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Rev. 4

WESTINGHOUSE SETPOINT METHODOLOGY FOR PROTECTION SYSTEMS SEQUOYAH UNITS 1 AND 2 EAGLE-21 VERSION

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C. R. Tuley

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

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1.0 INTRODUCTION

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

The basic underlying assumption used is that several of the error components and their parameter assumptions act independently, e.g., rack versus sensors and pressure/ temperature assumptions. This allows the use of a statistical summation of the various 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 standard, conservative approach, arithmetic summation, to form independent quantities, e.g., drift and calibration error. An explanation of the overall approach is provided in Section 2.0.

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

Section 4.0 notes what the current standardized Technical Specifications use for setpoints and an explanation of the impact of the Westinghouse approach on them. Detailed examples of how to determine the Technical Specification setpoint values are also provided. An Appendix is provided noting a recommended set of Technical Specifications using the plant specific data and Eagle-21 process rack errors in the Westinghouse 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 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 the "square root of the sum of the squares" which has been utilized in other Westinghouse reports. This technique, or other approaches of a similar nature, have been used in WCAP-10395[1] and WCAP-8567[2]. WCAP-8567 has been approved by the NRC Staff thus noting the acceptability of statistical techniques for the application requested. In addition, various ANSI, American Nuclear Society, and Instrument Society of America standards approve of the use of probabilistic and statistical techniques in determining safety-related setpoints[3][4]. The methodology used in this report is essentially the same as that used for V. C. Summer, which was approved in NUREG-0717, Supplement No. 4[5].

The relationship between the error components and the total error allowance for a channel is noted in Equation 2.1

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

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

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

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

(4) ISA Standard S67.04, 1987, "Setpoints for Nuclear Safety-Related Instrumentation Used in Nuclear Power Plants."

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

where:

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

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

As can be seen in Equation 2.1, drift and calibration accuracy allowances are interactive and thus not independent. The environmental allowance is not necessarily considered interactive with all other parameters, but as an additional degree of conservatism is added to the statistical sum. It should be noted that for this document 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. Several functions were identified by TVA as

having cable IR errors in excess of 0.1 percent span. These errors were incorporated into the calculations.

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. Analog Rack Drift and Sensor Drift are assumed, based on a survey of reported plant LERs, digital Rack Drift is based on system design, and with Process Measurement Accuracy are considered as conservative values.

2.2 SENSOR ALLOWANCES

Five parameters are considered to be sensor allowances, SCA, SMTE, SD, STE, and SPE (see Table 3-22). Of these parameters, two are considered to be statistically independent, STE and SPE, and three are considered interactive SCA, SMTE and SD. STE and SPE are considered to be independent due to the manner in which the instrumentation is checked, i.e., the instrumentation is calibrated and drift determined under conditions in which pressure and temperature are assumed constant. An example of this would be as follows; assume a sensor is placed in some position in the containment during a refueling outage. After placement, an instrument technician calibrates the sensor. This calibration is performed at ambient pressure and temperature conditions. Some time later with the plant shutdown, an instrument technician checks for sensor drift. Using the same technique as for calibrating the sensor, the technician determines if the sensor has drifted or not. The conditions under which this determination is made are again at ambient pressure and temperature conditions. Thus the temperature and pressure have no impact on the drift determination and are, therefore, independent of the drift allowance.

SCA, SMTE and SD are considered to be interactive for the same reason that STE and SPE are considered independent, i.e., due to the manner in which the instrumentation is checked. Instrumentation calibration techniques use the same process as determining instrument drift, that is, the end result of the two is the same. When calibrating a sensor, the sensor output is checked to determine if it is accurately representing the input. The same is performed for a determination of the

sensor drift. Thus unless "as left-as found" data is recorded and used, it is impossible to determine the differences between calibration errors and drift when a sensor is checked the second or any subsequent time. Based on this reasoning, SCA, SMTE and SD have been added to form an independent group which is then factored into Equation 2.1. An example of the impact of this treatment is; for Pressurizer Water Level-High (sensor parameters only):

[ ]$^{+a,c}$

SCA =
SMTE =
STE =
SPE =
SD =

using Equation 2.1 as written gives a total of;

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

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

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

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

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

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

2.3 RACK ALLOWANCES

Five parameters, as noted by Table 3-22, are considered to be rack allowances, RCA, RMTE, RCSA, RTE, and RD. Four of these parameters are considered to be interactive (for much the same reason outlined for sensors in 2.2), RCA, RMTE, RCSA, and RD. When calibrating or determining drift in the racks for a specific channel, the processes are performed at essentially constant temperature, i.e.,

ambient temperature. Because of this, the RTE parameter is considered to be independent of any factors for calibration or drift.

However, the same cannot be said for the other rack parameters. As noted in 2.2, when calibrating or determining drift for a channel, the same end result is desired, that is, for an analog protection function, at what point does the bistable change state. After initial calibration, without recording and using "as left-as found" data, it is not possible to distinguish the difference between a calibration error, rack drift or a comparator setting error. Based on this logic, these factors have been added to form an independent group. This group is then factored into Equation 2.1. The impact of this approach (formation of an independent group based on interactive components) is significant. For the same channel using the same approach outlined in Equations 2.1 and 2.2 and using analog process rack uncertainties, the following results are reached:

RCA =
RMTE =
RCSA =
RTE =
RD =
[ ]+a,c

using Equation 2.1 the result is;

$$[\ \{(RCA + RMTE + RCSA + RD)^2 + (RTE)^2\}^{1/2}\ ]^{+a,c} = 2.30\%$$

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

$$[\ \{(RCA)^2 + (RMTE)^2 + (RCSA)^2 + (RD)^2 + (RTE)^2\}^{1/2}\ ]^{+a,c} = 1.35\% \qquad \text{(Eq. 2.3)}$$

Thus, the impact of the use of Equation 2.1 is even greater in the area of rack effects than for the sensor. Similar results, with different magnitudes, would be

arrived at using digital process rack uncertainties. Therefore, accounting for interactive effects in the 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 factored into Equation 2.1 as independent quantities.

2.5 MEASUREMENT AND TEST EQUIPMENT ACCURACY

Westinghouse was informed by Sequoyah that the equipment used for calibration and functional testing of the transmitters and racks did not meet SAMA standard PMC 20.1-1973(1) with regards to test equipment accuracy of 10 percent or less of the calibration accuracy (referenced in 3.2.6.a or 3.2.7.a.) This then required the inclusion of the accuracy of this equipment in equations 2.1 and 3.1. Based on information provided by the plant, these additional uncertainties were included in the calculations, as noted on the tables included in this report, with minor impact on the final results. On Table 3-22, the values for SMTE and RMTE are specifically identified.

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

3.0 PROTECTION SYSTEM SETPOINT METHODOLOGY

3.1 MARGIN CALCULATION

As noted in Section Two, Westinghouse utilizes the square root of the sum of the squares for 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. The equation used to determine the margin, and thus the acceptability of the parameter values used, is:

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

where:

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

Again, please note that Eq. 3.1 is representative for a channel with analog process racks. Use of digital process racks results in deletion of the RCSA term. The magnitude of the RMTE term is typically different for digital process racks when compared to typical values for analog process racks.

Tables 3-1 through 3-21 provide individual channel breakdown and channel statistical allowance calculations for all protection functions, utilizing appropriate values for the process rack equipment. Table 3-22 provides a summary of the previous 21 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 trip is initiated (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 (for analog process racks), 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.

For a digital channel, it is the accuracy which includes the accuracy of the primary element and/or transmitter and the signal conditioning - A/D conversion modules. Since typically only one module is present, compensation between multiple modules for errors is not possible. Compensation between multiple modules for errors is possible for protection functions with multiple inputs.

6. Sensor Allowable Deviation

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

The tolerances are as follows:

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

b. Measurement and Test Equipment accuracy - usually included as an integral part of (a), Reference (calibration) accuracy, when less than 10 percent of the value of (a). For equipment (DVM, pressure gauge, etc.) used to calibrate the sensor with larger uncertainty values, a specific allowance is made.

