(WESTINGHOUSE PROPRIETARY CLASS 3)

WCAP-10992

# WESTINGHOUSE SETPOINT METHODOLOGY FOR PROTECTION SYSTEMS MILLSTONE NUCLEAR POWER STATION UNIT 3

November, 1985

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5189Q:1D/091785

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# 1.0 INTRODUCTION

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

The basic underlying assumption used is that several of the error components and their parameter assumptions act independently, e.g., [ $]^{+a,c}$. This allows the use of a statistical summation of the various breakdown components instead of a strictly arithmetic summation. A direct benefit of the use of this technique is increased margin in the total allowance. For those parameter assumptions known to be interactive, the technique uses the normal, conservative approach, arithmetic summation, to form independent quantities, e.g., [ $]^{+a,c}$. An explanation of the overall approach is provided in Section 2.0.

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

Section 4.0 notes what the current (read NRC) Technical Specifications use for setpoints and an explanation of the impact of the statistical approach on them. Detailed examples of how to determine the Technical Specification setpoint values are also provided. An Appendix is provided noting a recommended set of Technical Specifications using the plant specific data in the statistical approach. For those protection functions using both Veritrak and Rosemount transmitters, only the most limiting case is provided.

# 2.0 COMBINATION OF ERROR COMPONENTS

## 2.1 METHODOLOGY

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

The methodology used for this combination is not new. Basically it is the [ ]+a,c,e which has been utilized in other Westinghouse reports. This technique, or other statistical approaches of a similar nature, have been used in WCAP-10395[1] and WCAP-8567[2]. It should be noted that WCAP-8567 has been approved by the NRC Staff thus noting the acceptability of statistical techniques for the application requested. It should also be recognized that ANSI, the American Nuclear Society, and the Instrument Society of America approve of the use of probabilistic techniques in determining safety-related setpoints[3][4]. Thus it can be seen that the use of statistical approaches in analysis techniques is becoming more and more widespread.

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

[ ]+a,c

(Eq.2.1)

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

where:

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

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

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

## 2.2 SENSOR ALLOWANCES

Four parameters are considered to be sensor allowances, SCA, SD, STE, and SPE (see Table 3-16). Of these four parameters, two are considered to be statistically independent, [ ]+a,c, and two are considered interactive [ ]+a,c. [ ]+a,c are considered to be independent due to the manner in which the instrumentation is checked, i.e., the instrumentation is [ ]+a,c. An example of

+a,c

[ ]

[ ]+a,c are considered to be interactive for the same reason that [ ]+a,c are considered independent, i.e., due to the manner in which the instrumentation is checked. [ ]+a,c. Based on this reasoning, [ ]+a,c have been added to form an independent group which is then factored into Equation 2.1. An example of the impact of this treatment is; for Pressurizer Water Level-High (Veritrak parameters only):

[ ]+a,b,c

using Equation 2.1 as written gives a total of;

[ ]+a,c = 1.66 percent

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

[ ]+a,c (Eq. 2.2) = 1.32 percent

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

## 2.3 RACK ALLOWANCES

Four parameters, as noted by Table 3-16, are considered to be rack allowances, RCA, RCSA, RTE, and RD. Three of these parameters are considered to be interactive (for much the same reason outlined for sensors in 2.2), [ ]+a,c. [ ]+a,c

[

]+a,c. Based on this logic, these three factors have been added to form an independent group. This group is then factored into Equation 2.1. The impact of this approach (formation of an independent group based on interactive components) is significant. For the same channel using the same approach outlined in Equations 2.1 and 2.2 the following results are reached:

[ ]+a,b,c

using Equation 2.1 the result is;

[ ]+a,c = 1.82 percent

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

[ ]+a,c = 1.25 percent (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. Therefore, accounting for interactive effects in the statistical treatment of these allowances insures a conservative result.

