NON
WESTINGHOUSE PROPRIETARY CLASS 3

WESTINGHOUSE SETPOINT METHODOLOGY FOR PROTECTION SYSTEMS COMANCHE PEAK STATION

MAY, 1984

C. R. Tuley
R. B. Miller

WESTINGHOUSE ELECTRIC
Nuclear Energy Systems
P. O. Box 355
Pittsburgh, Pennsylvania 15230

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF ILLUSTRATIONS

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.

---

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

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

[ ]$^{+a,c}$

(Eq. 2-1)

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 [

]$^{+a,c}$. An example of this would be as follows; assume a [ ]$^{+a,c}$

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

]$^{+a,c}$

[

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

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

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

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

$$\left[\qquad\qquad\qquad \right]^{+a,c} \qquad \text{(Eq. 2.3)}$$

= 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 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.

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 (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 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.

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 N-16

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 [ ]+a,c	
Rack Accuracy [ ]+a,c	

TABLE 3-5 (Continued)

OVERTEMPERATURE N-16

Parameter	Allowance*
Total	[ ]+a,c
T_{c1}	
T_{c2}	
N-16	
Pressure Channel	
ΔI Channel	
Comparator	
Two inputs	
Rack Temperature Effects [ ]+a,c	
Rack Drift	
Setpoint reference signal	
N-16 channel	

* In percent span (T_c - 120°F, pressure - 800 psi, N-16 - 150 percent Rated Thermal Power, ΔI - ± 60 percent ΔI)

** See Table 3-17 for gain and conversion calculations

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-6

OVERPOWER N-16

Parameter	Allowance*
Process Measurement Accuracy	+a,c [ ] +a,c
[ ] +a,c	
Primary Element Accuracy	
Sensor Calibration	
[ ] +a,c	
Sensor Temperature Effects	
[ ] +a,c	
Sensor Pressure Effects	
Sensor Drift	
[ ] +a,c	
Environmental Allowance	
Rack Calibration	
[ ] +a,c	
Rack Accuracy	
[ ] +a,c	
Total	
T_C	
N-16	
Setpoint	
Comparator	
Two inputs	
Rack Temperature Effects [ ] +a,c	
Rack Drift	
Setpoint reference signal	
N-16 channel	

TABLE 3-6 (Continued)

OVERPOWER N-16

---

* In percent span (T_c - 120°F, N-16 - 150 percent Rated Thermal Power, ΔI - $\pm$ 60 percent ΔI)

** See Table 3-18 for conversion calculations

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	
Sensor Pressure Effects	
Sensor Temperature Effects [ ]+a,c	
Sensor Drift	
Low Pressure Trip	
High Pressure Trip [treated as a bias]+a,c	
Environmental Allowance	
Rack Calibration	
Rack Accuracy	
Comparator	
One input	
Rack Temperature Effects	
Rack Drift	

* In percent span (800 psi)

• Channel Statistical Allowance =

[ ]+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)
** See Table 3-23 for explanation

Channel Statistical Allowance = [ ]+a,c

TABLE 3-10a

STEAM GENERATOR WATER LEVEL - LOW-LOW UNIT 1 (D4)

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

* In percent span (100 percent span)

** See Table 3-19 for explanation

[ ]+a,c

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-10b

STEAM GENERATOR WATER LEVEL - LOW-LOW UNIT 2 (D5)

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	
Reference Leg Heatup	
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

TABLE 3-11

CONTAINMENT PRESSURE - HIGH, HIGH-HIGH, HIGH-HIGH-HIGH
Span = 65 psi

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 0.65 psig	]

* In percent span (65 psig)

Channel Statistical Allowance =

[ ] +a,c

TABLE 3-12

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	
Rack Calibration Rack Accuracy	
Comparator One input	
Rack Temperature Effects	
Rack Drift	

* In percent span (800 psi)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-13

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	
Rack Calibration Rack Accuracy	
Comparator One input	
Rack Temperature Effects	
Rack Drift	

* In percent span (1300 psig)

Channel Statistical Allowance = [ ]+a,c

TABLE 3-14

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 (200 psig)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-15a

STEAM GENERATOR WATER LEVEL - HIGH-HIGH UNIT 1 (D4)