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

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

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

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

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]. For an analog channel this includes all modules in a rack and is a total of [ ]+a,b,c 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 analog process modules individually must have a reference accuracy within [ ]+a,b,c percent.

For a digital channel, this accuracy represents calibration of the signal conditioning - A/D converter providing input to the central processing unit. Each signal conditioning - A/D converter module is calibrated to within an accuracy of [ ]+a,b,c percent span (for functions with rack inputs of 10-50 mA), or [ ]+a,b,c percent span (for functions with RTD rack inputs).

b. Measurement and Test Equipment Accuracy - usually included as an integral part of (a), Reference (calibration) accuracy, when less than 10 percent of the value of (a). For equipment (DVM, current source, voltage source, etc.) used to calibrate the racks, either analog or digital, with larger uncertainty values, a specific allowance is made.

c. Rack Environmental Effects

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

d. Rack Drift (instrument channel drift) - change in input-output relationship over a period of time at reference conditions (e.g., constant temperature) - ±1 percent of span for analog racks and [ ]$^{+a,c}$ percent span for digital racks.

e. Comparator Setting Accuracy

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

The tolerances assumed for Sequoyah (based on input from TVA) are as follows:

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

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

Digital channels do not have an electronic comparator, therefore no uncertainty is included for this term for these channels.

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 may be 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 the safety analyses.

12. Total Allowable Setpoint Deviation

Maximum setpoint deviation from a nominal value due to instrument (hardware) effects.

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 larger than 2σ values. Analog Rack Drift and Sensor Drift are assumed, based on a survey of reported plant LERs, digital Rack Drift is based on system design, 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 M&TE	
Comparator One input	
Rack Temperature Effects	
Rack Drift	

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

Channel Statistical Allowance =

[ ]+a,c

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

Parameter	Allowance*
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	
M&TE	
Comparator	
One input	
Rack Temperature Effects	
Rack Drift	

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

Channel Statistical Allowance =

[ ] +a,c

TABLE 3-3
INTERMEDIATE RANGE, NEUTRON FLUX**

Parameter	Allowance
See TVA calculation SQN-EEB-PS-TI28-0001	

** Not processed by Eagle-21 racks

TABLE 3-4
SOURCE RANGE, NEUTRON FLUX**

Parameter	Allowance
See TVA calculation SQN-EEB-PS-TI28-0001	

** Not processed by Eagle-21 racks

TABLE 3-5
OVERTEMPERATURE ΔT

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

TABLE 3-5 (Continued)
OVERTEMPERATURE ΔT

Parameter	Allowance*
Total Rack Calibration Accuracy	+a,c
[ ] +a,c	
Rack Temperature Effects	
[ ] +a,c	
Rack Drift	
ΔT	
Pressure	
ΔI	

* In % span, ΔT - 94.5 °F, T_{avg} - 100°F, Pressure - 800 psi, Power - 150% RTP, ΔI - ± 60% ΔI

** See Table 3-23 for gain calculations

\# Number of Hot Leg RTDs used

\## Number of Cold Leg RTDs used

Channel Statistical Allowance =

+a,c

TABLE 3-6
OVERPOWER ΔT

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

+ a,c

TABLE 3-6 (continued)
OVERPOWER ΔT

Parameter	Allowance*
	+a,c
Rack Temperature Effects	
ΔT	[ ]
Rack Drift	
ΔT	

* In % span ΔT - 94.5 °F, Tavg - 100°F
** See Table 3-24 for gain calculations
*** Per TVA Caclulation IR-WCAP11239
\# Number of Hot Leg RTDs used
\#\# Number of Cold Leg RTDs used

Channel Statistical Allowance = +a,c

[ ]

TABLE 3-7
PRESSURIZER PRESSURE - LOW AND HIGH, REACTOR TRIPS

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

* In percent span (800 psi)

Channel Statistical Allowance =
Pressurizer Pressure - Low

[ ]+a,c

Pressurizer Pressure - High

[ ]+a,c

TABLE 3-8
PRESSURIZER WATER LEVEL - HIGH

Parameter	Allowance*
Process Measurement Accuracy [ ]+a,c	[ ]+a,c
Primary Element Accuracy	
Sensor Calibration M&TE	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance	
Rack Calibration Rack Accuracy M&TE	
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 [ ]$^{+a,c}$ [ ]$^{+a,c}$	[ ]$^{+a,c}$
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 [± 0.4 percent Δp span]$^{+a,c}$ M&TE [ ]$^{+a,c}$	
Rack Temperature Effects [ ]$^{+a,c}$	
Rack Drift 0.3 percent Δp span	

* In percent flow span (110 percent Thermal Design Flow) percent Δp span converted to flow span via Equation 3-26.8, with F_{max} = 110% and F_N = 100%

Channel Statistical Allowance =

[ ]$^{+a,c}$

TABLE 3-10
STEAM GENERATOR WATER LEVEL - LOW-LOW ADVERSE AND EAM (51)
(Unmodified Barton)

Parameter	Allowance*
Process Measurement Accuracy	[ ]+a,c
Density variations with load due to changes in recirculation**	
Primary Element Accuracy	
Sensor Calibration	
M&TE	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance	
Transmitter - Adverse	
Transmitter - EAM	
Reference Leg Heatup - Adverse and EAM***	
Cable IR - Adverse#	
Rack Calibration	
Rack Accuracy	
M&TE	
Rack Temperature Effects	
Rack Drift	

* In percent span (100 percent span)
** See Table 3-25 for explanation
*** Per TVA calculation 1-LT-3-38
\# Per TVA calculation IR-WCAP-11239

Channel Statistical Allowance =

Steam Generator Level-low-low (EAM)

[ ]+a,c

Steam Generator Level-low-low (Adverse)

[ ]+a,c

TABLE 3-11
STEAM GENERATOR WATER LEVEL - LOW-LOW ADVERSE AND EAM (51)
(Modified Barton)

Parameter	Allowance*
Process Measurement Accuracy Density variations with load due to changes in recirculation**	[ ]+a,c
Primary Element Accuracy	
Sensor Calibration M&TE	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance Transmitter - Adverse Transmitter - EAM Reference Leg Heatup - Adverse and EAM*** Cable IR - Adverse#	
Rack Calibration Rack Accuracy M&TE	
Rack Temperature Effects	
Rack Drift	

* In percent span (100 percent span)
** See Table 3-25 for explanation
*** Per TVA calculation 1-LT-3-38
\# Per TVA calculation IR-WCAP-11239

Channel Statistical Allowance =

Steam Generator Level-low-low (EAM)

[ ]+a,c

Steam Generator Level-low-low (Adverse)

[ ]+a,c

TABLE 3-12
CONTAINMENT PRESSURE - HIGH, EAM AND HIGH-HIGH (FOXBORO)

Parameter	Allowance*
Process Measurement Accuracy	[ ]+a,c
Primary Element Accuracy	
Sensor Calibration	
M&TE	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance	
EAM	
High and High-High	
Rack Calibration	
Rack Accuracy	
M&TE	
Rack Temperature Effects	
Rack Drift	

* in percent span (16 psig)

Channel Statistical Allowance =

High and High-High

[ ]+a,c

EAM

[ ]+a,c

TABLE 3-13
CONTAINMENT PRESSURE - HIGH, EAM AND HIGH-HIGH (BARTON)

Parameter	Allowance*
Process Measurement Accuracy	[ ] +a,c
Primary Element Accuracy	
Sensor Calibration	
M&TE	
Sensor Pressure Effects	
Sensor Temperature Effects	
High and High-High	
EAM	
Sensor Drift	
Environmental Allowance (High and High-High only)	
Rack Calibration	
Rack Accuracy	
M&TE	
Rack Temperature Effects	
Rack Drift	

* In percent span (18 psig)

Channel Statistical Allowance =

High and High-High

[ ] +a,c

EAM

[ ] +a,c

TABLE 3-14
PRESSURIZER PRESSURE - LOW, SAFETY INJECTION

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

* In percent span (800 psi)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-15
STEAMLINE PRESSURE - LOW

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

* In percent span (1200 psig)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-16
NEGATIVE STEAMLINE PRESSURE RATE - HIGH

