WESTINGHOUSE CLASS 3

WCAP-12230
REVISION 2

WESTINGHOUSE SETPOINT METHODOLOGY FOR PROTECTION SYSTEMS

COMANCHE PEAK Unit 1

REVISION 1

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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 margin calculation demonstrating the technique and noting how each parameter value is derived. In all cases, margin exists between the summation and the total allowance.

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

2.0 COMBINATION OF ERROR COMPONENTS

2.1 METHODOLOGY

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

The methodology used is the "square root of the sum of the squares" which has been utilized in other Westinghouse reports. This technique, or others of a similar nature, have been used in WCAP-10395(1) and WCAP-8567(2). WCAP-8567 is approved by the NRC noting acceptability of statistical techniques for the application requested. Also, various ANSI, American Nuclear Society, and Instrument Society of America standards approve the use of probabilistic and statistical techniques in determining safety-related setpoints(3)(4). The methodology used in this report is essentially the same as that used for V. C. Summer in August, 1982; approved in NUREG-0717, Supplement No. 4(5).

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

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

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

(4) ISA Standard S67.04, 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.

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

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

where:

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

As can be seen in the equation, 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 is assumed that the accuracy effect on a channel due to cable degradation in an accident environment is less than 0.1 % of span. Less than this magnitude of uncertainty is considered negligible and is not factored into the calculations. An error due to this cause, found in excess of 0.1 % of span is arithmetically summed as an environmental (EA) error.

The Westinghouse setpoint methodology results in a value with a 95 % 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 two σ values. Rack Drift and Sensor Drift are assumed, based on a survey of reported plant LERs, and with Process Measurement Accuracy, are considered conservative values.

2.2 SENSOR ALLOWANCES

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

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

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

extracting the sensor portion of Equation 2.1 results in;

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

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

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

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

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

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

2.3 RACK ALLOWANCES

Five parameters, as noted by Table 3-20, are considered to be rack allowances, RCA, RMTE, RCSA, RTE, and RD. Four of these parameters 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, 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 a level transmitter channel, using the same approach outlined in Equations 2.1 and 2.2 results in the following:

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

extracting the rack portion of Equation 2.1 results in;

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

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

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

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

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

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 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 has been informed by Comanche Peak that some of the equipment used for calibration and analog channel operational testing (ACOT) of the transmitters and racks does not meet SAMA standard PMC 20.1-1973(1) with regards to test equipment accuracy of 10 % or less of the calibration accuracy (referenced in 3.2.6.a and 3.2.7.a.

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

of this report). This requires the inclusion of the accuracy of this equipment in the basic equations 2.1 and 3.1. Based on information provided by the plant, these additional uncertainties are included in the calculations (as noted on the tables included in this report) with some impact on the final results. On Table 3-20, the values of SMTE and RMTE are identified explicitly.

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:

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

where:

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

all other parameters are as defined for Equation 2.1.

Using Equation 2.1, Equation 3.1 may be simplified to:

$$\text{Margin} = \text{TA} - \text{CSA} \qquad \text{(Eq. 3.2)}$$

Tables 3-1 through 3-19 provide individual channel breakdown and CSA calculations for all protection functions utilizing 7300 process rack equipment. Table 3-20 provides a summary of the previous 19 tables and includes Safety 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 % 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 Δp transmitters, an allowance for the effect of static pressure variations.

The tolerances are as follows:

a. Reference (calibration) accuracy - [ ]$^{+a,c}$ 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 % 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.

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

c. Temperature effect - [ ]$^{+a,c}$ based on a nominal temperature coefficient of [ ]$^{+a,c}$/100 °F and a maximum assumed change of 50 °F from a reference temperature of 70 °F.

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

e. Drift - change in input-output relationship over a period of time at reference conditions (e.g., constant temperature - [ ]$^{+a,c}$ 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). This includes all modules in a rack and is a total of [ ]$^{+a,c}$ 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 [ ]$^{+a,c}$.

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

b. Measurement and Test Equipment Accuracy

Is usually included as an integral part of (a), Reference (calibration) accuracy, when less than 10 % of the value of (a). For equipment (DVM, current source, voltage source, etc.) used to calibrate the racks 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 [$]^{+a,c}$, is used 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) - ± 1.0 % of span.

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

The tolerances assumed for Comanche Peak are as follows:

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

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

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 safety analyses.

12. Total Allowable Setpoint Deviation

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

3.3 METHODOLOGY CONCLUSION

The Westinghouse setpoint methodology results in a value with a 95 % 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 two σ 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 Measurement & Test Equipment Accuracy	
Comparator One input	
Rack Temperature Effects	
Rack Drift	

---

* In % span (120 % 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	
Measurement & Test Equipment Accuracy	
Comparator	
One input [ ]$^{+a,c}$	
Rack Temperature Effects	
Rack Drift	

---

* In % span (120 % Rated Thermal Power)

TABLE 3-2 (Continued)

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

Channel Statistical Allowance =

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

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 Measurement & Test Equipment Accuracy	
Comparator One input	
Rack Temperature Effects	
Rack Drift 5 % RTP	

---

* In % span (conservatively assumed to be 120 % 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 Measurement & Test Equipment Accuracy	
Comparator One input	
Rack Temperature Effects	
Rack Drift 3×10^4 cps	

---

* In % span (1×10^6 cps)

Channel Statistical Allowance =

[ ]$^{+a,c}$

TABLE 3-5

OVERTEMPERATURE N-16

Parameter	Allowance*
Process Measurement Accuracy	$[\quad]^{+a,c}$
^{16}N - ^{16}N - ^{16}N - Δq - Δq - $[\quad]^{+a,c}$	
Primary Element Accuracy	
Sensor Calibration	
^{16}N - RTD - Pressure - $[\quad]^{+a,c}$	
Measurement & Test Equipment Accuracy Pressure - $[\quad]^{+a,c}$	
Sensor Pressure Effects	
Sensor Temperature Effects	
^{16}N - Pressure - $[\quad]^{+a,c}$	
Sensor Drift	
^{16}N - RTD - Pressure - $[\quad]^{+a,c}$	
Environmental Allowance	
Rack Calibration	
^{16}N - T_c - T_c - Pressure - Δq - $[\quad]^{+a,c}$	

TABLE 3-5 (Continued)

Parameter	Allowance*
Measurement & Test Equipment Accuracy	[ ]$^{+a,c}$
^{16}N - [T_c - T_c - Pressure - Δq -]$^{+a,c}$	
Rack Accuracy	
^{16}N	
Total	
^{16}N - [T_c - Pressure - Δq -]$^{+a,c}$	
Rack Comparator Setting Accuracy Two inputs	
Rack Temperature Effects	
[ ]$^{+a,c}$	
Rack Drift	
^{16}N Setpoint reference signal	