Parameter	Allowance*
Process Measurement Accuracy density variations with load due to changes in recirculation** [ ]+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)

** See Table 3-19 for explanation

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-15b

STEAM GENERATOR WATER LEVEL - HIGH-HIGH UNIT 2 (D5)

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

DOCUMENT/ PAGE PULLED

ANO. 8406260126

NO. OF PAGES 1

REASON

☐ PAGE ILLEGIBLE

☐ HARD COPY FILED AT. PDR CF

OTHER ______

☐ BETTER COPY REQUESTED ON __/__/__

☑ PAGE TOO LARGE TO FILM.

☑ HARD COPY FILED AT: PDR (CF)

OTHER ______

☐ FILMED ON APERTURE CARD NO 8406260126-01

TABLE 3-17

OVERTEMPERATURE N-16

$$OT^{16}N \le K_1 - K_2\left\{\left(\frac{1 + \tau_1 S}{1 + \tau_2 S}\right) \quad T_c - T_c^{\circ}\right\} + K_3\,(P-P^{\circ}) - f_1\,(\Delta I)$$

where:

$$OT^{16}N = \left(\frac{1 + \tau_1 S}{1 + \tau_2 S}\right) q_1$$

$$q_1 = K_8 \left\{ 1 - K_7 \left(\frac{1}{1 + \tau_3 S}\right)\left(\frac{1}{1 + \tau_4 S}\right)\left(\frac{1}{1 + \tau_5 S}\right)\right\}\left\{\frac{1 + K_5(T_c - T_c^{\circ})}{1 + K_6\,(1 - q_1)}\right\} {}^{16}N$$

$${}^{16}N = {}^{16}N \text{ PWR} - K_9 N_1 - K_{10} N_2$$

N_1, N_2 = outputs of top sections of excores

K_1^{nom}	=	1.069	percent RTP
K_1^{max}	=	[ ]$^{+a,c}$	percent RTP
K_2	=	0.00948	1/percent RTP -°F
K_3	=	0.000494	1/percent RTP -psi
Vessel ΔT	=	618.2-558.8°F = 59.4°F	

positive f(ΔI) gain = 1.55 percent RTP/percent ΔI

[ ]$^{+a,c}$

TABLE 3-17 (Continued)

OVERTEMPERATURE N-16 GAIN AND CONVERSION CALCULATIONS

+a,c

TABLE 3-18

OVERPOWER N-16 CONVERSION CALCULATIONS

$$OP^{16}N \leq K_4 - f_2\,(\Delta I)$$

where:

$$OP^{16}N = \left(\frac{1 + \tau_1 S}{1 + \tau_2 S}\right) q_1$$

$$q_1 = K_8 \left\{ 1 - K_7 \left(\frac{1}{1 + \tau_3 S}\right)\left(\frac{1}{1 + \tau_4 S}\right)\left(\frac{1}{1 + \tau_5 S}\right)\right\} \left\{\frac{1 + K_5\,(T_c - T_c^{\circ})}{1 + K_6\,(1 - q_1)}\right\} \; {}^{16}N$$

$${}^{16}N = {}^{16}N\ PWR - K_9 N_1 - K_{10} N_2$$

N_1, N_2 = outputs of top sections of excores

K_4^{max} = [ ]$^{+a,c}$

K_4^{nom} = 1.12

Vessel ΔT = 59.4°F 1 percent RTP = 0.59°F ~ 0.6°F

$f_2(\Delta I)$ = 0

+a

TABLE 3-18 (Continued)

OVERPOWER N-16 CONVERSION CALCULATIONS

+a,c

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:

Error in flow units is:

+a,

[ ]

Equation 3-20.8 is used to express errors in percent full span in this document.