## 2.4 PROCESS ALLOWANCES

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

# 3.0 PROTECTION SYSTEM SETPOINT METHODOLOGY

## 3.1 MARGIN CALCULATION

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

[ ] +a,c

(Eq. 3.1)

where:

TA = Total Allowance (Safety Analysis Limit - Nominal Trip Setpoint), and all other parameters are as defined for Equation 2.1.

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

## 3.2 DEFINITIONS FOR PROTECTION SYSTEM SETPOINT TOLERANCES

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

1. Trip Accuracy

   The tolerance band containing the highest expected value of the difference between (a) the desired trip point value of a process variable and (b) the

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

2. Process Measurement Accuracy

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

3. Actuation Accuracy

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

4. Indication Accuracy

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

5. Channel Accuracy

The accuracy of an analog channel which includes the accuracy of the primary element and/or transmitter and modules in the chain where

calibration of modules intermediate in a chain is allowed to compensate for errors in other modules of the chain. Rack environmental effects are not included here to avoid duplication due to dual inputs, however, normal environmental effects on field mounted hardware is included.

6. Sensor Allowable Deviation

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

The tolerances are as follows:

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

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

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

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

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

7. Rack Allowable Deviation

The tolerances are as follows:

a. Rack Calibration Accuracy

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

b. Rack Environmental Effects

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

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

d. Comparator Setting Accuracy

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

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

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

The tolerances are as follows:

(a) Fixed setpoint with a single input - [ ]$^{+a,b,c}$ 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.

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

8. Nominal Safety System Setting

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

9. Limiting Safety System Setting

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

10. Allowance for Instrument Channel Drift

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

11. Safety Analysis Limit

The setpoint value assumed in safety analyses.

12. Total Allowable Setpoint Deviation

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

## 3.3 STATISTICAL METHODOLOGY CONCLUSION

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

## 3.4 ROSEMOUNT TRANSMITTER CALCULATIONS

In addition to the Veritrak transmitters supplied by Westinghouse, Northeast Utilities Service Company has utilized Rosemount transmitters for many of the protection functions. Westinghouse has determined the instrument uncertainties for SCA, SPE, STE, and SD based on Rosemount Product Data Sheets 2388 (1153 series D), 2302 (1153 series B), and 2514 (1154) which were supplied to Westinghouse via Stone and Webster Engineering Corporaton letters NES-35935 (7/19/84), NES-32874 (8/16/83), and NES-37613 (2/18/85). In addition, Westinghouse received explicit instructions concerning the determination of the Environmental Allowance for these transmitters, NES-36886 (11/19/84), NES-37085 (12/13/84), and NES-37613 (2/18/85). Westinghouse has calculated these values in accordance with these instructions.

TABLE 3-1

POWER RANGE, NEUTRON FLUX - HIGH AND LOW SETPOINTS

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy | +a,c |
| [ ] +a,c | |
| Primary Element Accuracy | |
| Sensor Calibration | |
| [ ] +a,c | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects | |
| [ ] +a,c | |
| Sensor Drift | |
| [ ] +a,c | |
| Environmental Allowance | |
| Rack Calibration | |
| Rack Accuracy | |
| Comparator | |
| One input | |
| Rack Temperature Effects | |
| Rack Drift | |
| Tag No.'s - N41, N42, N43, N44 | |

* In percent span (120 percent Rated Thermal Power)

Channel Statistical Allowance =

[ ] +a,c

TABLE 3-2

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

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy [ ]+a,c | [ ]+a,c |
| Primary Element Accuracy | |
| Sensor Calibration [ ]+a,c | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects [ ]+a,c | |
| Sensor Drift [ ]+a,c | |
| Environmental Allowance | |
| Rack Calibration<br>Rack Accuracy | |
| Comparator<br>One input | |
| Rack Temperature Effects | |
| Rack Drift | |
| Tag No.'s - N41, N42, N43, N44 | |

* In percent span (120 percent Rated Thermal Power)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-3

