(WESTINGHOUSE [redacted] CLASS 3)

WESTINGHOUSE SETPOINT METHODOLOGY FOR PROTECTION SYSTEMS CATAWBA STATION

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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 (read NRC) 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 [ ]$^{+a,c,e}$ which has been utilized in other Westinghouse reports. This technique, or other statistical approaches of a similar nature, have been used in WCAP-9180[1] and WCAP-8567[2]. It should be noted that WCAP-8567 has been approved by the NRC Staff thus noting the acceptability of statistical techniques for the application requested. It should also be recognized that 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 becoming more and more widespread.

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

[(Eq. 2.1)]$^{+a,c}$

(1) Little, C.C., Kopelic, S. D., and Chelemer, H., "Consideration of Uncertainties in the Specification of Core Hot Channel Factor Limits." WCAP-9180 (Proprietary), WCAP-9181 (Non-Proprietary), September, 1977.

(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, Draft F, May 22, 1979, "Setpoints for Nuclear Safety-Related Instrumentation Used in Nuclear Power Plants."

where:

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

As can be seen in Equation 2.1, [$]^{+a,c}$ allowances are interactive and thus not independent. The [$]^{+a,c}$ 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 uncertainities 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 3-16). Of these four parameters, two are considered to be statistically independent, [ ]$^{+a,c}$, and two are considered interactive [ ]$^{+a,c}$. [ ]$^{+a,c}$ are considered to be independent due to the manner in which the instrumentation is checked, i.e., the instrumentation is

[ ]$^{+a,c}$

[ ]$^{+a,c}$ are considered to be interactive for the same reason that [ ]$^{+a,c}$ are considered independent, i.e., due to the manner in which the instrumentation is checked. [ ]$^{+a,c}$. Based on this reasoning, [ ]$^{+a,c}$ 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):

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

using Equation 2.1 as written gives a total of;

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

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

[ ]$^{+a,c}$ (Eq. 2.2)

= 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 3-16, 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). [ ]$^{+a,c}$. [

]$^{+a,c}$

[

]$^{+a,c}$. 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:

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

using Equation 2.1 the result is;

[ ]$^{+a,c}$ = 1.82 percent

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

[ ]$^{+a,c}$ (Eq. 2.3)

= 1.25 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 noninstrument 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.

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:

[ ] +a,c

(Eq. 3.1)

where:

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

Tables 3-1 through 3-15 provide individual channel breakdown and channel statistical allowance calculations for all protection functions utilizing 7300 process rack equipment. Table 3-16 provides a summary of the previous 15 tables and includes analysis and technical specification values, total allowance and margin.

3.2 DEFINITIONS FOR PROTECTION SYSTEM SETPOINT TOLERANCES

To insure a clear understanding of the channel 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 measurments.

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.

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 - [ ]$^{+abc}$ 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 - [ ]$^{+abc}$ percent based on a nominal temperature coefficient of [ ]$^{+abc}$ 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 [ ]$^{+abc}$ percent is used. Present data indicates a static pressure effect of approximately [ ]$^{+abc}$ percent/1000 psi.

d. Drift - change in input-output relationship over a period of time at reference conditions (e.g., [ ]$^{+a,c}$ - [ ]$^{+abc}$ 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 [ ]$^{+abc}$ percent of span assuming the chain of modules is tuned to this accuracy. For simple loops where a power supply (not used as a converter) is the only rack module, this accuracy may be ignored. All rack modules individually must have a reference accuracy within [ ]$^{+abc}$ percent.

b. Rack Environmental Effects

Includes effects of temperature, humidity, voltage and frequency changes of which temperature is the most significant. An accuracy of [ ]$^{+abc}$ 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., [ ]^{a,c}) - ±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 Manufactureres 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 - [ ]$^{+abc}$ percent accuracy. This assumes that comparator nonlinearities are compensated by the setpoint.

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

12. Total Allowable Setpoint Deviation

Same definition as 9, but the difference between 8 and 12 encompasses [ ].[+a,c]

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	
Sensor Pressure Effects	
Sensor Temperature Effects [ ]+a,c	
Sensor Drift [ ]+a,c	
Environmental Allowance	
Rack Calibration Rack 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	
Sensor Pressure Effects	
Sensor Temperature Effects [ ]+a,c	
Sensor Drift [ ]+a,c	
Environmental Allowance	
Rack Calibration Rack 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	
Sensor Pressure Effects	
Sensor Temperature Effects [ ]+a,c	
Sensor Drift [ ]+a,c	
Environmental Allowance	
Rack Calibration Rack 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	
Sensor Pressure Effects	
Sensor Temperature Effects [ ] +a,c	
Sensor Drift [ ] +a,c	
Environmental Allowance	
Rack Calibration Rack 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	
Sensor Pressure Effects	
Sensor Temperature Effects	
[ ]+a,c	
[ ]+a,c	
Sensor Drift	
[ ]+a,c	
Environmental Allowance	
Rack Calibration	
[ ]+a,c	
Rack Accuracy	
ΔT channel	
T_{avg} channel	
Pressure channel	
ΔI channel	
Total	
Δ channel	
T_{avg} channel	
Pressure channel	
ΔI channel	