---

* In % span (pressure - 800 psi, T_c - 120 °F, ^{16}N - 150 % RTP, Δq - ± 60 % Δq)

** See Table 3-21 for gain and conversion calculations

Channel Statistical Allowance =

[ ]$^{+a,c}$

TABLE 3-6

OVERPOWER N-16

<u>Parameter</u> <u>Allowance</u>* [ ]$^{+a,c}$

Process Measurement Accuracy

^{16}N - [
^{16}N -
^{16}N -]$^{+a,c}$

Primary Element Accuracy

Sensor Calibration

^{16}N - [
RTD -]$^{+a,c}$

Sensor Pressure Effects

Sensor Temperature Effects

^{16}N - [ ]$^{+a,c}$

Sensor Drift

^{16}N - [
RTD -]$^{+a,c}$

Environmental Allowance
RTD - [ ]$^{+a,c}$

Rack Calibration

^{16}N - [
T_c -
Setpoint -]$^{+a,c}$

Measurement & Test Equipment Accuracy

^{16}N - [
T_c -]$^{+a,c}$

Rack Accuracy

^{16}N

TABLE 3-6 Continued

Total

^{16}N

T_C

Setpoint

Rack Comparator Setting Accuracy

Two inputs

Rack Temperature Effects

[ ]+a,c

Rack Drift

^{16}N

Setpoint

[ ]+a,c

---

* In % span (T_C - 120 °F, ^{16}N = 150 % RTP)

** See Table 3-22 for gain and conversion calculation

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 Measurement & Test Equipment Accuracy	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift Low High [ ]$^{+a,c}$	
Environmental Allowance	
Rack Calibration Rack Accuracy Measurement & Test Equipment Accuracy	
Comparator One input	
Rack Temperature Effects	
Rack Drift	

---

* In % span (800 psi)

Channel Statistical Allowance =

[ ]$^{+a,c}$

TABLE 3-8

PRESSURIZER WATER LEVEL - HIGH

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

---

* In % span (100 % span)

Channel Statistical Allowance =

$$\left[\qquad\qquad\right]^{+a,c}$$

TABLE 3-9

LOSS OF FLOW

<u>Parameter</u> <u>Allowance</u>*

Process Measurement Accuracy
[ ]$^{+a,c}$ [ ]$^{+a,c}$

Primary Element Accuracy
[ ]$^{+a,c}$

Sensor Calibration
[ ]$^{+a,c}$

Sensor Pressure Effects
[ ]$^{+a,c}$

Sensor Temperature Effects
[ ]$^{+a,c}$

Sensor Drift
[ ]$^{+a,c}$

Environmental Allowance

Rack Calibration
Rack Accuracy [ ]$^{+a,c}$
Measurement & Test Equipment Accuracy [ ]$^{+a,c}$

Comparator
One input [ ]$^{+a,c}$

Rack Temperature Effects
[ ]$^{+a,c}$

Rack Drift
1.0 % ΔP span

---

* In % flow span (120 % Thermal Design Flow) % ΔP span converted to flow span via Equation 3-24.8, with F_{max} = 120 % and F_N = 100 %

Channel Statistical Allowance =

[ ]$^{+a,c}$

TABLE 3-10

STEAM GENERATOR WATER LEVEL - LOW-LOW (D4)

Parameter	Allowance*
Process Measurement Accuracy	[ ]$^{+a,c}$
Density variations with load **	
Primary Element Accuracy	
Sensor Calibration Accuracy	
Measurement & Test Equipment Accuracy	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance (For Feedbreak)	
Transmitter	
Reference leg heatup	
Cable IR	
Bias	
[ ]$^{+a,c}$	
Rack Calibration	
Rack Accuracy	
Measurement & Test Equipment Accuracy	
Rack Comparator Setting Accuracy	
One input	
Rack Temperature Effects	
Rack Drift	

---

* In % span (100 % span)
** See Table 3-23.

TABLE 3-10 (Continued)

STEAM GENERATOR WATER LEVEL - LOW-LOW (D4)

Channel Statistical Allowance =

Loss of Normal Feedwater

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

Feedbreak

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

TABLE 3-11

UNDERVOLTAGE

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	
Measurement & Test Equipment Accuracy	
Comparator	
Rack Temperature Effects	
Rack Drift	

---

* In % span (1800 VAC)

Channel Statistical Allowance =

$^{+a,c}$

TABLE 3-13

CONTAINMENT PRESSURE - HIGH 1, HIGH 2, AND HIGH 3

Parameter	Allowance*
	+a,c
Process Measurement Accuracy	
Primary Element Accuracy	
Sensor Calibration Measurement & Test Equipment Accuracy	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance	
Rack Calibration Rack Accuracy Measurement & Test Equipment Accuracy	
Comparator One input	
Rack Temperature Effects	
Rack Drift (0.65 psig)	

---

* In % span (65 psig)

Channel Statistical Allowance =

+a,c

TABLE 3-12

UNDERFREQUENCY

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

---

* In % span (4.5 Hz)

Channel Statistical Allowance =

+a,c

TABLE 3-14

PRESSURIZER PRESSURE - LOW, SAFETY INJECTION

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

---

* In % span (800 psi)

Channel Statistical Allowance =

+a,c

TABLE 3-15

STEAMLINE PRESSURE - LOW

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

---

* In % span (1300 psig)

Channel Statistical Allowance =

+a,c

TABLE 3-16

NEGATIVE STEAMLINE PRESSURE RATE - HIGH

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

---

* In percent span (1300 psig)

Channel Statistical Allownace =

+a,c

TABLE 3-17

STEAM GENERATOR WATER LEVEL - HIGH-HIGH (D4)

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

---

* In % span (100 % span)

** See Table 3-23.

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-18

TAVG - LOW, LOW-LOW N-16

Parameter	Allowance*
Process Measurement Accuracy	$[\quad]^{+a,c}$
^{16}N - $[$	
^{16}N -	
^{16}N - $]^{+a,c}$	
Primary Element Accuracy	
Sensor Calibration	
^{16}N - $[$	
RTD - $]^{+a,c}$	
Sensor Pressure Effects	
Sensor Temperature Effects	
^{16}N - $[\quad]^{+a,c}$	
Sensor Drift	
^{16}N - $[$	
RTD - $]^{+a,c}$	
Environmental Allowance	
Rack Calibration	
^{16}N - $[$	
T_c -	
T_c - $]^{+a,c}$	
Measurement & Test Equipment Accuracy	
^{16}N - $[$	
T_c -	
T_c - $]^{+a,c}$	
Rack Accuracy	
^{16}N - $[\quad]^{+a,c}$	

TABLE 3-18 (Continued)

Total

^{16}N

T_c

Rack Comparator Setting Accuracy
One input

Rack Temperature Effects

[ ]$^{+a,c}$

Rack Drift

^{16}N

T_c

[ ]$^{+a,c}$

---

* In % span (T_c - 120 ^{o}F, ^{16}N - 150 % RTP, Tavg - 100 ^{o}F).