INTERMEDIATE RANGE, NEUTRON FLUX

| Parameter | Allowance* |
| --- | --- |
| Process Measurement Accuracy [ ] +a,c | [ ] +a,c |
| Primary Element Accuracy | |
| Sensor Calibration [ ] +a,c | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects [ ] +a,c | |
| Sensor Drift [ ] +a,c | |
| Environmental Allowance | |
| Rack Calibration<br>Rack Accuracy | |
| Comparator<br>One input | |
| Rack Temperature Effects | |
| Rack Drift<br>5 percent of Rated Thermal Power | |
| Tag No.'s - N35, N36 | |

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

Channel Statistical Allowance =

[ ] +a,c

TABLE 3-4

SOURCE RANGE, NEUTRON FLUX

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy [ ]+a,c | [ ]+a,c |
| Primary Element Accuracy | |
| Sensor Calibration [ ]+a,c | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects [ ]+a,c | |
| Sensor Drift [ ]+a,c | |
| Environmental Allowance | |
| Rack Calibration | |
| Rack Accuracy | |
| Comparator | |
| One input | |
| Rack Temperature Effects | |
| Rack Drift | |
| $3 \times 10^4$ cps | |
| Tag No.'s - N31, N32 | |

* In percent span ($1 \times 10^6$ counts per second)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-5a

OVERTEMPERATURE ΔT (Veritrak Transmitter for Pressurizer Pressure)

| 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 [ ]+a,c | |
| Rack Calibration [ ]+a,c | |
| Rack Accuracy | |
| ΔT channel | |
| $T_{avg}$ channel | |
| Pressure channel | |
| ΔI channel | |
| Total | |
| ΔT channel | |
| $T_{avg}$ channel | |
| Pressure channel | |
| ΔI channel | |

TABLE 3-5a (Continued)

OVERTEMPERATURE ΔT

| Parameter | Allowance* |
|---|---|
| Comparator<br>Two inputs | [ ]$^{+a,c}$ |
| Rack Temperature Effects | |
| Rack Drift<br>ΔT channel<br>$T_{avg}$ channel | |

Tag No.'s - TE411A, TE411B, PT455, N41
TE421A, TE421B, PT456, N42

* In percent span ($T_{avg}$ - 100°F, pressure - 800 psi, power - 150 percent Rated Thermal Power, ΔT - 90.3°F, ΔI - ± 60 percent ΔI; 90.3°F span = 150 percent power)
** See Table 3-17a for gain calculations

Channel Statistical Allowance =

[ ]$^{+a,c}$

TABLE 3-5b

OVERTEMPERATURE ΔT (Rosemount Transmitter for Pressurizer Pressure)

All values are the same as Table 3-5a except:

| Parameter | Allowance* |
|---|---|
| Sensor Temperature Effects<br>[ ]+a,c | [ ]+a,c |
| Sensor Drift<br>[ ]+a,c | |

Tag No.'s - TE431A, TE431B, PT457, N43
TE441A, TE441B, PT458, N44

*In percent span (See Table 3-5b)
**See Table 3-17a for gain calculations

Channel Statistical Allowance =

[ ]+a,c

# TABLE 3-6

## OVERPOWER ΔT

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy | [ ]+a,c |
| [ ]+a,c | |
| Primary Element Accuracy | |
| Sensor Calibration | |
| [ ]+a,c | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects | |
| Sensor Drift | |
| [ ]+a,c | |
| Environmental Allowance | |
| Rack Calibration | |
| [ ]+a,c | |
| Rack Accuracy | |
| ΔT channel | |
| $T_{avg}$ channel | |
| Total | |
| ΔT channel | |
| $T_{avg}$ channel | |
| Comparator | |
| Two inputs | |
| Rack Temperature Effects | |
| Rack Drift | |
| ΔT channel | |
| $T_{avg}$ channel | |

TABLE 3-5 (Continued)

