100% SPAN	92% SPAN	93.9% SPAN	
.63	1.77	120% DESIGN FLOW	90% FLOW	89.2% FLOW	
.28	10.18	100% SPAN	12.0% SPAN	10.7% SPAN	
.91	2.18	100% SPAN	25.0% SPAN	23.1% SPAN	
.83	2.66	120% FLOW	40.0% STEAM FLOW	43.4% STEAM FLOW	
.00	1.39	1050 VOLTS	2750 VOLTS	2687 VOLTS	
.25	0.50	8 HZ.	57.5 HZ.	57.4 HZ.	
.91	14.41	800 PSIG	1845 PSIG	1830 PSIG	
.88	10.71	1400 PSI	500 PSIG	488 PSIG	
.31	0.71	65 PSIG	1.5 PSIG	2.4 PSIG	
.31	0.71	65 PSIG	8.0 PSIG	8.9 PSIG	
.31	0.71	65 PSIG	3.0 PSIG	3.9 PSIG	
.91	0.50	1400 PSI	100 PSI	127 PSI	
.91	2.18	100% SPAN	75.0% SPAN	76.9% SPAN	
.91	0.71	12 FEET	19 FEET 2.5 INCHES	19 FEET 0 INCHES	
.91	0.71	12 FEET	11 FEET	10 FEET 9 INCHES	
.00	1.39	1050 VOLTS	75.0% OF BUS VOLTAGE	73% OF BUS VOLTAGE	
.00	1.39	1050 VOLTS	83.0% OF BUS VOLTAGE	81% OF BUS VOLTAGE	
.00	1.39	1050 VOLTS	90.0% OF BUS VOLTAGE	88% OF BUS VOLTAGE	
.00	1.39	120 VOLTS	90.0% OF BUS VOLTAGE	88% OF BUS VOLTAGE	
.00	2.00	200 PSIG	468 PSIG	464 PSIG	

REV. 0
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APPENDIX A

SAMPLE BEAVER VALLEY UNIT 1

SETPOINT TECHNICAL SPECIFICATIONS

SAFETY LIMITS AND LIMITING SAFETY SYSTEM SETTINGS

2.2 LIMITING SAFETY SYSTEM SETTINGS

REACTOR TRIP SYSTEM INSTRUMENTATION SETPOINTS

2.2.1 The Reactor Trip System Instrumentation and Interlock Setpoints shall be 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, either:

   1. Adjust the Setpoint consistent with the Trip Setpoint value of Table 2.2-1 and determine within 12 hours that Equation 2.2-1 was satisfied for the affected channel, or

   2. Declare the channel inoperable and apply the applicalbe 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.

EQUATION 2.2-1 $$Z + R + S \leq TA$$

where:

Z = The value for column Z of Table 2.2-1 for the affected channel,

R = the "as measured" value (in percent span) of rack error for the affected channel,

S = either the "as measured" value (in percent span) of the sensor error, or the value in column S (Sensor Error) of Table 2.2-1 for the affected channel, and

TA = the value from column TA (Total Allowance in % of span) of Table 2.2-1 for the affected channel.

TABLE 2.2-1

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

FUNCTIONAL UNIT	TOTAL ALLOWANCE (TA)	Z	SENSOR ERROR S	TRIP SETPOINT	ALLOWABLE VALUE
1. Manual Reactor Trip	N.A.	N.A.	N.A.	N.A.	N.A.
2. Power Range , Neutron Flux a. High Setpoint	7.5	4.56	0	$\leq$109% of RTP*	$\leq$111.3% of RTP*
b. Low Setpoint	8.3	4.56	0	$\leq$25% of RTP*	$\leq$27.3% of RTP*
3. Power Range, Neutron Flux, High Positive Rate	1.6	0.50	0	$\leq$5% of RTP* with a time constant $\geq$2 seconds	$\leq$6.3% of RTP* with a time constant $\geq$2 seconds
4. Power Range, Neutron Flux, High Negative Rate	1.6	0.50	0	$\leq$5% of RTP* with a time constant $\geq$2 seconds	$\leq$6.3% of RTP* with a time constant $\geq$2 seconds
5. Intermediate Range, Neutron Flux	17.0	8.41	0	$\leq$25% of RTP*	$\leq$31.1% of RTP*
6. Source Range, Neutron Flux	17.0	10.01	0	$\leq 10^5$ cps	$\leq 1.4 \times 10^5$ cps
7. Overtemperature ΔT	8.0	4.34	1.40 + 0.69 (Temperature & Pressure)	See Note 1	See Note 2
8. Overpower ΔT	5.4	1.38	1.40	See Note 3	See Note 4
9. Pressurizer Pressure-Low	3.1	0.71	1.62	$\geq$1945 psig	$\geq$1934 psig
10. Pressurizer Pressure-High	6.4	4.96	0.62	$\leq$2385 psig	$\leq$ 2394 psig
11. Pressurizer Water Level-High	8.0	2.18	1.62	$\leq$92% of instrument span	$\leq$93.9% of instrument span
12. Low Reactor Coolant Flow	2.5	1.77	0.60	$\geq$90% of loop design flow**	$\geq$89.2% of loop design flow**