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

* In percent span (1200 psig)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-17
STEAM GENERATOR WATER LEVEL - HIGH-HIGH (51)

Parameter	Allowance*
Process Measurement Accuracy density variations with load**	[ ] +a,c
Primary Element Accuracy	
Sensor Calibration M&TE	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance	
Rack Calibration Rack Accuracy M&TE	
Rack Temperature Effects	
Rack Drift	

* In percent span (100 percent span)
** See TVA calculation SQN-CSS-005

Channel Statistical Allowance =

[ ] +a,c

TABLE 3-18
RWST LEVEL - LOW AND HIGH

Parameter	Allowance
See TVA calculation SQN-EEB-MS-TI28-0015 for RWST Level and TVA calculation SQN-EEB-MS-TI28-0013 for Reactor Building Sump Level	

TABLE 3-19
RCP UNDERFREQUENCY (W SDF-2)**

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

* In percent span (6 Hz)
** Not processed by Eagle-21 racks

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-20
RCP UNDERVOLTAGE (GE NGV-13)*

Parameter	Allowance

TVA-OE calculation No. RCP-UV-Device 27-System 202 RIMS accession # B43 '860221 902
* Not processed by Eagle-21 racks

TABLE 3-21
VESSEL ΔT EQUIVALENT TO POWER

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

| |+a,c

TABLE 3-21 (Continued)
VESSEL ΔT EQUIVALENT TO POWER

Parameter	Allowance*
Rack Temperature Effects	+a,c
ΔT	[ ]
Rack Drift	
ΔT	

* In % span ΔT = 94.5 °F, T_{avg} - 100°F
** See Table 3-21 for gain calculations
*** Per TVA calculation IR-WCAP-11239
\# Number of Hot Leg RTDs used
\#\# Number of Cold Leg RTDs used

Channel Statistical Allowance =

+a,c

[ ]

WESTINGHOUSE CLASS 3

NOTES FOR

1. ALL VALUES IN PERCENT SPAN.
2. AS NOTED IN TABLE 15.1.3-1 OF FSAR
3. AS CALCULATED USING THE APPROVED METHODOLOGY AND NOTED ON TABLE 4-3 OF THIS REPORT.
4. [ ] a,c
5. NOT USED IN SAFETY ANALYSIS
6. AS NOTED IN FIGURE 15.1.3-1 OF FSAR
7. AS NOTED IN TABLE 2.2-1 NOTE 1 OF PLANT TECHNICAL SPECIFICATIONS
8. AS NOTED IN TABLE 2.2-1 NOTE 3 OF PLANT TECHNICAL SPECIFICATIONS
9. NOT NOTED IN TABLE 15.1.3-1 OF FSAR BUT USED IN SAFETY ANALYSIS
10. SUPERSEDES INFORMATION IN FSAR TABLE 15.1.3-1
11. [ ] a,c
12. [ ] a,c
13. [ ] a,c
14. [ ] a,c
15. NOT IN WESTINGHOUSE SCOPE - SEE TVA CALCULATION SQN-EEB-PS-TI28-0001.
16. INCORE/EXCORE f(ΔI) COMPARISON AS NOTED IN TABLE 4.3-1 OF PLANT TECHNICAL SPECIFICATIONS
17. [ ] a,c
18. SAFETY ANALYSIS LIMIT ENSURES THIS RWST SWITCHOVER TO CONTAINMENT SUMP IS COMPLETED BEFORE VORTEXING OCCURS IN THE

TABLE

REACTOR PROTECTION SYSTEM/
ACTUATION SYSTEM CHAN
SEQUOYAH UNITS 1 AN

				SENSOR					
		1	2	3	4	5	6	7	8
	ROTECTION CHANNEL	PROCESS MEASUREMENT ACCURACY (1)	PRIMARY ELEMENT ACCURACY (1)	CALIBRATION ACCURACY (1)	M&TE ACCURACY (1)	PRESSURE EFFECTS (1)	TEMPERATURE EFFECTS (1)	DRIFT (1)	ENVIRONM ALLOWA (1)
1	POWER RANGE, NEUTRON FLUX - HIGH SETPOINT								
2	POWER RANGE, NEUTRON FLUX - LOW SETPOINT								
3	POWER RANGE, NEUTRON FLUX - HIGH POSITIVE RATE								
4	POWER RANGE, NEUTRON FLUX - HIGH NEGATIVE RATE								
5	INTERMEDIATE RANGE, NEUTRON FLUX								
6	SOURCE RANGE, NEUTRON FLUX								
7	OVERTEMPERATURE ΔT ΔT CHANNEL								
8	TAVG CHANNEL								
9									
10	PRESSURIZER PRESSURE CHANNEL								
11	f(ΔI) CHANNEL								
12	OVERPOWER ΔT ΔT CHANNEL								
13									
14	TAVG CHANNEL								
15	PRESSURIZER PRESSURE - LOW, REACTOR TRIP (BARTON)								
16	PRESSURIZER PRESSURE - HIGH (BARTON)								
17	PRESSURIZER WATER LEVEL - HIGH (BARTON)								
18	LOSS OF FLOW								
19	STEAM GENERATOR WATER LEVEL - LOW-LOW ADVERSE (UNMODIFIED BARTON)								
20	STEAM GENERATOR WATER LEVEL - LOW-LOW EAM (UNMODIFIED BARTON)								
21	STEAM GENERATOR WATER LEVEL - LOW-LOW ADVERSE (MODIFIED BARTON)								
22	STEAM GENERATOR WATER LEVEL - LOW-LOW EAM (MODIFIED BARTON)								
23	UNDERVOLTAGE - RCP								
24	UNDERFREQUENCY - RCP								
25	CONTAINMENT PRESSURE - EAM (FOXBORO)								
26	CONTAINMENT PRESSURE - HIGH (FOXBORO)								
27	CONTAINMENT PRESSURE - HIGH-HIGH (FOXBORO)								
28	CONTAINMENT PRESSURE - EAM (BARTON)								
29	CONTAINMENT PRESSURE - HIGH (BARTON)								
30	CONTAINMENT PRESSURE - HIGH-HIGH (BARTON)								
31	PRESSURIZER PRESSURE - LOW, SI (BARTON)								
32	STEAMLINE PRESSURE - LOW (FOXBORO)								
33	STEAM GENERATOR WATER LEVEL - HIGH-HIGH (BARTON)								
34	RWST LEVEL - LOW (BARTON)								
35	RWST LEVEL - HIGH (BARTON)								
36	NEGATIVE STEAMLINE PRESSURE RATE - HIGH								
37	VESSEL ΔT EQUIVALENT TO POWER								

19. [ ] +a,c

20. NOT IN WESTINGHOUSE SCOPE - SEE TVA CALCULATION RCP-UV-DEVICE 27-SYSTEM 202

21. [ ] +a,c

22. [ ] +a,c

23. [ ] +a,c

24. NOT IN WESTINGHOUSE SCOPE - SEE TVA CALCULATION SQN-EEB-MS-TI28-0015

25.