** See Table 25 for conversion calculations.

Channel Statistical Allowance =

[ ]$^{+a,c}$

TABLE 3-19

RWST LEVEL - LOW-LOW

Parameter	Allowance*
Process Measurement Accuracy	+a,c
Primary Element Accuracy	
Sensor Calibration	
Measurement & Test Equipment Accuracy	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift (9 month calibration interval)	
Environmental Allowance	
Rack Calibration	
Rack Accuracy	
Measurement & Test Equipment Accuracy	
Comparator	
One input	
Rack Temperature Effects	
Rack Drift	

---

* In % span (513.0 inches of water column)

Channel Statistical Allowance =

+a,c

TABLE
TU ELEC
COMANCHE PE

	PROTECTION CHANNEL				SENSOR				
			1	2	3	4	5	6	7
			PROCESS MEASUREMENT ACCURACY (1)	MARY ELEMENT ACCURACY (1)	CALIBRATION ACCURACY (1)	MEASUREMENT & TEST EQUIP ACCURACY (1)	PRESSURE EFFECTS (1)	TEMPERATURE EFFECTS (1)	DRIFT (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 N-16 -	N-16 CHANNEL							
8		T_c CHANNEL							
9									
10		PRESSURIZER PRESSURE CHANNEL							
11		F(DELTA-q) CHANNEL							
12	OVERPOWER N-16 -	N-16 CHANNEL							
13		SETPOINT							
14		T_c CHANNEL							
15	PRESSURIZER PRESSURE - LOW, REACTOR TRIP								
16	PRESSURIZER PRESSURE - HIGH								
17	PRESSURIZER WATER LEVEL - HIGH								
18	LOSS OF FLOW								
19	STEAM GENERATOR WATER LEVEL - LOW-LOW								
20	UNDERVOLTAGE - RCP								
21	UNDERFREQUENCY - RCP								
22	CONTAINMENT PRESSURE - HIGH 1								
23	PRESSURIZER PRESSURE - LOW, SI								
24	STEAMLINE PRESSURE - LOW								
25	STEAMLINE PRESSURE NEGATIVE RATE - HIGH								
26	CONTAINMENT PRESSURE - HIGH-2								
27	CONTAINMENT PRESSURE - HIGH-3								
28	STEAM GENERATOR WATER LEVEL - HIGH-HIGH								
29	RWST LEVEL - LOW-LOW								
30	Tavg - LOW-LOW	T_c CHANNEL							
31									
32		N-16 CHANNEL							

-20
RIC
K UNIT 1

--------------->|<----------------------INSTRUMENT RACK---------------------->|

8 NVIRONMENTAL ALLOWANCE (1)	9 CALIBRATION ACCURACY (1)	10 MEASUREMENT & TEST EQUIP ACCURACY (1)	11 COMPARATOR SETTING ACCURACY (1)	12 TEMPERATURE EFFECTS (1) +a,c	13 DRIFT (1)	14 SAFETY ANALYSIS LIMIT (2)	15 STS ALLOWABLE VALUE (3)	16 STS TRIP SETPOINT (3)	17 TOTAL ALLOWANCE (1)	18 CHANNEL STATISTICAL ALLOWANCE (1)	19 MARGIN (1) +a,c	
					1.0	118 % RTP	111.7 % RTP	109 % RTP				1
					1.0	35 % RTP	27.7 % RTP	25 % RTP				2
					0.5	(5)	6.3 % RTP	5.0 % RTP				3
					0.5	6.9 % RTP	6.3 % RTP	5.0 % RTF				4
					4.2	(5)	31.5 % RTP	25 % RTP				5
					3.0	(5)	1.4E+5 CPS	1.0E+5 CPS				6
					1.0							7
					1.0							8
						FUNCTION (6)	FUNCTION (7)	FUNCTION (7)				9
					---		+1.8 % SPAN					10
					---							11
					1.0							12
					0.5	118 % RTP	115.1 % RIP	112 % RIP				13
					---							14
					1.0	1845 PSIG	1863.6 PSIG	1880 PSIG				15
					1.0	2445 PSIG	2400.8 PSIG	2385 PSIG				16
					1.0	(5)	93.9 % SPAN	92 % SPAN				17
					0.6	87 % FLOW	88.6 % FLOW	90 % FLOW				18
					1.0	0 % SPAN	26.4 % SPAN	28.0 % SPAN				19
					1.4	4692 VAC (10)	4752.6 VAC	4830 VAC				20
					0.7	57.0 Hz (10)	57.1 Hz	57.2 Hz				21
					1.0	5.0 PSIG (10)	3.8 PSIG	3.2 PSIG				22
					1.0	1700 PSIG (10)	1803.6 PSIG	1820 PSIG				23
					1.0	580 PSIG (10)	593.5 PSIG	605 PSIG				24
					5.0	(5)	178.7 PSIG	100 PSIG				25
					1.0	8.0 PSIG (10)	6.8 PSIG	6.2 PSIG				26
					1.0	20.0 PSIG (10)	18.8 PSIG	18.2 PSIG				27
					1.0	90 % SPAN	84.3 % SPAN	82.4 % SPAN				28
					1.0	(5)	38.9 % SPAN	40.0 % SPAN				29
					1.0							30
						(5)	546.6 °F	550.0 °F				31
					1.0							32

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NOTES FOR TABLE 3-20

1. All values in % span.
2. As noted in Table 15.0-4 of FSAR.
3. As noted in Tables 2.2-1 and 3.3-4 of Plant Technical Specifications.
4. Included in [.]$^{+a,c}$
5. Not used in the Safety Analysis.
6. As noted in Figure 15.1-1 of FSAR.
7. As noted in Table 2.2-1 Note 1 of Plant Technical Specifications.
8. [ ]$^{+a,c}$
9. Included in [ ]$^{+a,c}$
10. Not noted in Table 15.0-4 of FSAR but used in Safety Analysis.

TABLE 3-21

OVERTEMPERATURE N-16 CALCULATIONS

The equation for Overtemperature N-16 is:

$OT^{16}N \leq K_1 - K_2[((1 + \tau_1 S)/(1 + \tau_2 S))T_c - T_c^{o}] + K_3(P - P') - f_1(\Delta q)$

where:

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

$q_1 = K_8(^{16}N)(1-$

$K_7[1/(1 + \tau_3 S)][1/(1 + \tau_4 S)][1/(1 + \tau_5 S)])([1 + K_5(T_c - T_c^{o})]/[1 + K_6(1 - q_1)])$

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

N_1, N_2 = outputs of the top two sections of the excore detectors.