* = RATED THERMAL POWER

**Loop design flow = 88,500 gpm

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

FUNCTIONAL UNIT	TOTAL ALLOWANCE (TA)	Z	SENSOR ERROR S	TRIP SETPOINT	ALLOWABLE VALUE
13. Steam Generator Water Level Low-Low	12.0	10.18	1.62	≥12.0% of narrow range instrument span	≥10.7% of narrow range instrument span
14a. Steam Generator Water Level Low	25.0	2.18	1.62	≥25.0% of narrow range instrument span	≥23.1% of narrow range instrument span
coincident with					
b. Steam/Feedwater Flow Mismatch	20.0	2.66	1.0 + 0.81 + 1.0	≤40% of full steam flow at rated thermal power	≤43.4% of full steam flow at rated thermal power
15. Undervoltage - Reactor Coolant Pumps	10.0	1.39	0	≥2750 volts - each bus	≥2687 volts - each bus
16. Underfrequency - Reactor Coolant Pumps	6.2	0.50	0	≥57.5 Hz - each bus	≥57.4 Hz - each bus
17. Turbine Trip					
a. Auto stop oil pressure	N.A.	N.A.	N.A.	Not Provided by Westinghouse	
b. Turbine Stop Valve	N.A.	N.A.	N.A.	Not Provided by Westinghouse	
18. Safety Injection Input from ESF	N.A.	N.A.	N.A.	N.A.	N.A.

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

FUNCTIONAL UNIT	TOTAL ALLOWANCE (TA)	Z	S	TRIP SETPOINT	ALLOWABLE VALUE
19. Reactor Coolant Pump Breaker Position Trip	N.A.	N.A.	N.A.	N.A.	N.A.
20. Reactor Trip System Interlocks	N.A.	N.A.	N.A.	N.A.	N.A.
a. Intermediate Range Neutron Flux, P-6	N.A.	N.A.	N.A.	$\geq 1 \times 10^{-10}$ amps	$\geq 6 \times 10^{-11}$ amps
b. Power Range Neutron Flux, P-8	N.A.	N.A.	N.A.	$\leq$30% of RTP*	$\leq$32.3% of RTP*
c. Power Range Neutron Flux, P-9	N.A.	N.A.	N.A.	$\leq$49% of RTP*	$\leq$51.3% of RTP*
d. Power Range Neutron Flux, P-10 (Input to P-7)	N.A.	N.A.	N.A.	10% of RTP*	$\geq$7.7% and $\leq$ 12.3% of RTP*
e. Turbine Impulse Chamber Pressure, P-13 (Input to P-7)	N.A.	N.A.	N.A.	$\leq$10% of RTP* turbine impulse pressure equivalent	$\leq$12.3% of RTP* turbine impulse pressure equivalent

*RTP = RATED THERMAL POWER

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

NOTATION

NOTE 1: OVERTEMPERATURE ΔT

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

Where: ΔT	=	Measured ΔT by RTD Manifold Instrumentation;
ΔT_o	=	Indicated ΔT at RATED THERMAL POWER;
K_1	=	1.18;
K_2	=	0.01655/°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 lead-lag controller for T_{avg}, $\tau_1 = 30$ s, $\tau_2 = 4$ s;
T	=	Average temperature, °F;
$\frac{1}{1 + \tau_4 S}$	=	The function generated by the lag controller for ΔT dynamic compensation;
τ_4	=	The time constant used in the lag controller for ΔT, $\tau_4 \leq 2$ seconds;
$\frac{1}{1 + \tau_5 S}$	=	The function generated by the lag controller for T_{avg} dynamic compensation;
τ_5	=	The time constant used in the lag controller for T_{avg}, $\tau_5 \leq 2$ seconds;

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

NOTE 1: (Continued)

T'	=	$\leq$ 576.3°F (Nominal T_{avg} at RATED THERMAL POWER);
K_3	=	0.000801;
P	=	Pressurizer Pressure, psig;
P'	=	2235 psig (Nominal RCS operating pressure) and
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 -23% and + 11%, $f_1(\Delta I) = 0$, 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 -23%, the ΔT Trip Setpoint shall be automatically reduced by 1.54% of its value at RATED THERMAL POWER; and

(iii) For each percent that the magnitude of $q_t - q_b$ exceeds +11%, the ΔT Trip Setpoint shall be automatically reduced by 1.91% 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 3.4% of ΔT span.