26. SAFETY ANALYSIS LIMIT ENSURES THAT AT RWST SWITCHOVER, THE CONTAINMENT SUMP LEVEL SAFETY LIMIT IS NOT VIOLATED.

27. CABLE IR, AS PROVIDED BY TVA, TREATED AS A BIAS.

28. NOTE 5 OF TABLE 2.2-1 OF PLANT TECHNICAL SPECIFICATIONS.

29. PER TVA CALCULATION SQN-CSS-005.

WST

SI APERTURE CARD

Also Available On Aperture Card

3-22

ENGINEERED SAFETY FEATURES
NEL ERROR ALLOWANCES
D 2 REVISION 5

	INSTRUMENT RACK											
	9	10	11	12	13	14	15	16	17	18	19	
ENTAL NCE	CALIBRATION ACCURACY (1)	M&TE ACCURACY (1)	COMPARATOR SETTING ACCURACY (1)	TEMPERATURE EFFECTS (1)	DRIFT (1)	SAFETY ANALYSIS LIMIT (2)	STS ALLOWABLE VALUE (3)	STS TRIP SETPOINT (3)	TOTAL ALLOWANCE (1)	CHANNEL STATISTICAL ALLOWANCE (1)	MARGIN (1)	+a,c
					1.0	118% RTP	111.4% RTP	109% RTP	7.5			1
					1.0	35% RTP	27.4% RTP	25% RTP	8.3			2
					0.5	(5)	6.3% RTP	5.0% RTP	---			3
					0.5	6.9% RTP (9)	6.3% RTP	5.0% RTP	1.6			4
					(15)	(5)	(15)	25% RTP	---			5
					(15)	(5)	(15)	1.0E+05 CPS	---			6
					0.4							7
					---							8
						(6)	(7) + 1.9% ΔT span	(7)	5.7			9
					0.3							10
					0.3							11
					0.4							12
						(6)	(8) + 1.7% ΔT span	(8)	4.8			13
					---							14
					0.3	1845 psig	1964.8 psig	1970 psig	15.6			15
					0.3	2445 psig (10)	2390.2 psig	2385 psig	7.5			16
					0.3	(5)	92.7% span	92% span	---			17
					0.1	86.9% design	89.4% design	90% design	2.8			18
					0.3	0% span	16.3% span	16.9% span	16.9			19
					0.3	0% span	12.4% span	13.0% span	13.0			20
					0.3	0% span	12.3% span	12.9% span	12.9			21
					0.3	0% span	10.1% span	10.7% span	10.7			22
					(20)	4692 VAC	(20)	5022 VAC (20)	(20)			23
					---	55.8 Hz. (9)	55.9 Hz.	56.0 Hz.	3.3			24
					0.3	1.2 psig (9)	0.6 psig	0.5 psig	4.4			25
					0.3	2.42 psig (9)	1.6 psig	1.54 psig	5.5			26
					0.3	3.69 psig (9)	2.9 psig	2.81 psig	5.5			27
					0.3	1.2 psig (9)	0.6 psig	0.5 psig	3.9			28
					0.3	2.42 psig (9)	1.7 psig	1.54 psig	4.9			29
					0.3	3.69 psig (9)	2.9 psig	2.81 psig	4.9			30
					0.3	1730 psig (10)	1864.8 psig	1870 psig	17.5			31
					0.3	433 psig (9)	592.2 psig	600 psig	13.9			32
					0.3	93.2% span (10)	81.7 % span	81.0% span	12.2			33
					(24)	(18) (24)	(24)	27.4% span	(24)			34
					(24)	(24) (26)	(24)	27.4% span	(24)			35
					0.3	(5)	107.8 psig	100.0 psig	---			36
					1.2	6.0% ΔT span (9) (28)	(28) + 1.7% ΔT span	(28)	6.0			37

9005010007-01

TABLE 3-23
OVERTEMPERATURE ΔT GAIN CALCULATIONS

The equation for Overtemperature ΔT is:

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

$$\Delta T_0 \{K_1 - K_2 \left(\frac{1+\tau_1 S}{1+\tau_2 S}\right) \{T - T'\} + K_3 (P - P') - f_1 (\Delta I)\}$$

K_1 (max)	=	[1.2357 (analysis value)] +a,c
K_1 (nominal)	=	1.15 (Technical Specification Trip Setpoint)
K_2	=	0.011
K_3	=	0.00055
Vessel T_H	=	609.7°F
Vessel T_C	=	546.7°F
Positive ΔI gain	=	0.86% FP ΔI/% ΔI

ΔT span = (609.7 - 546.7) (150)/(100)
= 94.5 °F

Process Measurement Accuracy

ΔT

PMA = [
=
=

ΔI

PMA1 =
=
=

PMA2 =
=
=] +a,c

TABLE 3-23 (Continued)
OVERTEMPERATURE ΔT GAIN CALCULATIONS

Pressure Gain

Gain =
=

[ ] +a,c

Pressure Channel Uncertainties

SCA =
=
=

M&TE =
=
=

STE =
=
=

SD =
=
=

Bias =
=
=

[ ] +a,c

Total Allowance

TA =
=
=

[ ] +a,c

TABLE 3-24

OVERPOWER ΔT GAIN CALCULATIONS

The equation for Overpower ΔT is:

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

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

K_4 (max)	=	[1.1590 (analysis value)] +a,c
K_4 (nominal)	=	1.087 (Technical Specification Trip Setpoint)
K_5	=	0.02
K_6	=	0.0011
Vessel T_H	=	609.7°F
Vessel T_C	=	546.7°F

ΔT span = (609.7 - 546.7) (150)/(100)
= 94.5 °F

Process Measurement Accuracy

ΔT

PMA = [
=
=] +a,c

Total Allowance

TA = [
=
=] +a,c

TABLE 3-25
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 point 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 have been defined as ΔP measurements only.[1]

Analysis specific for Sequoyah Units 1 and 2 indicates that the level density error is less than 11.0% of span. This is based on the calibration procedure used at Sequoyah which is different than the recommended calibration at 50% power, 50% level conditions. This error only affects the high level trip function.

INDICATED LEVEL (50% Power Calibration)

	0%	10%	70%	100%
				+a,c
Actual Level 0% Power				
Actual Level 100% Power				

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

TABLE 3-26
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:

$$F_N^2 = \Delta P_N \quad \text{where N = nominal flow}$$

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

$$\text{thus} \quad \partial F_N = \frac{\partial \Delta P_N}{2F_N} \qquad \text{Eq. 3-26.1}$$

Error at a point (not in percent) is:

$$\frac{\partial F_N}{F_N} = \frac{\partial \Delta P_N}{2F_N^2} = \frac{\partial \Delta P_N}{2\Delta P_N} \qquad \text{Eq. 3-26.2}$$

and

$$\frac{\Delta P_N}{\Delta P_{max}} = \frac{F_N^2}{F_{max}^2} \quad \text{where max = maximum flow} \qquad \text{Eq. 3-26.3}$$

and the transmitter ΔP error is:

$$\frac{\partial P_N}{\Delta P_{max}} \times 100 = \text{percent error (full scale } \Delta P) \qquad \text{Eq. 3-26.4}$$

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

Eq. 3-26.5

TABLE 3-26 (Continued)
ΔP MEASUREMENTS EXPRESSED IN FLOW UNITS

Error in flow units is:

$$\partial F_N = F_N \frac{\text{percent error (FS } \Delta P)}{2 \times 100} \left(\frac{F_{max}}{F_N}\right)^2 \quad \text{Eq. 3-26.6}$$

Error in percent nominal flow is:

$$\frac{\partial F_N}{F_N} \times 100 = \frac{\text{percent error (FS } \Delta P)}{2} \left(\frac{F_{max}}{F_N}\right)^2 \quad \text{Eq. 3-26.7}$$

Error in percent full span is:

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

$$= \frac{\text{percent error (FS } \Delta P)}{2} \left(\frac{F_{max}}{F_N}\right) \quad \text{Eq. 3-26.8}$$

Equation 3-26.8 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 does not recognize how setpoint calibrations and verifications are performed in the plant. In fact, this two column approach forces the plant to take a double penalty in the area of calibration error. As noted in Figure 4-1, the plant must allow for calibration error below the STS Trip Setpoint, in addition to the allowance assumed in the various accident analyses, if full utilization of the rack drift is wanted. This is due, as noted in 2.2, to the fact that calibration error may not be distinguished from rack drift after an initial calibration. Thus, the plant is left with two choices; 1) to assume a rack drift value less than that allowed for in the analyses (actual RD = assumed RD-RCA) or, 2) penalize the operation of the plant (and increasing the possibility of a spurious trip) by lowering the nominal trip setpoint into the operating margin.