TABLE 3-5 (Continued)

OVERTEMPERATURE ΔT

Parameter	Allowance*
Comparator	[ ]+a,c
Two inputs	
Rack Temperature Effects	
Rack Drift	
ΔT channel	
T_{avg} channel	

* In percent span (T_{avg} - 100°F, pressure - 800 psi, power - 150 percent Rated Thermal Power, ΔT - 100°F, ΔI - ± 60 percent ΔI; 100°F span = 170 percent power)
** See Table 3-17 for gain calculations

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	
Rack Accuracy Δ channel T_{avg} channel	
Total Δ channel T_{avg} channel	
Comparator Two inputs	
Rack Temperature Effects	
Rack Drift ΔT channel T_{avg} channel	

TABLE 3-6 (Continued)

OVERPOWER ΔT

* In percent span (T_{avg} - 100°F, pressure - 800 psi, power - 150 percent Rated Thermal Power, ΔT - 100°F, 100°F span = 170 percent power)

** See Table 3-18 for gain calculations

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-7

PRESSURIZER PRESSURE - LOW AND HIGH, REACTOR TRIPS

Parameter	Allowance*
Process Measurement Accuracy	[ ]+a,c
Primary Element Accuracy	
Sensor Calibration	
Sensor Pressure Effects	
Sensor Temperature Effects [ ]+a,c	
Sensor Drift (Low Pressurizer Pressure Trip Only)	
Environmental Allowance [ ]+a,c	
Rack Calibration	
Rack Accuracy	
Comparator	
One input	
Rack Temperature Effects	
Rack Drift	

* In percent span (800 psi)

Channel Statistical Allowance (Low Pressurizer Pressure Trip) =

[ ]+a,c

Channel Statistical Allowance (High Pressurizer Pressure Trip) =

[ ]+a,c

TABLE 3-8

PRESSURIZER WATER LEVEL - HIGH

Parameter	Allowance*
Process Measurement Accuracy [ ]+a,c	[ ]+a,c
Primary Element Accuracy	
Sensor Calibration	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance	
Rack Calibration Rack 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	
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)
Δp span converted to % flow span via Eq. 3-30.8

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-10

STEAM GENERATOR WATER LEVEL - LOW-LOW

Parameter	Allowance*
	[ ]+a,c
Process Measurement Accuracy Density variations with load due to changes in recirculation**	
Primary Element Accuracy	
Sensor Calibration	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance (allowance made for Reference leg heatup)	
Rack Calibration Rack Accuracy	
Comparator One input	
Rack Temperature Effects	
Rack Drift	

* In percent span (100 percent span)

** See Table 3-22 for explanation

*** To be provided later upon notification of the environmental compensation

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-11

CONTAINMENT PRESSURE - HIGH, HIGH-HIGH

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

* In percent span (10 psig)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-12

T_{AVG}-LOW, FEEDWATER ISOLATION

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

* In percent span (100 percent span)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-13

PRESSURIZER PRESSURE LOW, SAFETY INJECTION

Parameter	Allowance*
Process Measurement Accuracy	[ ]+a,c
Primary Element Accuracy	
Sensor Calibration	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance [ ]+a,c	
Rack Calibration Rack 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*
Process Measurement Accuracy	[ ]+a,c
Primary Element Accuracy	
Sensor Calibration	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance (Not Subject to Post Accident Environmental Conditions)	
Rack Calibration Rack Accuracy	
Comparator One input	
Rack Temperature Effects	
Rack Drift	

* In percent span (1300 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	
Comparator One input	
Rack Temperature Effects	
Rack Drift	

* In percent span (1300 psig)

Channel Statistical Allowance =

[ ] +a,c

TABLE 3-16

STEAM GENERATOR WATER LEVEL - HIGH-HIGH

Parameter	Allowance*
Process Measurement Accuracy density variations with load due to changes in recirculation**	[ ]+a,c
Primary Element Accuracy	
Sensor Calibration	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance	
Rack Calibration Rack Accuracy	
Comparator One input	
Rack Temperature Effects	
Rack Drift	

* In percent span (100 percent span)

** See Table 3-19 for explanation

Channel Statistical Allowance =

[ ]+a,c

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TABLE 3-17

OVERTEMPERATURE ΔT GAIN CALCULATIONS

The equation for Overtemperature ΔT is:

$$\text{Overtemperature } \Delta T \left(\frac{1 + \tau_1 S}{1 + \tau_2 S}\right) \left(\frac{1}{1 + \tau_3 S}\right) \leq$$

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

As an example to show calculational methodology and conservatism for Catawba

K_1 (nominal) = 1.39 TS trip setpoint

K_1 (max) [ ]+a,c

K_2 = 0.02401

K_3 = 0.001189

core ΔT = 58.4°F (Unit 1 ΔT is used. Unit 2 ΔT of 58.2°F is bounded by Unit 1 ΔT)

positive f(ΔI) penalty function gain = 1.641 percent FPΔI/percent ΔI

and all other parameters as defined in Note 1 of Table 2.2-1 of Appendix A.