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

NOTE 3: OVERPOWER ΔT

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

Where: ΔT = Measured ΔT by RTD Manifold Instrumentation;

ΔT_o = Indicated ΔT at RATED THERMAL POWER;

K_4 = 1.07;

K_5 = 0.02/°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 constants utilized in rate-lag controller for T_{avg}, τ_3 = 10 s;

$\frac{1}{1 + \tau_4 S}$ = The function generated by the lag controller for ΔT dynamic compensation;

τ_4 = The time constant used in the lag controller for ΔT, $\tau_4 \leq 2$ seconds;

$\frac{1}{1 + \tau_5 S}$ = The function generated by the lag controller for T_{avg} dynamic compensation;

τ_5 = The time constant used in the lag controller for T_{avg}, $\tau_5 \leq 2$ seconds;

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

NOTATION (Continued)

NOTE 3: (Continued)

K_6	=	0.00128/°F for $T > T''$ and $K_6 = 0$ for $T \leq T''$,
T	=	Average Temperature, °F;
T''	=	Indicated T_{avg} at RATED THERMAL POWER $\leq$ 576.3°F,
S	=	Laplace transform operator, s^{-1}; and
$f_2(\Delta I)$	=	0 for all ΔI

NOTE 4: The channel's maximum Trip Setpoint shall not exceed its computed Trip Setpoint by more than 3.4% of ΔT span.

2.2 LIMITING SAFETY SYSTEM SETTINGS

BASES

2.2.1 REACTOR TRIP SYSTEM INSTRUMENTATION SETPOINTS

The Reactor Trip Setpoint Limits specified in Table 2.2-1 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 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.

To accommodate the instrument drift assumed to 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 2.2-1. Operation with setpoints less conservative than the Trip Setpoint but within the Allowable Value is acceptable since an allowance has been made in the safety analysis to accommodate this error. An optional provision has been included for determining the OPERABILITY of a channel when its trip setpoint is found to exceed the Allowable Value. The methodology of this option utilizes the "as measured" deviation from the specified calibration point for rack and sensor components in conjunction with a statistical combination of the other uncertainties in calibrating the instrumentation. In Equation 2.2-1, $Z + R + S \leq TA$, the interactive effects of the errors in the rack and the sensor, and the "as measured" values of the errors are considered. Z, as specified in Table 2.2-1, in percent span, is the statistical summation of errors assumed in the analysis excluding those associated with the sensor and rack drift and the accuracy of their measurement. TA or Total Allowance is the difference, in percent span, between the trip setpoint and the value used in the analysis for reactor trip. R or Rack Error is the "as measured" deviation, in percent span, for the affected channel from the specified trip setpoint. S or Sensor Drift is either the "as measured" deviation of the sensor from its calibration point or the value specified in Table 2.2-1, in percent span, from the analysis assumptions. Use of Equation 2.2-1 allows for a sensor drift factor, an increased rack drift factor, and provides a threshold value for REPORTABLE OCCURRENCES.

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. Rack drift in excess of the Allowable Value exhibits the behavior that the rack has not met its allowance. Being that there is a small statistical chance that this will happen, an infrequent excessive drift is expected. Rack or sensor drift, in excess of the allowance that is more than occasional, may be indicative of more serious problems and should warrant further investigation.

3/4.3.2 ENGINEERED SAFETY FEATURE ACTUATION SYSTEM INSTRUMENTATION

LIMITING CONDITION FOR OPERATION

3.3.2 The Engineered Safety Feature 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 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, either:

   1. Adjust the Setpoint consistent with the Trip Setpoint value of Table 3.3-4 and determine within 12 hours that Equation 2.2-1 was satisfied for the affected channel, or

   2. 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 Setpoint adjusted consistent with the Trip Setpoint value.

EQUATION 2.2-1 $$Z + R + S \leq TA$$

where:

Z = The value for Column Z of Table 3.3-4 for the affected channel,

R = The "as measured" value (in percent span) of rack error for the affected channel,

S = Either the "as measured" value (in percent span) of the sensor error, or the value from Column S (Sensor Drift) of Table 3.3-4 for the affected channel, and

TA = The value from Column TA (Total Allowance) of Table 3.3-4 for the affected channel.