K_1 (nominal) = 1.078 Technical Specification value
K_1 (max) = [ ]$^{+a,c}$
K_2 = 0.00948
K_3 = 0.000494
vessel ΔT = 618.8 - 559.6 = 59.2°F
Δq gain = 1.40 % RTP/% Δq

Calculations converted to ^{16}N span (150 % RTP)

PMA$_1$ =
PMA$_2$ =
PMS$_3$ =
=
PMA$_4$ =
=
PMA$_5$ =
=

[ ]$^{+a,c}$

TABLE 3-21 Continued

Gain calculations:

Temperature = (100 % RTP)(K_2) = 0.948 $1/^\circ F$

Pressure = (100 % RTP)(K_3) = 0.049 1/psi

Temperature calculations:

$^{+a,c}$

SCA_1 =
SD_1 =
RCA_1 =
RCA_2 =

$RMTE_1$ =
$RMTE_2$ =

Pressure calculations:

$^{+a,c}$

SCA_2 =
$SMTE_2$ =
STE_2 =
SD_2 =
RCA_4 =
$RMTE_4$ =

Other calculations:

$^{+a,c}$

RCA_3 =
=
$RMTE_3$ =
=
RCA_5 =
$RMTE_5$ =

$^{+a,c}$

TA =
=

$^{+a,c}$

TABLE 3-22

OVERPOWER N-16 CALCULATIONS

The equation for Overpower ΔT is:

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

where:

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

$q_1 = K_8(^{16}N)\{1 -$
$K_7[1/(1 + \tau_3 S)][1/(1 + \tau_4 S)][1/(1 + \tau_5 S)]\}\{[1 + K_5(T_c - T_c^o)]/[1 + K_6(1 - q_1)]\}$

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

N_1, N_2 = outputs of the top two sections of the excore detectors.

K_4 (nominal) = 1.03 Technical Specification value
K_4 (max) = [ ]$^{+a,c}$
K_5 = 0.0006
vessel ΔT = 618.8 - 559.6 = 59.2°F
$f_2(\Delta q)$ gain = 0.0

Calculations converted to ^{16}N span (150 % RTP)
1.0 % RTP = 0.6°F

PMA_1 = [
PMA_2 =
PMS_3 =
=]$^{+a,c}$

TABLE 3-22 Continued

Temperature calculations:

SCA =
SD =
RCA_1 =
=
RMTE_1 =
=
EA =
=
$^{+a,c}$

Other calculations:

RCA_2 =
=
RMTE_2 =
=
RCA_3 =
$^{+a,c}$

TA =
=
$^{+a,c}$

$^{+a,c}$

TABLE 3-23

STEAM GENERATOR LEVEL DENSITY VARIATIONS

Because of density variations with load, it is impossible without some form of compensation to have the same accuracy under all load conditions. The recommended calibration point is at 70 % power conditions. Approximate errors at 0 % and 100 % water level readings and also for nominal trip points of 26 % and 82 % level are listed below for a 70 % power condition calibration. This is a specific calculation for Comanche Peak Unit 1 only. 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.

INDICATED LEVEL (70 % Power Calibration)

	0 %	26 %	82 %	100 %
Actual Level 0 % Power				
Actual Level 100 % Power				

+a,c

TABLE 3-24

ΔP MEASUREMENTS EXPRESSED IN FLOW UNITS

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

$(F_N)^2 = \Delta P_N$ where N = nominal flow

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

thus $\partial F_N = (\partial \Delta P_N)/2F_N$ Eq. 3-24.1

Error at a point (not in %) is:

$\partial F_N/F_N = (\partial \Delta P_N)/2(F_N)^2 = (\partial \Delta P_N)/2(\Delta P_N)$ Eq. 3-24.2

and

$(\Delta P_N)/(\Delta P_{max}) = (F_N)^2/(F_{max})^2$ Eq. 3-24.3

where max = maximum flow

and the transmitter ΔP error is:

$(\partial \Delta P_N/\Delta P_{max})(100)$ = % error in Full Scale ΔP (% FS ΔP) Eq. 3-24.4

therefore:

$$\begin{aligned} &\partial F_N/F_N \\ &\quad = (\Delta P_{max})((\%\ FS\ \Delta P)/100)/2(\Delta P_{max})(F_N/F_{max})^2 \\ &\quad = \{(\%\ FS\ \Delta P)/(2)(100)\}\{F_{max}/F_N\}^2 \qquad \text{Eq. 3-24.5} \end{aligned}$$

Error in flow units is:

$$\partial F_N = F_N((\%\ FS\ \Delta P)/(2)(100))\{F_{max}/F_N\}^2 \qquad \text{Eq. 3-24.6}$$

Error in % nominal flow is:

$$(\partial F_N/F_N)(100) = \{(\%\ FS\ \Delta P)/2\}\{F_{max}/F_N\}^2 \qquad \text{Eq. 3-24.7}$$

Error in % full span is:

$$\begin{aligned} &(\partial F_N/F_{max})(100) \\ &\quad = \{(F_N)(\%\ FS\ \Delta P)/(F_{max})(2)(100)\}\{F_{max}/F_N\}^2 \\ &\quad = \{(\%\ FS\ \Delta P)/2\}\{F_{max}/F_N\} \qquad \text{Eq. 3-24.8} \end{aligned}$$

Equation 3-24.8 is used to express errors in % full span in this document.

TABLE 3-25

TAVG - LOW, LOW-LOW N-16 GAIN CALCULATIONS

The equation for Tavg is:

$$\mathrm{Tavg} = T_c + {}^{16}N_s$$

where:

$${}^{16}N_s = \{(1)/(1 + \tau_1 S)\}q_1$$

$$q_1 = K_8({}^{16}N)(1- K_7[1/(1 + \tau_3 S)][1/(1 + \tau_4 S)][1/(1 + \tau_5 S)]\}\{[1 + K_5(T_c - T_c^{0})]/[1 + K_6(1 - q_1)]\})$$

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

N_1, N_2 = outputs of the top two sections of the excore detectors.