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

4.2 WESTINGHOUSE SETPOINT METHODOLOGY FOR STS SETPOINTS

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

4.2.1 RACK ALLOWANCE

The first item that will be covered is the interactive effects. When an instrument technician looks for rack drift he is seeing more than that, if "as left-as found" data is not used. This interaction has been noted several times and is treated in Equations 2.1 and 3.1 by the arithmetic summation of rack drift, rack measurement and test equipment accuracy, rack comparator setting accuracy, and rack calibration accuracy (for analog rack effects); rack drift, rack measurement and test equipment accuracy and rack calibration accuracy (for digital rack effects); and sensor drift, sensor measurement and test equipment accuracy and sensor calibration accuracy (for sensor effects). To provide a conservative "trigger value", the difference between the STS trip setpoint and the STS allowable value is determined by two methods. The first is simply the values used in the CSA calculation, T_1 = (RD + RCA + RMTE + RCSA) for analog racks; T_1 = (RD + RCA + RMTE) for digital racks. The second extracts these values from the calculation and compares the remaining values against the total allowance as follows:

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

where:

T = Rack trigger value

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

S = $(SCA + SMTE + SD)$

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

The smaller of the trigger values should be used for comparison with the "as measured" value (RD + RCA + RMTE + RCSA for analog racks, RD + RCA + RMTE for digital racks). 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 measured values should be used in the calculation described in Section 4.2.3.

This means that all the instrument technician has to do during the periodic surveillance is determine the value of the trip setpoint (bistable trip setpoint - analog racks,

trip setpoint as indicated by the MMI - digital racks), 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 (one analog, one digital). A comparison of the two different Allowable Values will show the net gain of the Westinghouse versions. Note that the digital channel error magnitude difference is due primarily to the reduced RCA and RD values when compared to the analog channel errors.

4.2.2 INCLUSION OF "AS MEASURED" SENSOR ALLOWANCE

If the approach used 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 Westinghouse methodology requires a somewhat more complicated approach. This methodology is based on the use of equation 4.2, and demonstrated in Section 4.2.3, Implementation.

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

where:

R = the "as measured rack value" (RD + RCA + RMTE + RCSA for analog racks, RD + RCA + RMTE for Digital Racks)

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

and all other parameters are as defined in Equation 4.1.

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

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

where:

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

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

4.2.3 IMPLEMENTATION OF THE WESTINGHOUSE SETPOINT METHODOLOGY

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

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

$$T_2 = TA - (\{A + (S)^2\}^{1/2} + EA)$$

where:

TA = 6 percent (an assumed value for this example)

+ a,c

A =

$(S)^2$ =

EA =

T_2 =

=

=

=

However, since only [0.65 percent] is assumed for T in the various analyses (RCA + RMTE + RD), that value will be used as the "trigger value". The lowest of two values is used for the "trigger value"; either the value for T assumed in the analyses or the value calculated by Equation 4.1.

Now assume that one channel's signal conditioning card has "drifted" more than that allowed by the STS for periodic surveillance. According to ACTION statement b.1, the plant staff must verify that Equation 2.2-1 is met. Going to Table 2.2-1, the following values are noted: Z = 2.14 and the assumed Total Allowance is (TA) = 8.0. Assume that the "as measured" rack setpoint value as determined with the MMI is 4.25 percent low and the "as measured" sensor value is 2.5 percent. Equation 2.2-1 looks like:

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

$$2.14 + 4.25 + 2.5 \leq 8.0$$

$$8.9 > 8.0$$

As can be seen, 8.9 percent is not less than 8.0 percent thus, the plant staff must follow ACTION statement b.2 (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 8.0 percent. In fact, for analog process rack channels, 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. For digital process rack channels this will occur less often due to the increased margin available. Reduction of process rack errors without setpoint adjustment created this additional margin.

If the sum of R + S was about one percent less, e.g., R = 3.5 percent, S = 2.0 percent thus, R + S = 5.5 percent, then the sum of Z + R + S would be less than 8 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. However, for a digital process rack channel, the amount of drift used in the example is more indicative of possible failure rather than an acceptable level of drift. Rack

drift in excess of [~0.5% span]$^{+a,c}$ is considered abnormal and should be thoroughly investigated.

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

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

or

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

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

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

$$T_3 = \{(RCA_1 + RMTE_1 + RCSA_1 + RD_1)^2 + (RCA_2 + RMTE_2 + RCSA_2 + RD_2)^2\}^{1/2} \qquad \text{(Eq. 4.6)}$$

or

Equation 4.5 as described above.

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

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

+a,c

TA = [ ]

A = [ ]

$(S_1)^2$ = [ ]

$(S_2)^2$ = [ ]

+a,c

$RCA_1 + RMTE_1 + RD_1$ = [ ]

$$RCA_2 + RMTE_2 + RD_2 = [\quad]^{+a,c}$$
$$RCA_3 + RMTE_3 + RD_3 = [\quad]$$
$$EA = [\quad]$$

Using Equation 4.4;

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

Using Equation 4.5;

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

Using Equation 4.6;

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

The value of T used is from Equation 4.6. In this document Equations 4.5 and 4.6, whichever results in the smaller value, are 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 process rack only, 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

	(Analog) Power Range Neutron Flux - High	(Analog) 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

	(Analog) Power Range Neutron Flux - High	(Digital) Pressurizer Pressure - High
Safety Analysis Limit	118 percent	2445 psig
STS Allowable Value (Trigger Value)	111.4 percent	2390.2 psig
STS Trip Setpoint	109 percent	2385 psig

Safety Analysis Limit

{ Process Measurement Accuracy

{ Primary Element Accuracy

{ Sensor Calibration Accuracy

{ Sensor Measurement & Test Equipment

{ Sensor Pressure Effects

{ Sensor Temperature Effects

{ Sensor Drift

{ Environmental Allowance

{ Rack Temperature Effects

{ Rack Comparator Setting Accuracy

{ Rack Calibration Accuracy

{ Rack Measurement & Test Equipment

STS Allowable Value

{ Rack Drift

STS Trip Setpoint

Actual Calibration Setpoint

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

Safety Analysis Limit

|-------------

{ Process Measurement Accuracy

|-------------

{ Primary Element Accuracy

|-------------

{ Sensor Calibration Accuracy

|-------------

{ Sensor Measurement & Test Equipment

|-------------

{ Sensor Pressure Effects

|-------------

{ Sensor Temperature Effects

|-------------

{ Sensor Drift

|-------------

{ Environmental Allowance

|-------------

{ Rack Temperature Effects

STS Allowable Value

|-------------

{ Rack Comparator Setting Accuracy

|-------------

{ Rack Calibration Accuracy

|-------------

{ Rack Measurement & Test Equipment

|-------------

{ Rack Drift

STS Trip Setpoint

Figure 4-2 Westinghouse STS Setpoint Error Breakdown - Analog Process Racks

```
Safety Analysis Limit

                                 |-------------
                                 {      Process Measurement Accuracy
                                 |-------------
                                 {      Primary Element Accuracy
                                 |-------------
                                 {      Sensor Calibration Accuracy
                                 |-------------
                                 {      Sensor Measurement & Test Equipment
                                 |-------------
                                 {      Sensor Pressure Effects
                                 |-------------
                                 {      Sensor Temperature Effects
                                 |-------------
                                 {      Sensor Drift
                                 |-------------
                                 {      Environmental Allowance
                                 |-------------
                                 {      Rack Temperature Effects
                                 |-------------
STS Allowable Value              {      Rack Calibration Accuracy
                                 |-------------
                                 {      Rack Measurement & Test Equipment
                                 |-------------
                                 {      Rack Drift
STS Trip Setpoint
```