[ ]+a,c

+a,c

[ ]

* Conservative assumption for temperature stratification error in the hot leg (2°F T_H + 0°F T_C)/2

** 1.7 is ΔT instrument span, equivalent to 170 percent Rated Thermal Power, ~ 100°F/58.4°F.

TABLE 3-18

OVERPOWER ΔT GAIN CALCULATIONS

The equation for Overpower ΔT is:

$$\text{Overpower } \Delta T \left(\frac{1 + \tau_1 S}{1 + \tau_2 S}\right) \left(\frac{1}{1 + \tau_3 S}\right) \leq$$

$$\Delta T_o \left\{ K_4 - K_5 \left(\frac{\tau_7 S}{1 + \tau_7 S}\right) \left(\frac{1}{1 + \tau_6 S}\right) T - K_6 \left[T \left(\frac{1}{1 + \tau_6 S}\right) - T'' \right] - f_2 (\Delta I) \right\}$$

For Catawba Units:

K_4 (nominal)	=	1.0704 TS trip setpoint
K_4 (max)	=	[ ]$^{+a,c}$
K_5	=	0.02
K_6	=	0.001707
core ΔT	=	58.4°F (Unit 1 ΔT is used. Unit 2 ΔT of 58.2°F is bounded by Unit 1 ΔT)

[ ]$^{+a,c}$

[ ]+a,c

---

* Conservative assumption for temperature stratification error in the hot leg (2°F T_H + 0°F T_C) /2.

TABLE 3-19

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. This is a general case and will change somewhat from plant to plant. 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

+a,c

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

TABLE 3-20

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 percent 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:

+a,c

Error in flow units is:

+a,c

[ ]

Equation 3-30.8 is used to express errors in percent full span in this document.

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 [

]+a,c

The use of the statistical summation technique described in Section 2 of this report allows for a natural extension of the two column approach. [

]+a,c 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 [ ]$^{+a,c}$ he is seeing more than that. This interaction has been noted several times and is handled in Equations 2.1 and 3.1 [

]$^{+a,c}$. 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 [ ].$^{+a,c}$ The second [

]$^{+a,c}$ as follows:

[ ]$^{+a,c}$ (Eq. 4.1)

where:

T = [

A =

S =]$^{+a,c}$

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

[$]^{+a,c}$ (Eq. 4.2)

where:

R = the "as measured rack value" [$]^{+a,c}$

S = the "as measured sensor value" [$]^{a,c}$

and all other parameters are as defined in Equation 4.1.

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

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

where:

[ ]+a,c

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 reasonable straight forward, Appendix A provides a text and tables for use in the Catawba TS. An example of how the specification would be used for the Pressurized Water Level - High reactor trip is as follows.

Every 31 dyas, 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:

[ ]+a,c

[ ]

However, since only [ ],$^{+a,c}$ that value will be used as the "trigger value". The lowest of two values is used for the "trigger value"; [ ].$^{+a,c}$

Now assume that one bistable has "drifted" more than that allowed by the STS for 31 days 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. Assume that the "as measured" sensor value is 1.5 percent. Equation 2.2-1 looks like:

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

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

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 of 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:

[ ] +a,c

(Eq. 4.4)

(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:

[ ] +a,c

(Eq. 4.6)

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

An example demonstrating all of the above noted equations for Overpower ΔT is provided below:

[ ] +a,c

[ ] +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, 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	2445 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 per.ent	2445 psig
STS Allowable Value (Trigger Value)	111.2 percent	2399 psig
STS Irip Setpoint	109 percent	2385 psig