Vessel ΔT = 618.8 - 559.2°F = 59.2°F
Tavg span = 100°F
1 % RTP = 0.6°F => 1.0°F = 1.7 % RTP

PMA$_1$ =
PMA$_2$ =
PMS$_3$ =
=
$^{+a,c}$

Temperature calculations:

SCA =
SD =
RCA$_1$ =
RCA$_2$ =
RMTE$_1$ =
RMTE$_2$ =
$^{+a,c}$

$^{+a,c}$

TABLE 3-25 Continued

^{16}N calculations:

RCA_3 =
=
$RMTE_3$ =
=
=
RTE =

$^{+a,c}$

TABLE 3-26

PRECISION RCS FLOW MEASUREMENT

Parameter	Allowance*
Pressurizer pressure uncertainty - Cold Leg Specific Volume [ ]$^{+a,c}$	[ ]$^{+a,c}$
Pressurizer pressure uncertainty - Hot Leg Specific Volume [ ]$^{+a,c}$	
T_C uncertainty - Cold Leg Specific Volume [ ]$^{+a,c}$	
T_C uncertainty - Hot Leg Specific Volume [ ]$^{+a,c}$	
Hot Leg Volumetric Flow uncertainty - random - systematic	
Hot Leg Volumetric Flow uncertainty - Hot Leg Specific Volume - random - systematic	
Precision Calorimetric Loop Power uncertainty - Hot Leg Specific Volume	
Procedure Convergence Error on Loop Power - Hot Leg Specific Volume [ ]$^{+a,c}$	

---

* In % Flow

Total Error =

[ ]$^{+a,c}$

4.0 TECHNICAL SPECIFICATION USAGE

4.1 CURRENT USE

The Standard 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 original intent was to reduce the number of reporting events in the area of instrumentation setpoint drift. It appears that this goal was achieved. However, it does not recognize how setpoint calibrations and verifications are performed in the plant. In fact, this two column approach forces the plant to take a double penalty in the area of calibration error. As noted in Figure 4-1, the plant must allow for calibration error below the STS Trip Setpoint, in addition to the allowance assumed in the various accident analyses, if full utilization of the rack drift is wanted. This is due, as noted in 2.2, to the fact that calibration error cannot be distinguished from rack drift after an initial calibration. Thus, the plant is left with two choices; 1) to assume a rack drift value less than that allowed for in the analyses (actual RD = assumed RD - RCA) or, 2) penalize the operation of the plant (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 determining reportability. 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 the plant experiences both rack and 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

Interactive effects will be covered first. When an instrument technician looks for rack drift, more than that is seen 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 the rack effects, RD, RM&TE, RCSA, and RCA; and the sensor effects, SD, SM&TE and SCA. 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,

$$T_1 = (RCA + RMTE + RCSA + RD) \qquad \text{(Eq. 4.1)}$$

The second extracts these values from the calculations and compares the remaining values against the total allowance:

$$T_2 = TA - \{(A) + (S)^2\}^{1/2} - EA \qquad \text{(Eq. 4.2)}$$

where:

T_2 = Rack trigger value

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

$S = (SCA + SMTE + SD)$

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

The smaller of the trigger values should be used for comparison with the "as measured" (RCA + RMTE + RCSA + RD) value. As long as the "as measured" value is smaller, the channel is within the accuracy allowance. If the "as measured" value exceeds the "trigger value", the actual number 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 bistable trip setpoint, verify that it is less than the STS Allowable Value, and does not have to account for any additional effects. The same approach is used for the sensor, i.e., the "as measured" value is used when required. Tables 4-1 and 4-2 show the current STS setpoint philosophy (NUREG-0452, Revision 4) and the Westinghouse rack allowance for Virgil C. Summer (31 day surveillance only), values larger than those noted in Table 3-20 will be justified by Comanche Peak. A comparison of the differences between the Safety Analysis Limits and Allowable Values will show the relative gain of the Westinghouse version.

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. The methodology is based on the use of Equation 4.3, and demonstrated in Section 4.2.3, Implementation.

$$TA \geq (A)^{1/2} + R + S + EA \qquad \text{(Eq. 4.3)}$$

where:

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

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

all other parameters are as defined in Equation 4.2.

Equation 4.3 can be reduced further, for use in the STS to:

$$TA \geq Z + R + S \qquad \text{(Eq. 4.4)}$$

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 Virgil C. Summer. An example of how the specification would be used for the Pressurizer Pressure - Low 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 4.2 as follows:

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

where:

TA = 4.5 % (an assumed value for this example)

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

A =
S =
EA =
T_2 =
=
=
=

However, since only T_1 = $[\quad]^{+a,c}$ is assumed for T in the various analyses, that value will be used as the "trigger value". The lowest of two values is used for the "trigger value"; either the value for T assumed in the analyses or the value calculated by Equation 4.2.

Now assume that one bistable 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 = 0.71 and the assumed Total Allowance is (TA) = 4.5. Assume that the "as measured" rack setpoint value is 2.75 % low and the "as measured" sensor value is 1.5 %. Equation 2.2-1 looks like:

$$TA \geq Z + R + S$$

$$0.71 + 2.75 + 1.5 \leq 4.5$$

$$5.0 > 4.5$$

As can be seen, 5.0 % is not less than 4.5 % 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 4.5 %. In fact, anytime the "as measured" value for rack drift is greater than T (the "trigger value") and there is less than 1.0 % margin, use of S in Table 2.2-1 will result in the sum of Z + R + S being greater than TA and require the reporting of the case to the NRC.

If the sum of R + S was about 0.5 % less, e.g., R = 2.25 %, S = 1.5 % thus, R + S = 3.75 %, then the sum of Z + R + S would be less than 4.5 %. Under this condition, the plant staff would recalibrate the instrumentation, as good engineering practice suggests, but the incident is not reportable, even though the "trigger value" is exceeded, because Equation 2.2-1 was satisfied.

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

$$T_1 = (RCA_1 + RMTE_1 + RCSA_1 + RD_1) + (RCA_2 + RMTE_2 + RCSA_2 + RD_2) \qquad \text{(Eq. 4.5)}$$

or

$$T_2 = TA - \{A + (S_1)^2 + (S_2)^2\}^{1/2} - EA \qquad \text{(Eq. 4.6)}$$

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

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

$$T_3 = \{(RCA_1 + RMTE_1 + RCSA_1 + RD_1)^2 + (RCA_2 + RMTE_2 + RCSA_2 + RD_2)^2\}^{1/2} \qquad \text{(Eq. 4.7)}$$

or

Equation 4.6 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.

The complete set of calculations follows for Overpower ^{16}N to demonstrate this aspect (values noted are from Table 3-6).

$$\begin{array}{ll} TA & = \\ A & = \\ S_1 & = \\ S_2 & = \end{array} \left[\qquad\qquad\qquad\qquad \right]^{+a,c}$$

$$T_2 = TA - (A + (S_1)^2 + (S_2)^2)$$

$$T_2 = [\qquad\qquad\qquad\qquad]^{+a,c}$$

$$T_3 = ((RCA_{Tc} + RMTE_{Tc})^2 + (RCA_{STPT} + RCSA_{STPT} + RD_{STPT} + (RCA16_N + RMTE16_N + Accuracy + RCSA16_N + RD16_N)^2)^{1/2}$$

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

The value of T used is based on Equation 4.6 (T_2). In this document Equations 4.6 and 4.7, 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 reportable events while allowing plant operation in a safe manner.