Figure 4-3 Westinghouse STS Setpoint Error Breakdown - Digital Process Racks

WESTINGHOUSE CLASS 3

WESTINGHOUSE PROTECTION SY

SEQUOYAH UN

TABLE 4-3

	PROTECTION CHANNEL	TOTAL ALLOWANCE (TA) (9)	(A) (9) (1)	(S) (9) (2)	(T)
1	POWER RANGE, NEUTRON FLUX-HIGH SETPOINT	7.5	[ ]a,c	0.0	
2	POWER RANGE, NEUTRON FLUX-LOW SETPOINT	8.3		0.0	
3	POWER RANGE, NEUTRON FLUX-HIGH POSITIVE RATE	1.6		0.0	
4	POWER RANGE, NEUTRON FLUX-HIGH NEGATIVE RATE	1.6		0.0	
5	INTERMEDIATE RANGE, NEUTRON FLUX	(14)		(14)	
6	SOURCE RANGE, NEUTRON FLUX	(14)		(14)	
7	OVERTEMPERATURE ΔT	5.7		1.6 + 0.6	
8	OVERPOWER ΔT	4.8		1.6	
9	PRESSURIZER PRESSURE-LOW, REACTOR TRIP (BARTON)	15.6		2.0	
10	PRESSURIZER PRESSURE-HIGH (BARTON)	7.5		1.0	
11	PRESSURIZER WATER LEVEL-HIGH (BARTON)	8.0		2.0	
12	LOSS OF FLOW	2.8		0.6	
13	STEAM GENERATOR WATER LEVEL - LOW-LOW ADVERSE (UNMODIFIED BARTON)	16.9		2.0	
14	STEAM GENERATOR WATER LEVEL - LOW-LOW EAM (UNMODIFIED BARTON)	13.0		2.0	
15	STEAM GENERATOR WATER LEVEL - LOW-LOW ADVERSE (MODIFIED BARTON)	12.9		2.0	
16	STEAM GENERATOR WATER LEVEL - LOW-LOW EAM (MODIFIED BARTON)	10.7		2.0	
17	UNDERVOLTAGE-RCP (12)	(16)		(16)	
18	UNDERFREQUENCY-RCP	3.33		0.0	
19	CONTAINMENT PRESSURE - EAM (FOXBORO)	4.4		1.5	
20	CONTAINMENT PRESSURE - HIGH (FOXBORO)	5.5		1.5	
21	CONTAINMENT PRESSURE - HIGH-HIGH (FOXBORO)	5.5		1.5	
22	CONTAINMENT PRESSURE - EAM (BARTON)	3.9		1.8	
23	CONTAINMENT PRESSURE - HIGH (BARTON)	4.9		1.8	
24	CONTAINMENT PRESSURE - HIGH-HIGH (BARTON)	4.9		1.8	
25	PRESSURIZER PRESSURE - LOW, S.I. (BARTON)	17.5		2.0	
26	STEAMLINE PRESSURE-LOW (FOXBORO)	13.9		1.8	
27	STEAM GENERATOR WATER LEVEL-HIGH-HIGH (BARTON) (SG-51)	12.2		2.0	
28	RWST LEVEL - LOW (BARTON)	(15)		(15)	
29	RWST LEVEL - HIGH (BARTON)	(15)		(15)	
30	NEGATIVE STEAMLINE PRESSURE RATE - HIGH	2.0		0.0	
31	VESSEL ΔT EQUIVALENT TO POWER	6.0		1.6	

NOTES:

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

(2) $S = SCA + SMTE + SD$

(3) $T_1 = RD + RCA + RMTE + RCSA$ OR $T_2 = TA - ((A + (S)^2)^{1/2} + EA)$

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

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

(5) TAVG - 100°F
P - 800 PSI
ϕ - 120% RTP
ΔT - 150% RTP
ΔI - ±60% ΔI

(6) TAVG - 100°F
P - 800 PSI
ϕ - 120% RTP
ΔT - 150% RTP

(7) [ ]a,c

(8) AS NOTED IN NOTE 1 OF TABLE 2.2-1 OF STS

(9) ALL VALUES IN PERCENT SPAN

(10) AS NOTED IN TABLE 3.3-4 IN STS

(11) AS NOTED IN NOTE 3 OF TABLE 2.2-1 OF STS

(12) VALUES REFLECT THE 93% GUARANTEED ACTUATION SETTING AS PER TVA-DE CALCULATION NO. RCP-UV-DEVICE 27.

(13) AS NOTED IN NOTE 5 OF TABLE 2.2-1 OF PLANT TECHNICAL SPECIFICATIONS

(14) NOT IN WESTINGHOUSE SCOPE - SEE TVA CALCULATION SQN-EEB-PS-T128-0001

STEM STS SETPOINT INPUTS
TS 1 AND 2

(9) (3)	(Z) (9) (4)	INSTRUMENT SPAN	STS TRIP SETPOINT	STS ALLOWABLE VALUE	MAXIMUM VALUE (7)	
2.0	4.56	120% RTP	109% RTP	111.4% RTP		1
2.0	4.56	120% RTP	25% RTP	27.4% RTP		2
1.1	0.50	120% RTP	5.0% RTP	6.3% RTP		3
1.1	0.50	120% RTP	5.0% RTP	6.3% RTP		4
(14)	(14)	(14)	25% RTP	(14)		5
(14)	(14)	(14)	1.0E+05 CPS	(14)		6
1.9	2.93	(5)	(8)	(8)+1.9% ΔT SPAN		7
1.7	2.39	(6)	(11)	(11)+1.7% ΔT SPAN		8
0.7	2.06	800 PSI	1970 PSIG	1964.8 PSIG		9
0.7	4.81	800 PSI	2385 PSIG	2390.2 PSIG		10
0.7	2.14	100% SPAN	92% SPAN	92.7% SPAN		11
0.5	2.14	110% DESIGN FLOW	90% FLOW	89.4% FLOW		12
0.7	15.44	100% SPAN	16.9% NARROW RANGE SPAN	16.3% NARROW RANGE SPAN		13
0.7	11.54	100% SPAN	13.0% NARROW RANGE SPAN	12.4% NARROW RANGE SPAN		14
0.7	11.44	100% SPAN	12.9% NARROW RANGE SPAN	12.3% NARROW RANGE SPAN		15
0.7	9.24	100% SPAN	10.7% NARROW RANGE SPAN	10.1% NARROW RANGE SPAN		16
(16)	(16)	1800 VAC	5022 VAC	(16)		17
2.3	0.0	6 Hz	56.0 Hz	55.9 Hz		18
0.6	2.94	16 PSI	0.5 PSIG	0.6 PSIG		19
0.7	3.44	16 PSI	1.54 PSIG	1.6 PSIG		20
0.7	3.44	16 PSI	2.81 PSIG	2.9 PSIG		21
0.7	1.03	18 PSI	0.5 PSIG	0.6 PSIG		22
[illegible]	2.14	18 PSI	1.54 PSIG	1.7 PSIG		23
0.7	2.14	18 PSI	2.81 PSIG	2.9 PSIG		24
0.7	14.26	800 PSI	1870 PSIG	1864.8 PSIG		25
0.7	11.27	1200 PSI	600 PSIG	592.2 PSIG		26
0.7	11.03	100% SPAN	81.0% SPAN	81.7% SPAN		27
(15)	(15)	100% SPAN	27.4% SPAN	(15)		28
(15)	(15)	100% SPAN	27.4% SPAN	(15)		29
0.7	0.25	1200 PSI	100 PSIG	107.8 PSIG		30
1.7	2.39	150% RTP	(13)	(13)+1.7% ΔT SPAN		31

5) NOT IN WESTINGHOUSE SCOPE - SEE TVA CALCULATION SQN-EEB-MS-TI28-0015
6) NOT IN WESTINGHOUSE SCOPE - SEE TVA CALCULATION RCP-UV-DEVICE 27-SYSTEM 202

REV. 5
FOR INTERNAL PLANT USE ONLY

APPENDIX A

SAMPLE SEQUOYAH

SETPOINT TECHNICAL SPECIFICATIONS

SAFETY LIMITS AND LIMITING SAFETY SYSTEM SETTINGS

2.2 LIMITING SAFETY SYSTEM SETTINGS

REACTOR TRIP SYSTEM INSTRUMENTATION SETPOINTS

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

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

ACTION:

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

b. With the Reactor Trip System Instrumentation or Interlock Setpoint less conservative than the value shown in the Allowable Values column of Table 2.2-1, 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 from 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 from Column S (Sensor Drift) of Table 2.2-1 for the affected channel, and