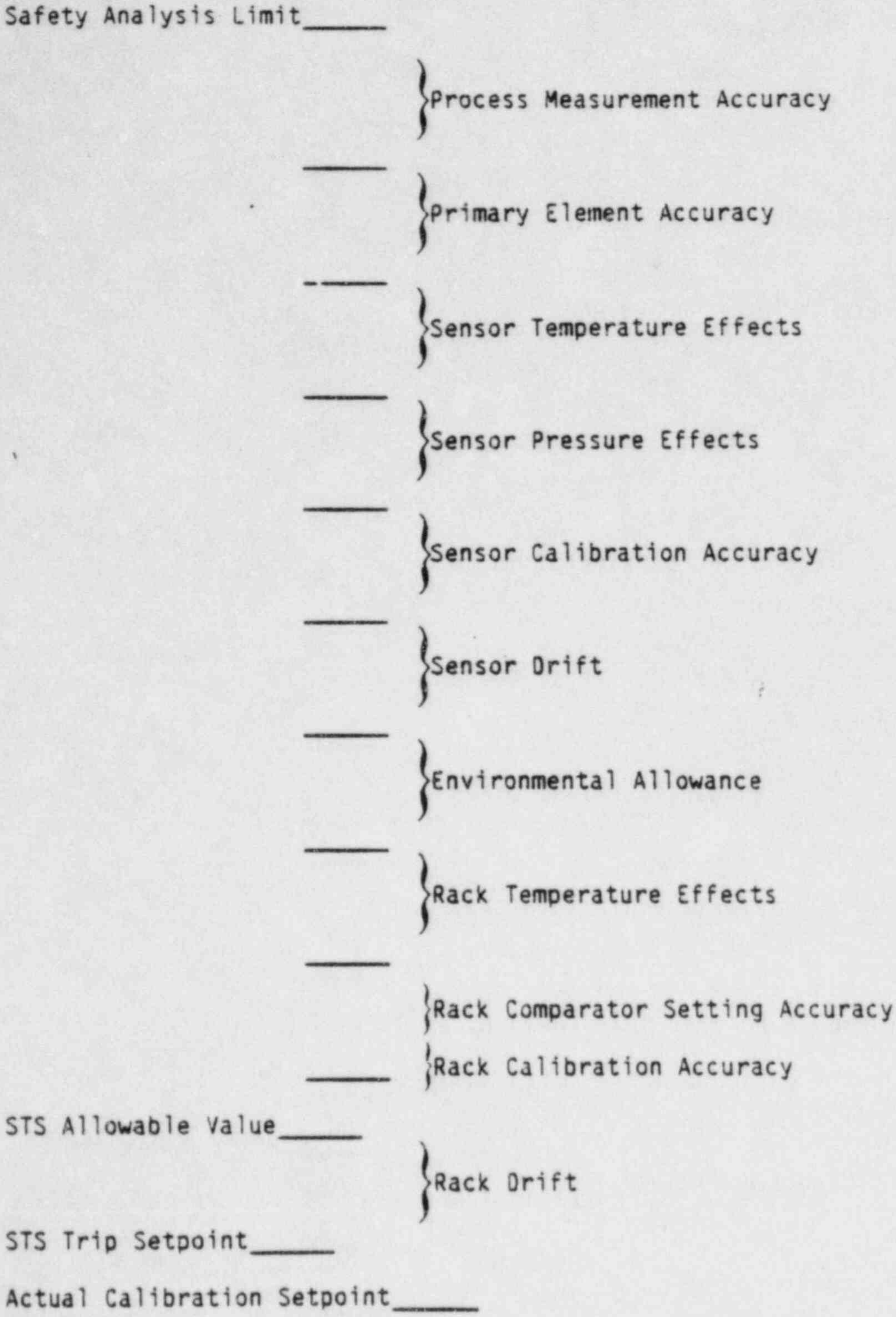

Figure 4-1 NUREG-0452 Rev. 4 Setpoint Error Breakdown

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

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APPENDIX A

CATAWBA TECHNICAL SPECIFICATION SETPOINTS

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 Interlocks 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 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 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.

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 is column S of Table 2.2-1 for the affected channel, and

TA = The value for Column TA (Total Allowance) 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	≤ 109% of RTP*	≤ 111.1% of RTP*
b. Low Setpoint	8.3	4.56	0	≤ 25% of RTP*	≤ 27.1% of RTP*
3. Power Range, Neutron Flux, High Positive Rate	1.6	0.5	0	≤ 5% of RTP* with a time constant ≥ 2 seconds	≤ 6.3% of RTP* with a time constant ≥ 2 seconds
4. Power Range, Neutron Flux, High Negative Rate	1.6	0.5	0	≤ 5% of RTP* with a time constant ≥ 2 seconds	≤ 6.3% of RTP* with a time constant ≥ 2 seconds
5. Intermediate Range, Neutron Flux	17.0	8.4	0	≤ 25% of RTP*	≤ 31% of RTP*
6. Source Range, Neutron Flux	17.0	10	0	≤ 10^5 cps	≤ 1.4 x 10^5 cps
7. Overtemperature ΔT	7.22	4.46	2.0	See Note 1	See Note 2
8. Overpower ΔT	4.3	1.3	1.2	See Note 3	See Note 4
9. Pressurizer Pressure-Low	4.0	2.21	1.5	≥ 1945 psig	≥ 1938 psig
10. Pressurizer Pressure-High	7.5	4.96	0.5	≤ 2385 psig	≤ 2399 psig
11. Pressurizer Water Level-High	5.0	2.18	1.5	≤ 92% of instrument span	≤ 93.8% of instrument span