TABLE 4-1

EXAMPLES OF CURRENT STS SETPOINT PHILOSOPHY

	Power Range Neutron Flux - High	Pressurizer Pressure - Low
Safety Analysis Limit	118 % RTP	1845 psig
STS Allowable Value	110 % RTP	1870 psig
STS Trip Setpoint	109 % RTP	1880 psig

TABLE 4-2

EXAMPLES OF WESTINGHOUSE STS RACK ALLOWANCE

	Power Range Neutron Flux - High	Pressurizer Pressure - Low
Safety Analysis Limit	118 % RTP	1845 psig
STS Allowable Value (Trigger Value)	111.7 % RTP	1864.8 psig
STS Trip Setpoint	109 % RTP	1880 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 E[illegible] 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

TABLE 4-3

WESTINGHOUSE PROTECTION SYSTEM

COMANCHE PEAK

PROTECTION CHANNEL	TOTAL ALLOWANCE (TA) (7)	(7) (A) (1)	(7) (S) (2)	(7) (T) (3)	(7) (Z) (4)
1 POWER RANGE, NEUTRON FLUX - HIGH SETPOINT	7.5	+B,C	0.0	2.3	4.56
2 POWER RANGE, NEUTRON FLUX - LOW SETPOINT	8.3		0.0	2.3	4.56
3 POWER RANGE, NEUTRON FLUX - HIGH POSITIVE RATE	1.6		0.0	1.1	0.5
4 POWER RANGE, NEUTRON FLUX - HIGH NEGATIVE RATE	1.6		0.0	1.1	0.5
5 INTERMEDIATE RANGE, NEUTRON FLUX	17.0		0.0	5.5	8.41
7 SOURCE RANGE, NEUTRON FLUX	17.0		0.0	4.3	10.01
8 OVERTEMPERATURE N-16	5.8		1.2 + 0.8	1.8	3.65
9 OVERPOWER N-16	4.0		0.0	2.1	1.93
10 PRESSURIZER PRESSURE - LOW, REACTOR TRIP	4.4		2.0	2.1	0.71
11 PRESSURIZER PRESSURE - HIGH	7.5		1.0	2.0	5.01
13 PRESSURIZER WATER LEVEL - HIGH	8.0		2.0	1.9	2.18
14 LOSS OF FLOW	2.5		0.6	1.1	1.18
15 STEAM GENERATOR WATER LEVEL - LOW-LOW	28.0		2.0	1.6	25.58
16 UNDERVOLTAGE - RCP	7.7		0.0	4.3	0.0
17 UNDERFREQUENCY - RCP	4.4		0.0	2.0	0.0
19 CONTAINMENT PRESSURE - HIGH-1	2.7		1.7	0.9	0.71
20 PRESSURIZER PRESSURE - LOW, S.I.	15.0		2.0	2.1	10.91
21 STEAMLINE PRESSURE - LOW	17.3		2.0	0.9	15.01
22 STEAMLINE PRESSURE NEGATIVE RATE - HIGH	8.0		0.0	6.1	0.50
23 CONTAINMENT PRESSURE - HIGH-2	2.7		1.7	0.9	0.71
25 CONTAINMENT PRESSURE - HIGH-3	2.7		1.7	0.9	0.71
26 STEAM GENERATOR WATER LEVEL - HIGH-HIGH	7.6		2.0	1.9	4.28
27 RWST LEVEL - LOW-LOW	2.5		1.3	1.1	0.71
28 Tavg-LOW-LOW	5.6		1.2	3.4	1.75

TS SETPOINT INPUTS

NIT 1

INSTRUMENT SPAN	[illegible] TRIP SETPOINT	STS ALLOWABLE VALUE	MAXIMUM VALUE (9)	
120 % RTP	109 % RTP	111.7 % RTP	112.5 % RTP	1
120 % RTP	25 % RTP	27.7 % RTP	29.5 % RTP	2
120 % RTP	5.0 % RTP	6.3 % RTP	6.3 % RTP	3
120 % RTP	5.0 % RTP	6.3 % RTP	6.3 % RTP	4
120 % RTP	25 % RTP	31.5 % RTP	35.3 % RTP	5
1E+06 CPS	1E+05 CPS	1.4E+05 CPS	1.7E+05 CPS	7
(5)	FUNCTION (8)	FUNCTION (8)+1.8 % SPAN	FUNCTION (8)+0.7 % SPAN	8
(6)	112 % RTP	115.1 % RTP	115.1 % RTP	9
800 PSI	1880 PSIG	1863.6 PSIG	1866.7 PSIG	10
800 PSI	2385 PSIG	2400.8 PSIG	2396.9 PSIG	11
100 % SPAN	92 % SPAN	93.9 % SPAN	95.8 % SPAN	13
20 % DESIGN FLOW	90 % FLOW	88.6 % FLOW	89.1 % FLOW	14
100 % SPAN	28 % SPAN	26.4 % SPAN	27.6 % SPAN	15
1800 VAC	4830 VAC	4752 VAC	4692 VAC	16
4.5 Hz	57.2 Hz	57.1 Hz	57.0 Hz	17
65 PSI	3.2 PSIG	3.8 PSIG	3.5 PSIG	19
800 PSI	1820 PSIG	1803.6 PSIG	1803.3 PSIG	20
1300 PSI	605 PSIG	593.5 PSIG	601.1 PSIG	21
1300 PSI	100 PSIG	178.7 PSIG	197.5 PSIG	22
65 PSI	6.2 PSIG	6.8 PSIG	6.5 PSIG	23
65 PSI	18.2 PSIG	18.8 PSIG	18.5 PSIG	25
100 % SPAN	82.4 % SPAN	84.3 % SPAN	83.7 % SPAN	26
513 IN H_2O	40.0 % SPAN	38.9 % SPAN	39.4 % SPAN	27
100 $^{\circ}$F	550 $^{\circ}$F	546.6 $^{\circ}$F	547.4 $^{\circ}$F	28

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NOTES FOR TABLE 4-3

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

(2) $S = SCA + SD$

(3) $T_1 = RCA + RMTE + RCSA + RD$

$T_2 = TA - \{A + (S_1)^2 + (S_2)^2\}^{1/2} - EA$

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

T = minimum of T_1, T_2 or T_3

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

(5)

Parameter	Span
^{16}N	150 % RTP
Pressure	800 PSIG
T_c	120°F
Δq	120 % Δq

(6)

Parameter	Span
^{16}N	150 % RTP
T_c	120°F

(7) All values in % Span

(8) As noted in Notes 1 and 2 of Table 2.2-1 of Technical Specifications

NOTES FOR TABLE 4-3 (Continued)

(9) This column provides the maximum value for a bistable assuming that the transmitter is not evaluated and the values for S, Z and TA from this table are used in the following equation: R = TA - Z - S. This implys that the transmitter is assumed to be at it's maximum allowed calibration and drift deviation in the non-conservative direction. With a bistable's Trip Setpoint found in excess of the value noted in this column, it is possible (but not known absolutely) that a channel would be considered inoperable. This must be tempered by the transmitter assumption noted above, i.e., the transmitter is assumed to be at it's worst acceptable condition.