TA = The value from 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 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	≤ 111.4% of RTP
	Low Setpoint	8.3	4.56	0	≤ 25% of RTP	≤ 27.4% of RTP
3.	Power Range, Neutron Flux, High Positive Rate	1.6	0.50	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	0.50	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	NWS	NWS	NWS	≤ 25% of RTP	≤ NWS
6.	Source Range, Neutron Flux	NWS	NWS	NWS	≤ 10^5 cps	≤ NWS
7.	Overtemperature ΔT	5.7	2.93	1.6 + 0.6**	See note 1	See note 2
8.	Overpower ΔT	4.8	2.39	1.6	See note 3	See note 4
9.	Pressurizer Pressure - Low	15.6	2.06	2.0	≥ 1970 psig	≥ 1964.8 psig
10.	Pressurizer Pressure - High	7.5	4.81	1.0	≤ 2385 psig	≤ 2390.2 psig
11.	Pressurizer Water Level-High	8.0	2.14	2.0	≤ 92% of instrument span	≤ 92.7% of instrument span

** 1.6% ΔT span for ΔT, 0.6% ΔT span for Pressurizer Pressure
NA - Information not applicable
NWS - Value not within Westinghouse scope - see TVA calculations

TABLE 2.2-1 (continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

	Functional Unit	Total Allowance (TA)	Z	Sensor Drift (S)	Trip Setpoint	Allowable Value
12.	Loss of Flow	2.8	2.14	0.6	≥ 90% of loop design flow*	≥ 89.4% of loop design flow*
13.	Steam Generator Water Level - Low-Low					
	a. Vessel ΔT Equivalent to Power ≤ 50% RTP	6.0	2.39	1.6	Vessel ΔT variable input ≤ 50% RTP	Vessel ΔT variable input ≤ trip setpoint + 2.5% RTP
	Coincident with Steam Generator Water Level-Low-Low (Adverse)	16.9	15.44	2.0	≥ 16.9% of Narrow Range Instrument span	≥ 16.3% of Narrow Range Instrument span
	and Containment Pressure-EAM	4.4	2.94	1.5	≤ 0.5 psig	≤ 0.6 psig
	or					
	Steam Generator Water Level-Low-Low (EAM)	13.0	11.54	2.0	≥ 13.0% of Narrow Range Instrument span	≥ 12.4% of Narrow Range Instrument span
	With a time delay (T_s) if one Steam Generator is affected				≤ T_s (Note 5)	≤ (1.01) T_s (Note 5)
	or					
	A Time Delay (T_m) if two or more Steam Generators are affected				≤ T_m (Note 5)	≤ (1.01) T_m (Note 5)

*Loop design flow = 91,400 GPM

TABLE 2.2-1 (continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

Functional Unit	Total Allowance (TA)	Z	Sensor Drift (S)	Trip Setpoint	Allowable Value
b. Vessel ΔT Equivalent to Power >50% RTP					
Coincident with					
Steam Generator Water Level-Low-Low (Adverse)	16.9	15.44	2.0	≥16.9% of Narrow Range Instrument span	≥16.3% of Narrow Range Instrument span
and					
Containment Pressure-EAM	4.4	2.94	1.5	≤0.5 psig	≤0.6 psig
or					
Steam Generator Water Level-Low-Low (EAM)	13.0	11.54	2.0	≥ 13.0% of Narrow Range Instrument span	≥ 12.4% of Narrow Range Instrument span
14. Undervoltage - Reactor Coolant Pump	NWS	NWS	NWS	≥ 5022 volts	≥ NWS volts
15. Underfrequency - Reactor Coolant Pumps	3.33	0.0	0.0	≥ 56 Hz	≥ 55.9 Hz
16. Safety Injection Input from ESF	NA	NA	NA	NA	NA

NWS – Value not within Westinghouse scope – see TVA calculations.

TABLE 2.2-1 (continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

	Functional Unit	Total Allowance (TA)	Z	Sensor Drift (S)	Trip Setpoint	Allowable Value
17.	Reactor Trip System Interlocks					
	a. Intermediate Range Neutron Flux, P-6	NWS	NWS	NWS	≥ 1×10^{-10} amps	≥ NWS amps
	b. Low Power Reactor Trips Block, P-7					
	1) P-10 Input	NA	NA	NA	Nominal 10 percent of Rated Thermal Power	≤ 12.4 percent of Rated Thermal Power
	2) P-13 Input	NA	NA	NA	Nominal 10 percent Turbine Impulse Pressure Equivalent	≤ 12.4 percent Turbine Impulse Pressure Equivalent
	c. Power Range Neutron Flux, P-8	NA	NA	NA	≤ 35 percent of Rated Thermal Power	≤ 37.4 percent of Rated Thermal Power
	d. Power Range Neutron Flux, P-10	NA	NA	NA	Nominal 10 percent of Rated Thermal Power	≥ 7.6 percent of Rated Thermal Power
	e. Turbine Impulse Chamber Pressure, P-13	NA	NA	NA	Nominal 10 percent Turbine Impulse Pressure Equivalent	≤ 12.4 percent Turbine Impulse Pressure Equivalent
	f. Reactor Trip, P-4	NA	NA	NA	NA	NA
	g. Power Range Neutron Flux, P-9	NA	NA	NA	≥ 50% RTP	≥ 52.4% RTP

NWS - Value not within Westinghouse scope - see TVA calculations

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS NOTATION

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

Where:

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

τ_4, τ_5 = Time constants utilized in the lead – lag controller for ΔT, $\tau_4 = 12$ secs, $\tau_5 = 3$ secs.

ΔT_O = Indicated ΔT at RATED THERMAL POWER

K_1 = 1.15

K_2 = 0.011

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

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS NOTATION

NOTE 1: (continued)

τ_1, τ_2	=	Time constants utilized in the lead-lag controller for T_{avg}, τ_1 = 33 secs., τ_2 = 4 secs.
T	=	Average temperature °F
T'	=	≤ 578.2°F (Nominal T_{avg} at RATED THERMAL POWER)
K_3	=	0.00055
P	=	Pressurizer pressure, psig
P'	=	2235 psig (Nominal RCS operating pressure)
S	=	Laplace transform operator

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

(i) for qt - qb between -29 percent and + 5 percent $f_1(\Delta I)$ = 0 (where qt and qb are percent RATED THERMAL POWER in the top and bottom halves of the core respectively, and qt + qb is total THERMAL POWER in percent of RATED THERMAL POWER).

(ii) for each percent that the magnitude of (qt - qb) exceeds -29 percent, the ΔT trip setpoint shall be automatically reduced by 1.50 percent of its value at RATED THERMAL POWER.

(iii) for each percent that the magnitude of (qt - qb) exceeds + 5 percent, the ΔT trip setpoint shall be automatically reduced by 0.86 percent of its value at RATED THERMAL POWER.

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS NOTATION

NOTE 2: The channel's maximum trip setpoint shall not exceed its computed trip point by more than 1.9 percent ΔT span.

NOTE 3: Overpower $\Delta T \left(\frac{1 + \tau_4 S}{1 + \tau_5 S}\right) \leq \Delta T_0 \{K_4 - K_5 \left(\frac{\tau_3 S}{1 + \tau_3 S}\right) T - K_6 [T - T''] - f_2(\Delta I)\}$

Where:

$\frac{1 + \tau_4 S}{1 + \tau_5 S}$ = as defined in Note 1

τ_4, τ_5 = as defined in Note 1

ΔT_0 = as defined in Note 1

K_4 = 1.087

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

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

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

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS NOTATION

NOTE 3: (continued)

K_6 = 0.0011/°F for T > T" and K_6 = 0 for T ≤ T"

T = as defined in Note 1

T" = Indicated T_{avg} at RATED THERMAL POWER (calibration temperature for ΔT instrumentation, ≤ 578.2°F)

S = as defined in Note 1

$f_2(\Delta I)$ = 0 for all ΔI

NOTE 4: The channel's maximum trip setpoint shall not exceed its computed trip point by more than 1.7 percent ΔT span.

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

$T_S = \{A1(P)^3 + A2(P)^2 - A3(P) + A4\}\ \{0.99\}$

$T_M = \{B1(P)^3 + B2(P)^2 - B3(P) + B4\}\ \{0.99\}$

Where:

P = Vessel ΔT Equivalent to Power (% RTP), P ≤ 50% RTP.

T_S = Time delay for Steam Generator Water Level-Low-Low Reactor Trip, one Steam Generator affected.

T_M = Time delay for Steam Generator Water Level-Low-Low Reactor Trip, two or more Steam Generators affected.