TABLE 3-21

Tavg - LOW, LOW-LOW

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	

TABLE 3-21 (Continued)

Tavg - LOW, LOW-LOW

Parameter	Allowance*
Rack Calibration [ ]+a,c	[ ]+a,c
Rack Accuracy [ ]+a,c	
Total T_{C1} T_{C1} N-16	
Comparator One input	
Rack Temperature Effects [ ]+a,c	
Rack Drift N-16 Channel T_c Channel	

*In percent span (T_c - 120°F, N-16 - 150 percent Rated Thermal Power, ΔI - $\pm$ 60 percent ΔI, T_{avg} - 100°F)

**See Table 3-22 for gain/conversion calculations

TABLE 3-21 (Continued)

T_{avg} - LOW, LOW-LOW

Channel Statistical Allowance =

+a,c

TABLE 3-22

T_{AVG} - LOW, LOW-LOW N-16 GAIN CALCULATIONS

$$T_{avg} = T_c + {}^{16}N_S$$

$${}^{16}N_S = \left(\frac{1}{1 + \tau_1 S}\right) q_1$$

$$q_1 = K_8 \left\{1 - K_7 \left(\frac{1}{1+\tau_3 S}\right) \left(\frac{1}{1+\tau_4 S}\right) \left(\frac{1}{1+\tau_5 S}\right)\right\} \left\{\frac{1 + K_5 \left(T_c - \mathring{T}_c\right)}{1 + K_6 \left(1 - q_1\right)}\right\} {}^{16}N$$

$${}^{16}N = {}^{16}N \text{ Pwr.} - K_9 N_1 - K_{10} N_2$$

N_1, N_2 = outputs of top sections of excores

Vessel ΔT = 618.2 - 558.8°F = 59.4°F

100 percent RTP ≈ 60°F

∴ 1 percent RTP = 0.6°F or 1°F = 1.7 percent RTP

+a,c

TABLE 3-22 (Continued)

T_{AVG} - LOW, LOW-LOW N-16 GAIN CALCULATIONS

[ ]+a,c

TABLE 3-23

PRECISION FLOW MEASUREMENT

Parameter	Allowance*
	[ ]+a,c
Pressurizer pressure uncertainty [ ]+a,c on cold leg specific volume	
Pressurizer pressure uncertainty [ ]+a,c on hot leg specific volume	
T_c uncertainty [ ]+a,c on cold leg specific volume	
T_c uncertainty [ ]+a,c on hot leg specific volume	
Uncertainty on hot leg volumetric flow [ ]+a,c	
Hot leg volumetric flow uncertainty on hot leg specific volume [ ]+a,c	
Precision calorimetric loop power uncertainty on hot leg specific volume [ ]+a,c	
Procedure convergence error on loop power [ ]+a,c, impact on hot leg specific volume	

*In percent flow

TABLE 3-23 (Continued)

PRECISION FLOW MEASUREMENT

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-24

RWST LEVEL - AUTOMATIC SWITCHOVER

Parameter	Allowance*
	+a,c
Process Measurement Accuracy	
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 Δp)

TABLE 3-24 (Continued)

RWST LEVEL - AUTOMATIC SWITCHOVER

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 [

]$^{+a,c}$

- 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:

[ ]$^{+a,c}$

[ ]+a,c

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 val e", 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 t 31 day periodic surveillance is determine the value of the bistable rip 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 usec 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 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:

[ ]+a,c

TA = 5 percent (an assumed value)

[ ]+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 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. 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:

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

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

$$5.9 \nleq 5.0$$

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 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:

[ ] +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 N-16 is provided below:

[ ] +a,c

[ ] +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, 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