APPENDIX A

SAMPLE COMANCHE PEAK UNIT 1

SETPOINT TECHNICAL SPECIFICATIONS

SAFETY LIMITS AND LIMITING SAFETY SYSTEM SETTINGS

2.2 LIMITING SAFETY SYSTEM SETTINGS

REACTOR TRIP SYSTEM INSTRUMENTATION SETPOINTS

2.2.1 The Reactor Trip System Instrumentation and Interlock Setpoints shall be 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.

$$TA \geq Z + R + S \qquad \text{(Equation 2.2-1)}$$

where:

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

R = The "as measured" value ("as found" - nominal in % span) of rack error for the affected channel,

S = Either the "as measured" value ("as found" - nominal in % 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.

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" ("as left") 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" ("as found") 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, $TA \geq Z + R + S$, the interactive effects of the errors in the rack and the sensor, and the "as measured" ("as found" - nominal) values of the errors are considered. Z, as specified in Table 2.2-1, in

% 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 % span, between the trip setpoint and the value used in the analysis for reactor trip. R or Rack Error is the "as measured" deviation ("as found" - nominal), in % span, for the affected channel from the specified trip setpoint. S or Sensor Drift is either the "as measured" deviation ("as found" - nominal) of the sensor from its calibration point or the value specified in Table 2.2-1, in % 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 determining 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 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 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.

$$TA \geq Z + R + S \qquad \text{(Equation 2.2-1)}$$

where:

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

R = The "as measured" value ("as found" - nominal in % span) of rack error for the affected channel,

S = Either the "as measured" value ("as found" - nominal in % 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.

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 ("as left") 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" ("as found") 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, $TA \geq Z + R + S$, 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 % 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 % span, between the trip setpoint and the value used in the analysis for the actuation. R or Rack Error is the "as measured" ("as found" - nominal) deviation, in % span, for the affected channel from the specified trip setpoint. S or Sensor Drift is either the "as measured" ("as found" - nominal) deviation of the sensor from its calibration point or the value specified in Table 3.3-4, in % 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 determining 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.

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	0.0	≤ 109 % RTP	≤ 111.7 % RTP
Low Setpoint	8.3	4.56	0.0	≤ 25 % RTP	≤ 27.7 % RTP
High Positive Rate	1.6	0.50	0.0	≤ 5 % RTP with a time constant ≥ 2 seconds	≤ 6.3 % RTP with a time constant ≥ 2 seconds
High Negative Rate	1.6	0.50	0.0	≤ 5 % RTP with a time constant ≥ 2 seconds	≤ 6.3 % RTP with a time constant ≥ 2 seconds
3. Intermediate Range, Neutron Flux	17.0	8.41	0.0	≤ 25 % RTP	≤ 31.5 % RTP
4. Source Range, Neutron Flux	17.0	10.01	0.0	≤ 10^5 CPS	≤ 1.4×10^5 CPS
5. Overtemperature N-16	5.8	3.65	1.2+0.8 (1)	See Note 1	See Note 2
6. Overpower N-16	4.0	1.93	0.0	≤ 112 % RTP	≤ 115.1 % RTP
7. Pressure Pressure					
Low Reactor Trip	4.4	0.71	2.0	≥ 1880 PSIG	≥ 1863.6 PSIG
High Reactor Trip	7.5	5.01	1.0	≤ 2385 PSIG	≤ 2400.8 PSIG
8. Pressurizer Water Level High	8.0	2.18	2.0	≤ 92 % Span	≤ 93.9 % Span
9. Loss Of Flow	2.5	1.18	0.6	≥ 90 % Loop Flow (2)	≥ 88.6 % Loop Flow (2)
10. Steam Generator Water Level Low-Low	28.0	25.58	2.0	≥ 28 % Span	≥ 26.4 % Span
11. Undervoltage RCP	7.7	0.0	0.0	4830 VAC	4753 VAC
12. Underfrequency RCP	4.4	0.0	0.0	57.2 Hz	57.1 Hz
13. Turbine Trip					
Low Trip System Pressure	NA	NA	NA	≥ 45 PSIG	≥ 43 PSIG
Turbine Stop Valve Closure	NA	NA	NA	≥ 1 % Open	≥ 1 % Open
14. Safety Injection Input from ESF	NA	NA	NA	NA	NA
15. Reactor Trip System Interlocks					
Intermediate Range Neutron Flux, P-6	NA	NA	NA	Nominal 1.0×10^{-10} amps	≥ 6.0×10^{-11} amps
Low Power Reactor Trips Block, P-7					
P-10 Input	NA	NA	NA	Nominal 10 % RTP	≤ 12.7 % RTP
P-13 Input	NA	NA	NA	Nominal 10 % Turbine 1st Stage Pressure equivalent	≤ 12.7 % Turbine 1st Stage Pressure equivalent
Power Range Neutron Flux,					
P-8	NA	NA	NA	Nominal 48 % RTP	≤ 50.7 % RTP
P-10	NA	NA	NA	Nominal 10 % RTP	≥ 7.3 % RTP
Turbine 1st Stage Pressure, P-13	NA	NA	NA	Nominal 10 % Turbine 1st Stage Pressure equivalent	≤ 12.7 % Turbine 1st Stage Pressure equivalent
16. Reactor Trip Breakers	NA	NA	NA	NA	NA
17. Automatic Actuation Logic	NA	NA	NA	NA	NA

(1) 1.2 % Span for Delta-T (RTDs) and 0.8 % for Pressurizer Pressure

(2) Loop Flow = 95,700 gpm

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

NOTATION

NOTE 1: OVERTEMPERATURE N-16

$N = K_1 - K_2[((1 + tau_1S)/(1 + tau_2S))T_c - T_c^o] + K_3(P - P') - f_1(DELTA\text{-}q)$

Where:

N = Measured N-16 Power by ion chambers

T_c = Cold Leg temperature, ^oF

T_c^o = 559.6 ^oF, Reference T_c at RATED THERMAL POWER

K_1 = 1.078

K_2 = 0.00948

$\frac{(1 + tau_1S)}{(1 + tau_2S)}$ = The function generated by the lead-lag controller for T_c dynamic compensation

tau_1 & tau_2 = Time constants utilized in the lead-lag controller for T_c, $tau_1 \geq 10$ secs., $tau_2 \leq 3$ secs.