A1	=	-0.00583	B1	=	-0.00532
A2	=	+0.735	B2	=	+0.678
A3	=	+33.560	B3	=	+31.340
A4	=	+649.5	B4	=	+589.5

2.2 LIMITING SAFETY SYSTEM SETTINGS

BASES

2.2.1 REACTOR TRIP SYSTEM INSTRUMENTATION SETPOINTS

The Reactor Trip Setpoint Limits specified in Table 2.2-1 are the nominal values at which the Reactor Trips are set for each functional unit. The Trip Setpoints have been selected to ensure that the reactor core and reactor coolant system are prevented from exceeding their safety limits during normal operation and design basis anticipated operational occurrences and to assist the Engineered Safety Features Actuation System in mitigating the consequences of accidents. The setpoint for a reactor trip system or interlock function is considered to be adjusted consistent with the nominal value when the "as measured" setpoint is within the band allowed for calibration accuracy.

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

analysis assumptions. Use of Equation 2.2-1 allows for a sensor drift factor, an increased rack drift factor, and provides a threshold value for reportability.

The methodology to derive the trip setpoints is based upon combining all of the uncertainties in the channels. Inherent to the determination of the trip setpoints are the magnitudes of these channel uncertainties. Sensors and other instrumentation utilized in these channels are expected to be capable of operating within the allowances of these uncertainty magnitudes. Rack drift in excess of the Allowable Value exhibits the behavior that the rack has not met its allowance. Being that there is a small statistical chance that this will happen, an infrequent excessive drift is expected. Rack or sensor drift, in excess of the allowance that is more than occasional, may be indicative of more serious problems and should warrant further investigation.

3/4.3.2 ENGINEERED SAFETY FEATURE ACTUATION SYSTEM INSTRUMENTATION

LIMITING CONDITION FOR OPERATION

3.3.2 The Engineered Safety Feature Actuation System (ESFAS) instrumentation channels and interlocks shown in Table 3.3-3 shall be OPERABLE with their Trip Setpoints set consistent with the values shown in the Trip Setpoint column of Table 3.3-4 and with RESPONSE TIMES as shown in Table 3.3-5.

APPLICABILITY: As shown in Table 3.3-3.

ACTION:

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

b. With an ESFAS Instrumentation or Interlock Trip Setpoint less conservative than the value shown in the Allowable Value column of Table 3.3-4, either:

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

   2. Declare the channel inoperable and apply the applicable ACTION statement requirements of Table 3.3.3 until the channel is restored to OPERABLE status with its Setpoint adjusted consistent with the Trip Setpoint value.

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

where:

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

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

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

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

TABLE 3.3-4

ENGINEERED SAFETY 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	5.5	3.44	1.5	≤ 1.54 psig	≤ 1.6 psig
D. Pressurizer Pressure - Low	17.5	14.26	2.0	≥ 1870 psig	≥ 1864.8 psig
E. Steamline Pressure - Low	13.9	11.27	1.8	≥ 600 psig (Note 1)	≥ 592.2 psig (Note 1)
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	5.5	3.44	1.5	≤ 2.81 psig	≤ 2.9 psig
3. CONTAINMENT ISOLATION					
A. Phase "A" Isolation					
1. Manual	NA	NA	NA	NA	NA
2. From Safety Injection Automatic Actuation Logic	NA	NA	NA	NA	NA
B. Phase "B" Isolation					
1. Manual	NA	NA	NA	NA	NA
2. Automatic Actuation	NA	NA	NA	NA	NA
3. Containment Pressure - High-High	5.5	3.44	1.5	≤ 2.81 psig	≤ 2.9 psig

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
C. Containment Ventilation Isolation					
1. Manual	NA	NA	NA	NA	NA
2. From Safety Injection Automatic Actuation Logic	NA	NA	NA	NA	NA
4. STEAM LINE ISOLATION					
A. Manual	NA	NA	NA	NA	NA
B. Automatic Actuation	NA	NA	NA	NA	NA
C. Containment Pressure - High-High	5.5	3.44	1.5	≤ 2.81 psig	≤ 2.9 psig
D. Steamline Pressure - Low	13.9	11.27	1.8	≥ 600 psig (Note 1)	≥ 592.2 psig (Note 1)
E. Negative Steamline Pressure Rate-High	2.0	0.25	0.0	≤ 100.0 psi (Note 2)	≤ 107.8 psi (Note 2)
5. TURBINE TRIP AND FEEDWATER ISOLATION					
A. Steam Generator Water Level - High-High	12.2	11.03	2.0	≤ 81.0% of narrow range instrument span	≤ 81.7% of narrow range instrument span
6. AUXILIARY FEEDWATER					
A. Steam Generator Water Level - Low-Low					
1. Vessel ΔT Equivalent to Power ≤ 50% RTP	6.0	2.39	1.6	Vessel ΔT variable input ≤ 50% RTP	Vessel ΔT variable input ≤ trip setpoint + 2.5% RTP

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
Coincident with					
Steam Generator Water Level-Low-Low (Adverse)	16.9	15.44	2.0	≥16.9% of Narrow Range Instrument span	≥16.3% of Narrow Range Instrument span
and					
Containment Pressure-EAM	4.4	2.9	1.5	≤0.5 psig	≤0.6 psig
or					
Steam Generator Water Level-Low-Low (EAM)	13.0	11.54	2.0	≥ 13.0% of Narrow Range Instrument span	≥ 12.4% of Narrow Range Instrument span
With a time delay (T_s) if one Steam Generator is affected				≤T_s (Note 5 Table 2.2-1)	≤(1.01) T_s (Note 5 Table 2.2-1)
or					
A Time Delay (T_m) if two or more Steam Generators are affected				≤T_m (Note 5 Table 2.2-1)	≤(1.01) T_m (Note 5 Table 2.2-1)
2. Vessel ΔT Equivalent to Power >50% RTP					
Coincident with					
Steam Generator Water Level-Low-Low (Adverse)	16.9	15.44	2.0	≥16.9% of Narrow Range Instrument span	≥16.3% of Narrow Range Instrument span
and					
Containment Pressure-EAM	4.4	2.9	1.5	≤0.5 psig	≤0.6 psig

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
or					
Steam Generator Water Level-Low-Low (EAM)	13.0	11.54	2.0	≥ 13.0% of Narrow Range Instrument span	≥ 12.4% of Narrow Range Instrument span
B. Safety Injection	See 1 above (all SI setpoints)				
C. Station Blackout					
D. Trips of Main Feedwater Pumps	NA	NA	NA	NA	NA
7. ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INTERLOCKS					
A. Pressurizer Pressure NOT - P-11	NA	NA	NA	Nominal 1970 psig	≤ 1975.2 psig
B. Pressurizer Pressure P-11	NA	NA	NA	Nominal 1970 psig	≥ 1964.8 psig
C. Reactor Trip, P-4	NA	NA	NA	NA	NA

Note 1: Time constants utilized in the lead-lag controller for Steam Pressure-Low are $\tau_1 \geq 50$ seconds and $\tau_2 \leq 5$ seconds.

Note 2: Time constant utilized in the rate-lag controller for Negative Steamline Pressure Rate-High is $\tau \geq 50$ seconds.

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. AUTOMATIC SWITCHOVER TO CONTAINMENT SUMP					
A. RWST Level - Low	NWS	NWS	NWS	130" from tank base	NWS
COINCIDENT WITH Containent Sump Level - High	NWS	NWS	NWS	30" above elev. 680'	NWS
AND Safety Injection				(See 1 above for all Safety Injection Setpoints/ Allowable Value)	

NWS - Value not within Westinghouse scope - see TVA calculation

3/4.3 INSTRUMENTATION

BASES

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

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

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

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

To accommodate the instrument drift assumed to occur between operational tests and the accuracy to which setpoints can be measured and calibrated, Allowable Values for the setpoints have been specified in Table 3.3-4. Operation with setpoints less conservative than the Trip Setpoint but within the Allowable Value is acceptable since an allowance has been made in the safety analysis to accommodate this error. An optional provision has been included for determining

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

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.