*RTP = RATED THERMAL POWER
**Loop design flow = 96,900 gpm

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TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

FUNCTIONAL UNIT	TOTAL ALLOWANCE (TA)	Z	SENSOR ERROR (S)	TRIP SETPOINT	ALLOWABLE VALUE
12. Reactor Coolant Flow-Low	2.5	1.77	0.6	≥ 90% of loop design flow**	≥ 89.2% of loop design flow**
13. Steam Generator Water Level Low-Low	17	14.2	1.5	≥ 17% of span from 0% to 30% RTP* increasing linearly to ≥ 54.9% of span from 30% to 100% RTP*	≥ 15.3% of span from 0% to 30% RTP* increasing linearly to ≥ 53.2% of span from 30% to 100% RTP*
14. Undervoltage - Reactor Coolant Pumps	5.0	(1.28)		≥ 4692 volts	≥ (4760) volts
15. Underfrequency - Reactor Coolant Pumps	1.3	(0)	(0.1)	≥ 57.2 Hz	≥ (57.1) Hz
16. Turbine Trip					
a. Low Control Valve EH Pressure	N.A.	N.A.	N.A.	≥ 550 psig	≥ 500 psig
b. Turbine Stop Valve Closure	N.A.	N.A.	N.A.	≥ 1% open	≥ 1% open
17. Safety Injection Input from ESF	N.A.	N.A.	N.A.	N.A.	N.A.

*RTP = RATED THERMAL POWER

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TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

FUNCTIONAL UNIT	TOTAL ALLOWANCE (TA)	Z	SENSOR ERROR (S)	TRIP SETPOINT	ALLOWABLE VALUE
18. Reactor Trip System Interlocks					
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. Low Power Reactor Trips Block, P-7					
1) P-10 input	N.A.	N.A.	N.A.	≤ 10% of RTP*	≤ 12.1% of RTP*
2) P-13 input	N.A.	N.A.	N.A.	≤ 10% RTP* Turbine Impulse Pressure Equivalent	≤ 12.1% of RTP* Turbine Impulse Pressure Equivalent
c. Power Range Neutron Flux, P-8	N.A.	N.A.	N.A.	≤ 48% of RTP*	≤ 50.1% of RTP*
d. Power Range Neutron Flux, P-9	N.A.	N.A.	N.A.	≤ 69% of RTP*	≤ 71.1% of RTP*
e. Power Range Neutron Flux, P-10	N.A.	N.A.	N.A.	≥ 10% of RTP*	≥ 7.8% of RTP*
f. Turbine Impulse Chamber Pressure, P-13	N.A.	N.A.	N.A.	≤ 10% RTP* Turbine Impulse Pressure Equivalent	≤ 12.1% RTP* Turbine Impulse Pressure Equivalent
19. Reactor Trip Breakers	N.A.	N.A.	N.A.	N.A.	N.A.
20. Automatic Trip and Interlock Logic	N.A.	N.A.	N.A.	N.A.	N.A.

*RTP = RATED THERMAL POWER

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TABLE 2.2-1 (Continued)

TABLE NOTATIONS

NOTE 1: OVERTEMPERATURE ΔT

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

Where: ΔT = Measured ΔT by RTD Manifold Instrumentation;

$\frac{1 + \tau_1 S}{1 + \tau_2 S}$ = Lead-lag compensator on measured ΔT;

τ_1, τ_2 = Time constants utilized in lead-lag compensator for τT, τ_1, = 8 s, τ_2 = 3 s;

$\frac{1}{1 + \tau_3 S}$ = Lag compensator on measured ΔT;

τ_3 = Time constants utilized in the lag compensator for ΔT, τ_3 = 2 s;

ΔT_o = Indicated ΔT at RATED THERMAL POWER;

K_1 = 1.39;

K_2 = 0.02401/°F;

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

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REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS
NOTATION (Continued)

NOTE 1: (Continued)

τ_4, τ_5	=	Time constants utilized in lead-lag compensator for T_{avg}, τ_4 = 28 s, τ_5 = 4 s;
T	=	Average temperature, °F;
$\frac{1}{1 + \tau_6 S}$	=	Lag compensator on measured T_{avg};
τ_6	=	Time constant utilized in the measured T_{avg} lag compensator, τ_6 = 2 s;
T'	=	$\leq$ 590.8°F (Nominal T_{avg} at RATED THERMAL POWER);
K_3	=	0.001189;
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 neutron 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 -43% and -6.5%, $f_1(\Delta I)$ = 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 -43%, the ΔT Trip Setpoint shall be automatically reduced by 2% of its value at RATED THERMAL POWER; and

(iii) For each percent that the magnitude of $q_t - q_b$ exceeds -6.5%, the ΔT Trip Setpoint shall be automatically reduced by 1.641% 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 2.48%.