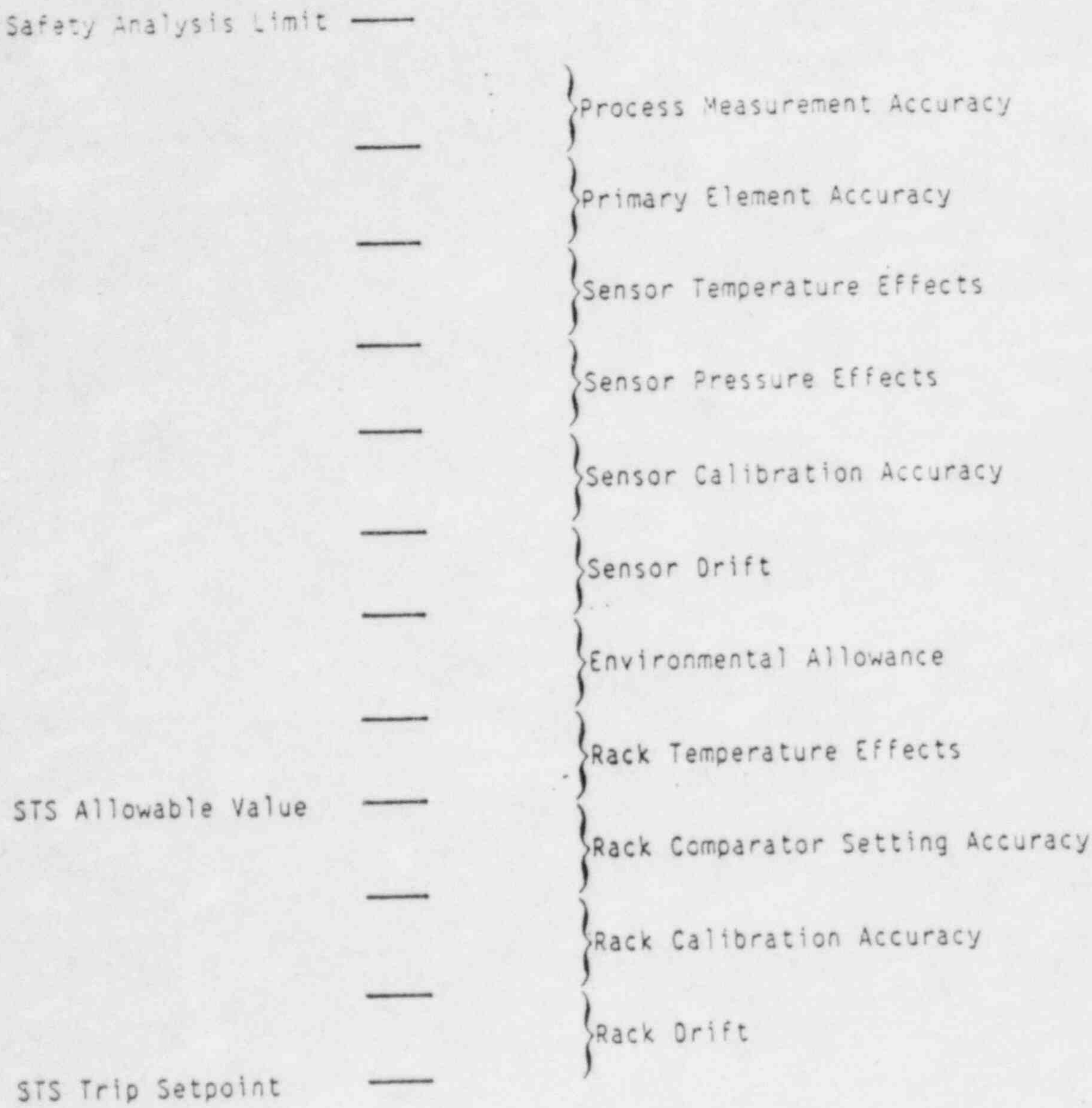

Figure 4-2 Westinghouse STS Setpoint Error Breakdown

DOCUMENT/ PAGE PULLED

ANO. 8406260126

NO. OF PAGES 1

REASON

- ☐ PAGE ILLEGIBLE
  - ☐ HARD COPY FILED AT: PDR CF
    OTHER ______
  - ☐ BETTER COPY REQUESTED ON __/__/__
- ☑ PAGE TOO LARGE TO FILM
  - ☑ HARD COPY FILED AT: PDR (CF)
    OTHER ______
  - ☐ FILMED ON APERTURE CARD NO 8406260126-02

APPENDIX A

SAMPLE COMANCHE PEAK

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 interlocks 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 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, place the channel in the tripped condition within 1 hour, and within the following 12 hours either:

   1. Determine that Equation 2.2-1 was satisfied for the affected channel and adjust the setpoint consistent with the Trip Setpoint value of Table 2.2-1, 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 in column S of Table 2.2-1 for the affected channel, and