OVERPOWER ΔT

Tag No.'s - TE411A, TE411B
TE421A, TE421B
TE431A, TE431B
TE441A, TE441B

---

* In percent span ($T_{avg}$ - 100°F, pressure - 800 psi, power - 150 percent Rated Thermal Power, ΔT - 90.3°F; 90.3°F span = 150 percent power)

** See Table 3-18 for gain calculations

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-7a

PRESSURIZER PRESSURE - LOW AND HIGH, REACTOR TRIPS
(With Veritrak Transmitter)

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy | [ ]+a,c |
| Primary Element Accuracy | |
| Sensor Calibration | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Environmental Allowance | |
| Rack Calibration<br>Rack Accuracy | |
| Comparator<br>One input | |
| Rack Temperature Effects | |
| Rack Drift | |
| Tag No.'s - PT455, PT456 | |

* In percent span (800 psi)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-7b

PRESSURIZER PRESSURE - LOW AND HIGH, REACTOR TRIPS
(With Rosemount Transmitter)

All values are the same as Table 3-7a except:

| Parameter | Allowance* |
| --- | --- |
| | [ ]+a,c |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Tag No.'s - PT457, PT458 | |

---

*In percent span (100 percent span)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-8a

PRESSURIZER WATER LEVEL - HIGH
(With Veritrak Transmitter)

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy [ ]+a,c | [ ]+a,c |
| Primary Element Accuracy | |
| Sensor Calibration | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Environmental Allowance | |
| Rack Calibration<br>Rack Accuracy | |
| Comparator<br>One input | |
| Rack Temperature Effects | |
| Rack Drift | |
| Tag No.'s - LT459 | |

* In percent span (100 percent span)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-8b

PRESSURIZER WATER LEVEL - HIGH
(With Rosemount Transmitter)

All values are the same as Table 3-8a except:

| Parameter | Allowance* |
| --- | --- |
| Sensor Pressure Effects | [ ]+a,c |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Tag No.'s - LT460, LT461 | |

*In percent span (100 percent span)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-9a

LOSS OF FLOW
(With Rosemount Transmitter)

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy<br>[ ]+a,c | [ ]+a,c |
| Primary Element Accuracy<br>[ ]+a,c | |
| Sensor Calibration<br>[ ]+a,c | |
| Sensor Pressure Effects<br>[ ]+a,c | |
| Sensor Temperature Effects<br>[ ]+a,c | |
| Sensor Drift [ ]+a,c | |
| Environmental Allowance | |
| Rack Calibration<br>Rack Accuracy [ ]+a,c | |
| Comparator<br>One input [ ]+a,c | |
| Rack Temperature Effects [ ]+a,c | |
| Rack Drift<br>1.0 percent Δp span | |

Tag No.'s - FT414, FT415, FT416, FT424, FT425, FT426
FT434, FT435, FT436, FT444, FT445, FT446

---

* In percent span (120 percent Thermal Design Flow)
Percent Δp span converted to flow span via Eq. 3-20.8

Channel Statistical Allowance =

[ ]+a,c

## TABLE 3-10a

## STEAM GENERATOR WATER LEVEL - LOW-LOW
(With Veritrak Transmitter)

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

Tag No.'s - LT517, LT518, LT519
LT527, LT528, LT529
LT537, LT538, LT539
LT547, LT548, LT549

---

* In percent span (100 percent span)

** See Table 3-22 for explanation

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-10b

STEAM GENERATOR WATER LEVEL - LOW-LOW
(With Rosemount Transmitter)

All values the same as Table 3-10a except:

| Parameter | Allowance* |
|---|---|
| Sensor Pressure Effects | [ ]+a,c |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Environmental Allowance | |
| Reference Leg Heatup | |

Tag No.'s - LT551, LT552, LT553, LT554

* In percent span (100 percent span)