TABLE NOTATIONS (Continued)

NOTE 3: OVERPOWER ΔT

$$\Delta T \left(\frac{1 + \tau_1 S}{(1 + \tau_2 S)}\right) \left(\frac{1}{1 + \tau_3 S}\right) \leq \Delta T_o \{K_4 - K_5 \left(\frac{\tau_7 S}{1 + \tau_7 S}\right) \left(\frac{1}{1 + \tau_6 S}\right) T - K_6 [T \left(\frac{1}{1 + \tau_6 S}\right) - T'' + f_2(\Delta I) \}$$

Where: ΔT = As defined in Note 1,

$\frac{1 + \tau_1 S}{1 + \tau_2 S}$ = As defined in Note 1,

τ_1, τ_2 = As defined in Note 1,

$\frac{1}{1 + \tau_3 S}$ = As defined in Note 1,

τ_3 = As defined in Note 1,

ΔT_o = As defined in Note 1,

K_4 = 1.0704;

K_5 = 0.02/°F for increasing average temperature and 0 for decreasing average temperature,

$\frac{1 + \tau_7 S}{1 + \tau_7 S}$ = The function generated by the rate-lag controller for T_{avg} dynamic compensation,

τ_7 = Time constant utilized in rate-lag controller for T_{avg}, τ_7 = 10 s,

$\frac{1}{1 + \tau_6 S}$ = As defined in Note 1,

τ_6 = As defined in Note 1,

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TABLE NOTATIONS (Continued)

NOTE 3: (Continued)

K_6	=	0.001707/°F for T > 590.8°F and K_6 = 0 for T ≤ 590.8°F,
T	=	As defined in Note 1,
T"	=	Indicated T_{avg} at RATED THERMAL POWER (Calibration temperature for ΔT instrumentation, ≤ 590.8°F),
S	=	As defined in Note 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 2.54%.

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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 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 of Table 3.3-4, adjust the Setpoint consistent with the Trip Setpoint value.

b. With an ESFAS Instrumentation or Interlock Setpoint less conservative than the value shown in the Allowable Values 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 is Column S of Table 3.3-4 for the affected channel, and

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

INSTRUMENTATION

SURVEILLANCE REQUIREMENTS

4.3.2.1 Each ESFAS instrumentation channel and interlock and the automatic actuation logic and relays shall be demonstrated OPERABLE by performance of the Engineered Safety Features Actuation System Instrumentation Surveillance Requirements specified in Table 4.3-2.

4.3.2.2 The ENGINEERED SAFETY FEATURES RESPONSE TIME of each ESFAS function shall be demonstrated to be within the limit at least one per 18 months. Each test shall include at least one train such that both trains are tested at least once per 36 months and one channel per function such that all channels are tested at least once per N times 18 months where N is the total number of redundant channels in a specific ESFAS function as shown in the "Total No. of Channels" Column of Table 3.3-3.

TABLE 3.3-4

ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

FUNCTIONAL UNIT	TOTAL ALLOWANCE (TA)	Z	SENSOR ERROR (S)	TRIP SETPOINT	ALLOWABLE VALUE
1. Safety Injection, (Reactor Trip, Phase "A" Isolation, Feedwater Isolation, Auxiliary Feedwater-Motor-Driven Pump, Purge & Exhause Isolation, Annulus Ventilation Operation, Auxiliary Building Ventilation Isolation, Emergency Diesel Generator Operation, Component Cooling Water, Turbine Trip, and Nuclear Service Water Operation)					
a. Manual Initiation	N.A.	N.A.	N.A.	N.A.	N.A.
b. Automatic Acutation Logic and Actuation Relays	N.A.	N.A.	N.A.	N.A.	N.A.
c. Containment Pressure-High	8.2	0.71	1.5	$\leq$ 1.2 psig	$\leq$ 1.4 psig
d. Pressurizer Pressure-Low	16.1	14.4	1.5	$\geq$ 1845 psig	$\geq$ 1839 psig
e. Steam Line Pressure-Low	4.6	0.71	1.5	$\geq$ 725 psig	$\geq$ 687 psig
2. Containment Spray (Nuclear Service Water Operation)					
a. Manual Initiation	N.A	N.A.	N.A.	N.A.	N.A.
b. Automatic Acutation Logic and Actuation Relays	N.A.	N.A.	N.A.	N.A.	N.A.
c. Containment Pressure-High-High	12.7	0.71	1.5	$\leq$ 3 psig	$\leq$ 3.2 psig

TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

FUNCTIONAL UNIT	TOTAL ALLOWANCE (TA)	Z	SENSOR ERROR (S)	TRIP SETPOINT	ALLOWABLE VALUE
3. Containment Isolation					
a. Phase "A" Isolation					
1) Manual Initiation	N.A.	N.A.	N.A.	N.A.	N.A.
2) Automatic Actuation Logic and Actuation Relays	N.A.	N.A.	N.A.	N.A.	N.A.
3) Safety Injection	See Item 1. above for all Safety Injection Setpoints and Allowable Values.				
b. Phase "B" Isolation (Nuclear Service Water Operation)					
1) Manual Initiation	N.A.	N.A.	N.A.	N.A	N.A.
2) Automatic Actuation Logic and Actuation Relays	N.A.	N.A.	N.A.	N.A.	N.A.
3) Containment Pressure-High-High	12.7	0.71	1.5	≤ 3 psig	≤ 3.2 psig
c. Purge and Exhaust Isolation					
1) Manual Initiation	N.A.	N.A.	N.A.	N.A.	N.A.
2) Automatic Actuation Logic and Actuation Relays	N.A.	N.A.	N.A.	N.A.	N.A.
3) Safety Injection	See Item 1. above for all Safety Injection Setpoints and Allowable Values.				

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ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

FUNCTIONAL UNIT	TOTAL ALLOWANCE (TA)	Z	SENSOR ERROR (S)	TRIP SETPOINT	ALLOWABLE VALUE
4. Steam Line Isolation					
a. Manual Initiation	N.A.	N.A.	N.A.	N.A.	N.A.
b. Automatic Actuation Logic and Actuation Relays	N.A.	N.A.	N.A.	N.A.	N.A.
c. Containment Pressure-High-High	12.7	0.71	1.5	≤ 3 psig	≤ 3.2 psig
d. Steam Line Pressure-Low	4.6	0.71	1.5	≥ 725 psig	≥ 687 psig
e. Steam Line Pressure-Negative Rate - High	8.0	0.5	0	≤ -100 psi/s	≤ -122.8 psi/s**
5. Feedwater Isolation					
a. Automatic Actuation Logic and Actuation Relays	N.A.	N.A.	N.A.	N.A.	N.A.
b. Steam Generator Water Level--High-High (P-14)	5.4	2.18	1.5	≤ 82.4% of narrow range instrument span	≤ 84.2% of narrow range instrument span
c. T_{avg}-Low	4.0	1.12	1.2	≥ 564°F	≥ 562°F
d. Doghouse Water Level-High	( )	( )	( )	( )	( )
e. Safety Injection	See Item 1. above for all Safety Injection Setpoints and Allowable Values.				

(WESTINGHOUSE PROPRIETARY CLASS 3)

TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

FUNCTIONAL UNIT	TOTAL ALLOWANCE (TA)	Z	SENSOR ERROR (S)	TRIP SETPOINT	ALLOWABLE VALUE
6. Auxiliary Feedwater					
a. Manual Initiation	N.A.	N.A.	N.A.	N.A.	N.A.
b. Automatic Actuation Logic and Actuation Relays	N.A.	N.A.	N.A.	N.A.	N.A.
c. Steam Generator Water Level-High-High (P-14)	5.4	2.18	1.5	≤ 82.4% of narrow range instrument	≤ 84.2% of narrow range instrument span
d. Trip of All Main Feedwater Pumps	N.A.	N.A.	N.A.	N.A.	N.A.
e. Safety Injection	See Item 1. above for all Safety Injection Setpoints and Allowable Values.				
7. Contanment Pressure Control System					
a. Start Permissive	N.A.	N.A.	N.A.	≤ 0.25 psig	≤ 0.25 psig
b. Termination	N.A.	N.A.	N.A.	≤ 0.25 psig	≤ 0.25 psig
8. Auxiliary Feedwater					
a. Manual Initiation	N.A.	N.A.	N.A.	N.A.	N.A.
b. Automatic Actuation Logic and Actuation Relays	N.A.	N.A.	N.A.	N.A.	N.A.
c. Steam Generator Water Level - Low-Low	17	14.2	1.5	≥ 17% of span from 0% to 30% RTP increasing linearly to ≥ 54.9% of span from 30% to 100% RTP	≥ 15.3% of span from 0% to 30% RTP increasing linearly to ≥ 53.2% of span from 30% to 100% RTP

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TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