TA = the value from column TA 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 Drift (S)	Trip Setpoint	Allowable Value
1.	Manual Reactor Trip	NA	NA	NA	NA	NA
2.	Power Range, Neutron Flux, High Setpoint	7.5	4.56	0	≤ 109% of RTP	≤ 111.2% of RTP
	Low Setpoint	8.3	4.56	0	≤ 25% of RTP	≤ 27.2% 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 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 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	0	≤ 10^5 cps	≤ 1.4 x 10^5 cps
7.	Overtemperature N-16	6.4	4.71	0.6&1.2	See note 1	See note 2
8.	Overpower N-16	4.0	1.91	1.3	≤ 112% RTP	≤ 114.5% RTP
9.	Pressurizer Pressure - Low	8.8	2.81	1.5	≥ 1910 psig	≥ 1896 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
12.	Low Reactor Coolant Flow	2.5	1.31	0.6	≥ 90% of loop design flow*	≥ 88.8% of loop design flow*

*Loop design flow = 95,700 gpm

WESTINGHOUSE PROPRIETARY CLASS 3

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

Functional Unit	Total Allowance (TA)	Z	Sensor Drift (S)	Trip Setpoint	Allowable Value
13. a. Steam Generator Water Level - Low-Low Unit 1	8.8	7.08	1.5	≥ 43.4% of narrow range instrument span	≥ 42.1% of narrow instrument span
b. Steam Generator Water Level - Low-Low Unit 2	19.4	17.38	1.5	≥ 19.4% of narrow range instrument span	≥ 17.8% of narrow instrument span
14. Undervoltage - Reactor Coolant Pump	7.7	0	0	≥ 4830 Volts	4781 volts
15. Underfrequency - Reactor Coolant Pumps	4.4	0	0	≥ 57.2 Hz	57.1 Hz
16. Turbine Trip					
A. Low Trip System Pressure	Not Westinghouse Scope				
B. Turbine Stop Valve Closure	Not Westinghouse Scope				
17. Safety Injection Input from ESF	NA	NA	NA	NA	NA
18. Reactor Trip System Interlocks					
a. Intermediate Range Neutron Flux, P-6	NA	NA	NA	nominal 1×10^{-10} amps	$\geq 6 \times 10^{-11}$ amps
b. Low Power Reactor Trips Block, P-7					
1) P-10 Input	NA	NA	NA	nominal 10 percent of Rated Thermal Power	≤ 12.2 percent of Rated Thermal Power

WESTINGHOUSE PROPRIETARY CLASS 3

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS NOTATION

Functional Unit	Total Allowance (TA)	Z	Sensor Drift (S)	Trip Setpoint	Allowable Value
2) P-13 Input	NA	NA	NA	nominal 10 percent Turbine Impulse Pressure Equivalent	≤ 12.2 percent Turbine Impulse Pressure Equivalent
c. Power Range Neutron Flux, P-8	NA	NA	NA	nominal 48 percent of Rated Thermal Power	≤ 50.2 percent of Rated Thermal Power
d. Low Setpoint Power Range Neutron Flux, P-10	NA	NA	NA	nominal 10 percent of Rated Thermal Power	≥ 7.8 percent of Rated Thermal Power
e. Turbine Impulse Chamber Pressure, P-13	NA	NA	NA	nominal 10 percent Turbine Impulse Pressure Equivalent	≤ 12.2 percent Turbine Impulse Pressure Equivalent
9. Reactor Trip Breakers	NA	NA	NA	NA	NA
0. Automatic Trip and Interlock Logic	NA	NA	NA	NA	NA

OTE 1: Overtemperature ^{16}N trip setpoint $= K_1 - K_2 \left(\frac{1 + \tau_1 S}{1 + \tau_2 S}\right)\left(T_c - T_c^{\circ}\right) + K_3 (P - P^{\circ}) - f_1 (\Delta q)$

where:

T_c = Cold leg temperature, °F

T_c° = 558.4°F, reference T_c at Rated Thermal Power

P = Pressurizer pressure, psig

P° = 2235 psig (indicated RCS nominal operating pressure)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS NOTATION

NOTE 1: (continued)

K_1 = 1.069

K_2 = 0.00948

K_3 = 0.000494

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

τ_1, τ_2 = Time constants utilized in the lead-lag controller for T_c, τ_1 = 10 secs., τ_2=3 secs.