K_3 = 0.000494

P = Pressurizer pressure (psig)

P' $\geq$ 2235 psig, Nominal RCS operating pressure

S = Laplace transform operator, sec^{-1}.

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

(i) for $q_t - q_b$ between -35 % and +10 %, f_1(Delta-q) = 0 where q_t and q_b are % RATED THERMAL POWER in the top and bottom halves of the core respectively, and $q_t + q_b$ is the total THERMAL POWER in % of RATED THERMAL POWER.

(ii) for each % that the magnitude of $q_t - q_b$ exceeds -35 %, the N-16 trip setpoint shall be automatically reduced by 1.22 % of its value at RATED THERMAL POWER.

(iii) for each % that the magnitude of $q_t - q_b$ exceeds +10 %, the N-16 trip setpoint shall be automatically reduced by 1.40 % 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 1.8 % span.

TABLE 3.3-4

ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

	Functional Unit	Total Allowance (TA)	(Z)	Sensor Drift (S)	Trip Setpoint	Allowable Value
1.	SAFETY INJECTION (ECCS, REACTOR TRIP, PHASE "A" ISOLATION, AUXILIARY FEEDWATER-MOTOR DRIVEN PUMP, TURBINE TRIP, CONTROL ROOM EMERGENCY RECIRCULATION, FEEDWATER ISOLATION, COMPONENT COOLING WATER, EMERGENCY DIESEL GENERATOR OPERATION, CONTAINMENT VENT ISOLATION, ESSENTIAL VENTILATION SYSTEMS, CONTAINMENT SPRAY PUMP, AND STATION SERVICE WATER.					
a.	Manual Initiation	NA	NA	NA	NA	NA
b.	Automatic Actuation Logic	NA	NA	NA	NA	NA
c.	Containment Pressure - High 1	2.7	0.71	1.7	≤ 3.2 PSIG	≤ 3.8 PSIG
d.	Pressurizer Pressure - Low	15.0	10.91	2.0	≥ 1820 PSIG	≥ 1803.6 PSIG
e.	Steam Line Pressure - Low	17.3	15.01	2.0	≥ 605 PSIG (1)	≥ 593.5 PSIG (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 3	2.7	0.71	1.7	≤ 18.2 PSIG	≤ 18.8 PSIG
3.	CONTAINMENT ISOLATION					
a.	Phase "A" Isolation					
[1]	Manual	NA	NA	NA	NA	NA
[2]	Automatic Actuation Logic	NA	NA	NA	NA	NA
[3]	Safety Injection	See 1. above for all Safety Injection Setpoints and Allowable Values				
b.	Phase "B" Isolation					
[1]	Manual	See Item 2.a above, Phase "B" Isolation manually initiated when Containment Spray is manually initiated.				
[2]	Automatic Actuation Logic	NA	NA	NA	NA	NA
[3]	Containment Pressure - High 3	2.7	0.71	1.7	≤ 18.2 PSIG	≤ 18.8 PSIG
c.	Containment Vent Isolation					
[1]	Manual	See Item 2.a and 3.a.1 above, Containment Vent Isolation is manually initiated when Phase "A" or Containment Spray are manually initiated.				
[2]	Automatic Actuation Logic	NA	NA	NA	NA	NA
[3]	Safety Injection	See 1. above for all Safety Injection Setpoints and Allowable Values				
4.	STEAM LINE ISOLATION					
a.	Manual	NA	NA	NA	NA	NA
b.	Automatic Actuation Logic	NA	NA	NA	NA	NA
c.	Containment Pressure - High 2	2.7	0.71	1.7	≤ 6.2 PSIG	≤ 6.8 PSIG
d.	Steam Line Pressure - Low	17.3	15.01	2.0	≥ 605 PSIG (1)	≥ 593.5 PSIG (1)
e.	Steam Line Pressure Negative Rate - High	8.0	0.50	0.0	≤ 100 PSIG	≤ 178.7 PSIG

(1) Time constants utilized in lead-lag controller are: $tau_1 \geq 50$ secs and $tau_2 \leq 5$ secs.

ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

Functional Unit	Total Allowance (TA)	(Z)	Sensor Drift (S)	Trip Setpoint	Allowable Value
5. TURBINE TRIP AND FEEDWATER ISOLATION					
a. Automatic Actuation Logic	NA	NA	NA	NA	NA
b. Steam Generator Water Level - High-High	7.6	4.28	2.0	≤ 82.4 % Span	≤ 84.3 % Span
c. Safety Injection	See 1. above for all Safety Injection Setpoints and Allowable Values				
6. AUXILIARY FEEDWATER					
a. Automatic Actuation Logic	NA	NA	NA	NA	NA
b. Steam Generator Water Level - Low-Low	28.0	25.58	2.0	≥ 28 % Span	≥ 26.4 % Span
c. Safety Injection - Start Motor-Driven Pumps	See 1. above for all Safety Injection Setpoints and Allowable Values				
d. Loss of Offsite Power	NA	NA	NA	NA	NA
7. AUTOMATIC INITIATION OF ECCS SWITCHOVER TO CONTAINMENT SUMP					
a. Automatic Actuation Logic	NA	NA	NA	NA	NA
b. RWST Level Low-Low	2.5	0.71	1.25	≥ 40.0 % Span	≥ 38.9 % Span
coincident with Safety Injection	See 1. above for all Safety Injection Setpoints and Allowable Values				
8. LOSS OF POWER (6.9 KV SAFEGUARDS SYSTEM UNDERVOLTAGE)					
a. Preferred Offsite Source Undervoltage	NA	NA	NA	≥ NWS* VAC	≥ NWS VAC
b. Alternate Offsite Source Undervoltage	NA	NA	NA	≥ NWS VAC	≥ NWS VAC
c. Bus Undervoltage	NA	NA	NA	≥ NWS VAC	≥ NWS VAC
d. Degraded Voltage	NA	NA	NA	≥ NWS VAC	≥ NWS VAC
9. CONTROL ROOM EMERGENCY RECIRCULATION					
a. Manual	NA	NA	NA	NA	NA
b. Automatic Actuation Logic	NA	NA	NA	NA	NA
c. Safety Injection	See 1. above for all Safety Injection Setpoints and Allowable Values				
10. ENGINEERED SAFETY FEATURE ACTUATION SYSTEM INTERLOCKS					
a. Pressurizer Pressure					
P-11 (Block)	NA	NA	NA	Nominal 1960 PSIG	≥ 1944.8 PSIG
Not P-11 (Enable)	NA	NA	NA	Nominal 1960 PSIG	≤ 1975.2 PSIG
b. Reactor Trip, P-4	NA	NA	NA	NA	NA
11. SOLID STATE SAFEGUARD SEQUENCER (SSSS)	NA	NA	NA	NA	NA

* NWS = Not Westinghouse Scope

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