FUNCTIONAL UNIT	TOTAL ALLOWANCE (TA)	Z	SENSOR ERROR (S)	TRIP SETPOINT	ALLOWABLE VALUE
d. Safety Injection	See Item 1. above for all Safety Injection Setpoints and Allowable Values.				
e. Loss-of-Offsite Power	N.A.	N.A.	N.A.	≥ (4800) V	≥ (4692) V
f. Trip of All Main Feed-water Pumps	N.A.	N.A.	N.A.	N.A.	N.A.
g. Auxiliary Feedwater Pressure-Low	N.A.	N.A.	N.A.	≥ 2 psig	≥ 1 psig
9. Containment Sump Recirculation					
a. Automatic Actuation Logic and Actuation Relays	N.A.	N.A.	N.A.	N.A.	N.A.
b. Refueling Water Storage Tank Level-Low Coincident	N.A.	N.A.	N.A.	≥ 120 inches	≥ 114 inches
With Safety Injection	See Item 1. above for all Safety Injection Setpoints and Allowable Values.				
10. Loss of Power					
4 kV Bus Undervoltage-Grid Degraded Voltage	N.A.	N.A.	N.A.	3500 ± 175 volts with a 8.5 ± 0.5 second time delay	≥ 3200 volts
11. Control Room Area Ventilation Isolation					
a. Manual Initiation	N.A.	N.A.	N.A.	N.A.	N.A.
b. Automatic Actuation Logic and Actuation Relays	N.A.	N.A.	N.A.	N.A.	N.A.
c. Loss-of-Offsite Power	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 ERROR (S)	TRIP SETPOINT	ALLOWABLE VALUE
12. Containment Air Return and Hydrogen Skimmer Operation					
a. Manual Initiation	N.A.	N.A.	N.A.	N.A.	N.A.
b. Automatic Actuation Logic and Actuation Relays	N.A.	N.A.	N.A.	N.A.	N.A.
c. Containment Pressure-High-High	12.7	0.71	1.5	≤ 3 psig	≤ 3.2 psig
13. Annulus Ventilation Operation					
a. Manual Initiation	N.A.	N.A.	N.A.	N.A.	N.A.
b. Automatic Actuation Logic and Actuation Relays	N.A.	N.A.	N.A.	N.A.	N.A.
c. Safety Injection	See Item 1. above for all Safety Injection Setpoints and Allowable Values.				
14. Nuclear Service Water Operation					
a. Manual Initiation	N.A.	N.A.	N.A.	N.A.	N.A.
b. Automatic Actuation Logic and Actuation Relays	N.A.	N.A.	N.A.	N.A.	N.A.
c. Containment Spray	See Item 2. above for all Containment Spray Setpoints and Allowable Values.				
d. Phase "B" Isolation	See Item 3.b above for all Phase "B" Isolation Setpoints and Allowable Values.				
e. Safety Injection	See Item 1. above for all Safety Injection Setpoints and Allowable Values.				

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TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

FUNCTIONAL UNIT	TOTAL ALLOWANCE (TA)	Z	SENSOR ERROR (S)	TRIP SETPOINT	ALLOWABLE VALUE
15. Emergency Diesel Generator Operation (Diesel Building Ventilation Isolation)					
a. Manual Initiation	N.A.	N.A.	N.A.	N.A.	N.A.
b. Automatic Actuation Logic and Actuation Relays	N.A.	N.A.	N.A.	N.A.	N.A.
c. Loss-of-Offsite Power	N.A.	N.A.	N.A.	$\geq$ (4800)V	$\geq$ (4692)V
d. Safety Injection	See Item 1. above for all Safety Injection Setpoints and Allowable Values.				
16. Auxiliary Building Ventilation Isolation					
a. Manual Initiation	N.A.	N.A.	N.A.	N.A.	N.A.
b. Automatic Actuation Logic and Actuation Relays	N.A.	N.A.	N.A.	N.A.	N.A.
c. Loss-of-Offsite Power	N.A.	N.A.	N.A.	$\geq$ (4800)V	$\geq$ (4692)V
d. Safety Injection	See Item 1. above for all Safety Injection Setpoints and Allowable Values.				
17. Diesel Building Vantilation Isolation					
a. Manual Initiation	N.A.	N.A.	N.A.	N.A.	N.A.
b. Automatic Actuation Logic and Actuation Relays	N.A.	N.A.	N.A.	N.A.	N.A.
c. Emergency Diesel Generator Operation	See Item 15. above for all Emergency Diesel Generator Operation Setpoints and Allowable Values.				

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TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

FUNCTIONAL UNIT	TOTAL ALLOWANCE (TA)	Z	SENSOR ERROR (S)	TRIP SETPOINT	ALLOWABLE VALUE
18. Engineered Safety Features Actuation System Interlocks					
a. Pressurizer Pressure, P-11	N.A.	N.A.	N.A.	≤ 1955 psig	≤ 1941 psig
b. Reactor Trip, P-4	N.A.	N.A.	N.A.	N.A.	N.A.

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