TABLE 3.3-4

ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

FUNCTIONAL UNIT	TOTAL ALLOWANCE (TA)	Z	SENSOR DRIFT (S)	TRIP SETPOINT	ALLOWABLE VALUE
1. Safety Injection, Turbine Trip and Feedwater Isolation					
a. Manual Initiation	N.A.	N.A.	N.A.	N.A.	N.A.
b. Automatic Acutation Logic	N.A.	N.A.	N.A.	N.A.	N.A.
c. Containment Pressure - High	3.1	0.71	1.62	$\leq$ 1.5 psig	$\leq$2.4 psig
d. Pressurizer Pressure - Low	18.1	14.41	1.62	$\geq$ 1845 psig	$\geq$ 1830 psig
e. Steam Line Pressure - Low	12.6	10.71	1.62	$\geq$ 500 psig	$\geq$ 488 psig

TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

FUNCTIONAL UNIT	TOTAL ALLOWANCE (TA)	Z	SENSOR DRIFT (S)	TRIP SETPOINT	ALLOWABLE VALUE
1.1 Safety Injection-Transfer From Injection to the Recirculation Mode					
a. Manual Initiation	N.A.	N.A.	N.A.	N.A.	N.A.
b. Automatic Actuation Logic Coincident with Safety Injection Signal	N.A.	N.A.	N.A.	N.A.	N.A.
c. Refueling Water Storage Tank Level-Low	3.7	0.71	1.62	$\geq$19'2-1/2"	$\geq$19'0"
d. Refueling Water Storage Tank Level - Auto QS Flow Reduction	4.0	0.71	1.62	$\geq$11'0"	$\geq$10'9"
2. Containment Spray					
a. Manual Initiation	N.A.	N.A.	N.A.	N.A.	N.A.
b. Automatic Acutation Logic	N.A.	N.A.	N.A.	N.A.	N.A.
c. Containment Pressure - High-High	3.1	0.71	1.62	$\leq$ 8.0 psig	$\leq$ 8.9 psig
3. Containment Isolation					
a. Phase "A" Isolation					
1) Manual Initiation	N.A.	N.A.	N.A.	N.A.	N.A.

TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

FUNCTIONAL UNIT	TOTAL ALLOWANCE (TA)	Z	SENSOR DRIFT (S)	TRIP SETPOINT	ALLOWABLE VALUE
3. Containment Isolation (continued)					
2) From Safety Injection Automatic Actuation Logic	N.A.	N.A.	N.A.	N.A.	N.A.
b. Phase "B" Isolation					
1) Manual	N.A.	N.A.	N.A.	N.A.	N.A.
2) Automatic Actuation Logic	N.A.	N.A.	N.A.	N.A.	N.A.
3) Containment Pressure -- High-High	3.1	0.71	1.62	$\leq$ 8 psig	$\leq$ 8.9 psig
4. Steam Line Isolation					
a. Manual Initiation	N.A.	N.A.	N.A.	N.A.	N.A.
b. Automatic Actuation Logic	N.A.	N.A.	N.A.	N.A.	N.A.
c. Containment Pressure-Intermediate High-High	3.1	0.71	1.62	$\leq$ 3.0 psig	$\leq$ 3.9 psig
d. Steam Line Pressure-Low	12.6	10.71	1.62	$\geq$ 500 psig	$\geq$ 488 psig
e. High Negative Steam Pressure Rate	3.0	0.50	0	$\leq$ -100 psi with a time constant $\geq$ 50 seconds	$\leq$ -127 psi with a time constant $\geq$ 50 seconds

TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

FUNCTIONAL UNIT	TOTAL ALLOWANCE (TA)	Z	SENSOR DRIFT (S)	TRIP SETPOINT	ALLOWABLE VALUE
5. Turbine Trip and Feedwater Isolation					
a. Steam Generator Water Level--High-High	5.0	2.18	1.62	$\leq$ 75% of narrow range instrument span	$\leq$ 76.9% of narrow range instrument span
6. Loss of Power					
a. 1. 4.16kv Emergency Bus Undervoltage (Loss of Voltage) (Trip Feed)	15.0	1.39	0	$\geq$ 75% of nominal bus voltage with a 1 $\pm$ 0.1 second time delay	$\geq$ 73% of nominal bus voltage with a 1 $\pm$ 0.1 second time delay
2. 4.16kv Emergency Bus (Start Diesel)	15.0	1.39	0	$\geq$ 83% of nominal bus voltage - 12 cycles	$\geq$ 81% of nominal bus voltage
b. 4.16kv Emergency Bus Undervoltage (Degraded Voltage)	15.0	1.39	0	$\geq$ 90% of nominal bus voltage with a 90 $\pm$ 5 second time delay	$\geq$ 88% of nominal bus voltage with a 90 $\pm$ 5 second time delay
c. 480v Emergency Bus Undervoltage (Degraded Voltage)	15.0	1.39	0	$\geq$ 90% of nominal bus voltage with a 90 $\pm$ 5second time delay	$\geq$ 88% of nominal bus voltage with a 90 $\pm$ 5 second time delay

TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

FUNCTIONAL UNIT	TOTAL ALLOWANCE (TA)	Z	SENSOR DRIFT (S)	TRIP SETPOINT	ALLOWABLE VALUE
7. Auxiliary Feedwater					
a. Steam Generator Water Level-low-low	12.0	10.18	1.62	$\geq$ 12% of narrow range instrument span each steam generator	$\geq$ 10.7 of narrow range instrument span each steam generator
b. Undervoltage - RCP	10.0	1.39	0	$\geq$ 2750 volts RCP bus voltage	$\geq$ 2687 volts RCP bus voltage
c. S.I.				See 1 above (all SI Setpoints)	
d. Turbine Driven Pump Discharge Pressure Low	5.0	2.00	0	$\geq$ 468 psig	$\geq$ 464 psig
e. Emergency Bus Undervoltage	Not Provided by Westinghouse				
f. Trip of Main Feedwater Pumps	N.A.	N.A.	N.A.	N.A.	N.A.
8. Engineered Safety Feature Interlocks					
a. Reactor Trip, P-4	N.A.	N.A.	N.A.	N.A.	N.A.
b. Pressurizer Pressure, P-11	N.A.	N.A.	N.A.	$\leq$2000 psig	$\leq$2010 psig
c. P-12	N.A.	N.A.	N.A.	$\geq$ 541°F	$\leq$ 539°F

3/4.3 INSTRUMENTATION

BASES

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

The OPERABILITY of the Reactor Protection System and Engineered Safety Feature Actuation System Instrumentation and interlocks ensure 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 accident analyses. The surveillance requirements specified for these systems ensure that the overall system functional capability is maintained comparable to the original design standards. The periodic surveillance tests performed at the minimum frequencies are sufficient to demonstrate this capability.

The Engineered Safety Feature Actuation System Instrumentation Trip Setpoints specified in Table 3.3-4 are the nominal values at which the bistables are set for each functional unit. A setpoint is considered to be adjusted consistent with the nominal value when the "as measured" setpoint is within the band allowed for calibration accuracy.

To accommodate the instrument drift assumed to 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 since an allowance has been made in the safety analysis to accommodate this error. An optional provision has been included for determining the OPERABILITY of a channel when its trip setpoint is found to exceed the Allowable Value. The methodology of this option utilizes the "as measured" deviation from the specified calibration point for rack and sensor components in conjunction with a statistical combination of the other uncertainties of the instrumentation to measure the process variable and the uncertainties in calibrating the instrumentation. In Equation 2.2-1, $Z + R + S \leq TA$, the interactive effects of the errors in the rack and the sensor, and the "as measured" values of the errors are considered. Z, as specified in Table 3.3-4, in percent span, is the statistical summation of errors assumed in the analysis excluding those associated with the sensor and rack drift and the accuracy of their measurement. TA or Total Allowance is the difference, in percent span, between the trip setpoint and the value used in the analysis for the actuation. R or Rack Error is the "as measured" deviation, in percent span, for the affected channel from the specified trip setpoint. S or Sensor Drift is either the "as measured" deviation of the sensor from its calibration point or the value specified in Table 3.3-4, in percent span, from the analysis assumptions. Use of Equation 2.2-1 allows for a sensor drift factor, an increased rack drift factor, and provides a threshold value for REPORTABLE OCCURRENCES.

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. Sensor and rack instrumentation utilized in these channels are expected to be capable of operating within the allowances of these uncertainty magnitudes. Rack drift in excess of the Allowable Value exhibits the behavior that the rack has not met its allowance. Being that there is a small statistical chance that this will happen, an infrequent excessive drift is expected. Rack or sensor drift, in excess of the allowance that is more than occasional, may be indicative of more serious problems and should warrant further investigation.