S = Laplace transform operator sec^{-1}

and $f_1(\Delta q)$ is a function of the indicated difference between the sum of the upper detector pair and the sum of the lower detector pair 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 qt - qb between -35 percent and +10.0 percent $f_1(\Delta q)$ = 0 (where qt equals the sum of the upper detector pair and qb equals the sum of the lower detector pair in percent RATED THERMAL POWER, and qt + qb equals the total THERMAL POWER in percent of RATED THERMAL POWER).

(ii) for each percent that the magnitude of (qt - qb) exceeds -35 percent, the N-16 trip setpoint shall be automatically reduced by 1.25 percent of its value at RATED THERMAL POWER.

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS NOTATION

NOTE 1: (continued)

(iii) for each percent that the magnitude of (qt - qb) exceeds +10 percent, the N-16 trip setpoint shall be automatically reduced by 1.55 percent of its value at RATED THERMAL POWER.

NOTE 2: The channel's maximum trip setpoint shall not exceed its computed trip point by more than 1.4 percent N-16 span (150 percent RTP).

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 Error 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 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, place the channel in the tripped condition within 1 hour, and within the following 12 hours either:

   1. Determine that Equation 2.2-1 was satisfied for the affected channel and adjust the setpoint consistent with the Trip Setpoint value of Table 3.3-4, 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 in column S of Table 3.3-4 for the affected channel, and

TA = the value from column TA of Table 3.3-4 for the affected channel.

TABLE 3.3-4

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM 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	NA	NA	NA	NA	NA
B. Automatic Actuation Logic	NA	NA	NA	NA	NA
C. Containment Pressure - High	2.5	0.71	1.5	≤ 3.35 psig	≤ 3.9 psig
D. Pressurizer Pressure - Low	16.1	14.41	1.5	≥ 1829 psig	≥ 1823 psig
E. Steamline Pressure - Low	17.3	14.81	1.5	≥ 605 psig	≥ 586 psig (Note a)
2. CONTAINMENT SPRAY					
A. Manual Initiation	NA	NA	NA	NA	NA
B. Automatic Actuation Logic	NA	NA	NA	NA	NA
C. Containment Pressure - High High-High	2.5	0.71	1.5	≤ 18.35 psig	≤ 18.9 psig
3. CONTAINMENT ISOLATION					
A. Phase "A" Isolation					
1. Manual Initiation	NA	NA	NA	NA	NA
2. Automatic Actuation Logic	NA	NA	NA	NA	NA
3. Safety Injection	See Item 1 above for all Safety Injection Trip Setpoints/Allowable Values				

WESTINGHOUSE PROPRIETARY CLASS 3

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM TRIP SETPOINTS

Functional Unit	Total Allowance (TA)	Z	Sensor Drift (S)	Trip Setpoint	Allowable Value
B. Phase "B" Isolation					
1. Manual Initiation	NA	NA	NA	NA	NA
2. Automatic Actuation	NA	NA	NA	NA	NA
3. Containment Pressure - High-High-High	2.5	0.71	1.5	≤ 18.35 psig	≤ 18.9 psig
C. Ventilation Isolation					
1. Manual Initiation	NA	NA	NA	NA	NA
2. Automatic Actuation Logic	NA	NA	NA	NA	NA
3. Safety Injection	See Item 1 above for all Safety Injection Trip Setpoints/Allowable Values				
4. STEAM LINE ISOLATION					
A. Manual Initiation	NA	NA	NA	NA	NA
B. Automatic Actuation Logic	NA	NA	NA	NA	NA
C. Containment Pressure - High High	2.5	0.71	1.5	≤ 6.35 psig	≤ 6.9 psig
D. Steamline Pressure - Low	17.3	14.81	1.5	≥ 605 psig	≥ 586 psig (Note a)
E. Negative Steam Pressure Rate High	8.0	0.5	0.0	≤ 100 psi	≤ 111.6 psi (Note b)

WESTINGHOUSE PROPRIETARY CLASS 3

TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM TRIP SETPOINTS

Functional Unit	Total Allowance (TA)	Z	Sensor Drift (S)	Trip Setpoint	Allowable Value
5. TURBINE TRIP AND FEEDWATER ISOLATION					
a. Automatic Actuation Logic	NA	NA	NA	NA	NA
b. a. Steam Generator Water Level - High-High Unit 1	7.6	4.3	1.5	≤ 82.4% of narrow range instrument span	≤ 84.2% of narrow r instrument span
b. b. Steam Generator Water Level - High-High Unit 2	4.2	2.18	1.5	≤ 76.8% of narrow range instrument span	≤ 78.4% of narrow r instrument span
6. AUXILIARY FEEDWATER					
A. Manual Initiation	NA	NA	NA	NA	NA
B. Automatic Actuation Logic	NA	NA	NA	NA	NA
C. a. Steam Generator Water Level - Low-Low Unit 1	8.8	7.08	1.5	≥ 43.4% of narrow range instrument span	≥ 42.1% of narrow r instrument span
C. b. Steam Generator Water Level - Low-Low Unit 2	19.4	17.38	1.5	≥ 19.4% of narrow range instrument span	≥ 17.8% of narrow r instrument span
D. Safety Injection	See Item 1 above for all Safety Injection Trip Setpoints/Allowble Values				
E. Station Blackout	NA	NA	NA	≥ 4830 kV	≥ 4781 kV
F. Trip of Main Feedwater Pumps	NA	NA	NA	NA	NA
7. Automatic Switchover to Containment Sump					
A. Automatic Actuation Logic And Actuation Relays	NA	NA	NA	NA	NA
B. RWST level - low Coincident with Safety Injection	2.6	0.71	1.5	≥ 18'-10" from tank base	≥ 18'-5.5" from tank base

(a) Time constants utilized in the lead-lad controller for steam pressure low are $\tau_1 \geq 50$ seconds and $\tau_2 \leq 5$ seconds.

(b) The time constant utilized in the rate-lag controller for steam pressure rate - high = 50 seconds.

WESTINGHOUSE PROPRIETARY CLASS 3

TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM TRIP SETPOINTS

Functional Unit	Total Allowance (TA)	Z	Sensor Drift (S)	Trip Setpoint	Allowable Value
8. Loss of Power (6.9 kV Safeguards) System Undervoltage					
a. Preferred Offsite Source Undervoltage:					
Undervoltage Relays	NA	NA	NA	4830 V	≥ 4781 V
Diesel Start Timer	NA	NA	NA	0.75 sec.	≤ 0.825 sec.
Source Bkr. Trip Timer	NA	NA	NA	0.5 sec.	≤ 0.55 sec.
b. Bus Undervoltage					
1) Diesel Start					
Undervoltage Relays	NA	NA	NA	4830 V	≥ 4781 V
Timer	NA	NA	NA	0.75 sec.	≤ 0.825 sec.
2) Initiation of Solid State Safeguards System Sequences					
Undervoltage Relays	NA	NA	NA	4830 V	≤ 4781 V
Timers	NA	NA	NA	sec.	≤ 0.55 sec.
9. Safety Chilled Water System Actuation					
a. Automation Actuation Logic and Actuation Relays	NA	NA	NA	NA	NA
b. Safety Injection	See Item 1 above for all Safety Injection Trip Setpoints/Allowble Values				
c. Blackout Sequence	NA	NA	NA	NA	NA

WESTINGHOUSE PROPRIETARY CLASS 3

TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM TRIP SETPOINTS

Functional Unit	Total Allowance (TA)	Z	Sensor Drift (S)	Trip Setpoint	Allowable Value
0. Control Room Isolation					
a. Manual Initiation	NA	NA	NA	NA	NA
b. Automatic Actuation Logic and Actuation Relays	NA	NA	NA	NA	NA
c. Blackout Sequence	NA	NA	NA	NA	NA
d. Smoke Density	NA	NA	NA	NA	NA
1. Engineered Safety Features Actuation System Interlocks					
a. Pressurizer Pressure, NOT P-11	NA	NA	NA	nominal 1960 psig	≤ 1974 psig
b. Pressurizer Pressure, P-11	NA	NA	NA	nominal 1960 psig	≥ 1946 psig
c. T_{avg} Low-Low, P-12	NA	NA	NA	nominal 553°F	≥ 550.1°F
d. Reactor Trip, P-4	NA	NA	NA	NA	NA

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 Error 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.