Channel Statistical Allowance =

[ ]+a,c

## TABLE 3-11

## CONTAINMENT PRESSURE - HIGH, HIGH-HIGH, HIGH-HIGH-HIGH

| Parameter | Allowance* |
|---|---|
| | [ ]+a,c |
| Process Measurement Accuracy | |
| Primary Element Accuracy | |
| Sensor Calibration | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Environmental Allowance | |
| Rack Calibration<br>Rack Accuracy | |
| Comparator<br>One input | |
| Rack Temperature Effects | |
| Rack Drift<br>(0.6 psig) | |

Tag No.'s - PT934, PT935, PT936, PT937

---

* In percent span (60 psig)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-12a

PRESSURIZER PRESSURE - LOW, SAFETY INJECTION
(With Veritrak Transmitter)

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

Tag No.'s - PT455, PT456

* In percent span (800 psi)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-12b

PRESSURIZER PRESSURE - LOW, SAFETY INJECTION
(With Rosemount Transmitter)

All values are the same as Table 3-12a except:

| Parameter | Allowance* |
|---|---|
| Sensor Temperature Effects | [ ]+a,c |
| Sensor Drift | |
| Environmental Allowance | |
| Tag No.'s - PT457, PT458 | |

* In percent span (800 psi)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-13

STEAMLINE PRESSURE - LOW

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

Tag No.'s - PT514, PT515, PT516
PT524, PT525, PT526
PT534, PT535, PT536
PT544, PT545, PT546

---

* In percent span (1300 psig)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-14

NEGATIVE STEAMLINE PRESSURE RATE - HIGH

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

Tag No.'s - PT514, PT515, PT516
PT524, PT525, PT526
PT534, PT535, PT536
PT544, PT545, PT546

---

* In percent span (1300 psig)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-15a

STEAM GENERATOR WATER LEVEL - HIGH-HIGH
(With Veritrak Transmitter)

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

Tag No.'s - LT517, LT518, LT519
LT527, LT528, LT529
LT537, LT538, LT539
LT547, LT548, LT549

* In percent span (100 percent span)

** See Table 3-19 for explanation

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-15b

STEAM GENERATOR WATER LEVEL - HIGH-HIGH
(With Rosemount Transmitter)

All values are the same as Table 3-15a except:

| Parameter | Allowance* |
|---|---|
| Sensor Pressure Effects | [ ]+a,c |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Tag No.'s - LT551, LT552, LT553, LT554 | |

* In percent span (100 percent span)

Channel Statistical Allowance =

[ ]+a,c

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TABLE 3-17a

OVERTEMPERATURE ΔT GAIN CALCULATIONS
(Veritrak Transmitter for Pressurizer Pressure)

The equation for Overtemperature ΔT is:

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

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

As an example to show calculational methodology and conservatism for Millstone Unit 3;

$K_1$ (nominal) = 1.08 TS trip setpoint
$K_1$ (max) = [ ]+a,c
$K_2$ = 0.0131
$K_3$ = 0.000603
vessel ΔT = 60.2°F
positive f(ΔI) penalty function gain = 2.0 percent FP/percent ΔI

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

[ ]+a,c

[ ]$^{+a,c}$

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

** 1.5 is ΔT instrument span, equivalent to 150 percent Rated Thermal Power.

TABLE 3-17b

OVERTEMPERATURE ΔT GAIN CALCULATIONS
(Rosemount Transmitter for Pressurizer Pressure)

All values noted in Table 3-17a are the same except:

[ ]+a,c

TABLE 3-18

OVERPOWER ΔT GAIN CALCULATIONS

The equation for Overpower ΔT is:

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

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

For Millstone Unit 3:

$K_4$ (nominal) = 1.09 TS trip setpoint

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

$K_6$ = 0.00129

vessel ΔT = 60.2°F

[ ]$^{+a,c}$

[ ]+a,c

---

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

TABLE 3-19

STEAM GENERATOR LEVEL DENSITY VARIATIONS

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

INDICATED LEVEL (50 Percent Power Calibration)

| 0 percent | 10 percent | 70 percent | 100 percent |
|---|---|---|---|

[ ]+a,c

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

TABLE 3-20

ΔP MEASUREMENTS EXPRESSED IN FLOW UNITS

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

[ ] +a,c

Error in flow units is:

[ ]+a,c

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

TABLE 3-21

RCP SHAFT - LOW SPEED

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

Tag No.'s - SE475, SE476, SE477, SE478

---

* In percent span (100% nominal rotation speed)

Channel Statistical Allowance =

[ ]+a,c

# 4.0 TECHNICAL SPECIFICATION USAGE

## 4.1 CURRENT USE

The Standardized Technical Specifications (STS) as used for Westinghouse type plant designs (see NUREG-0452, Revision 4) utilizes a two column format for the RPS and ESF system. This format recognizes that the setpoint channel breakdown, as presented in Figure 4-1, allows for a certain amount of rack drift. The intent of this format is to reduce the number of Licensee Event Reports (LERs) in the area of instrumentation setpoint drift. It appears that this approach has been successful in achieving its goal. However, the approach utilized is fairly simplistic [

]+a,c

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

]+a,c and allows for a more flexible approach in reporting LERs. Also of significant benefit to the plant is the incorporation of sensor drift parameters on an 18 month basis (or more often if necessary).

## 4.2 WESTINGHOUSE STATISTICAL SETPOINT METHODOLOGY FOR STS SETPOINTS

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

### 4.2.1 RACK ALLOWANCE

The first item that will be covered is the interactive effects. When an instrument technician looks for [ ]+a,c he is seeing more than that. This interaction has been noted several times and is handled in Equations 2.1 and 3.1 [

]+a,c. To provide a conservative "trigger value", the difference between the STS trip setpoint and the STS allowable value is determined by two methods. The first is simply the values used in the [ ].+a,c The second [ ]+a,c as follows:

[ ]+a,c (Eq. 4.1)

where:

[ ]+a,c

The smaller of the trigger values should be used for comparison with the "as measured" [ ]$^{+a,c}$ value. As long as the "as measured" value is smaller, the channel is well within the accuracy allowance. If the "as measured" value exceeds the "trigger value", the actual numbers should be used in the calculation described in Section 4.2.3.

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

### 4.2.2 INCLUSION OF "AS MEASURED" SENSOR ALLOWANCE

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

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

where:

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

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

and all other parameters are as defined in Equation 4.1.

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

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

where:

[ ] +a,c

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

### 4.2.3 IMPLEMENTATION OF THE WESTINGHOUSE SETPOINT METHODOLOGY

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

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

[ ] +a,c

[ ]+a,c

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

Now assume that one bistable has "drifted" more than that allowed by the STS for 31 day surveillance. According to ACTION statement "A", the plant staff must verify that Equation 2.2-1 is met. Going to Table 2.2-1, the following values are noted: Z = 2.18 and the Total Allowance (TA) = 8.0. Assume that the "as measured" rack setpoint value is 4.5 percent high and the "as measured" sensor value is 1.5 percent. Equation 2.2-1 looks like:

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

$$2.18 + 4.5 + 1.5 \leq 8.0$$
$$8.2 > 8.0$$

As can be seen, 8.2 percent is not less than 8.0 percent thus, the plant staff must follow ACTION statement "B" (declare channel inoperable and place in the "tripped" condition). It should be noted that if the plant staff had not measured the sensor drift, but instead used the value of S in Table 2.2-1 then the sum of Z + R + S would also be greater than 8.0 percent. In fact, almost

anytime the "as measured" value for rack drift is greater than T (the "trigger value"), use of S in Table 2.2-1 will result in the sum of Z + R + S being greater than TA and requiring the reporting of the case of the NRC.

If the sum of R + S was about 0.3 percent less, e.g., R = 4.1 percent, S = 1.3 percent thus, R + S = 5.4 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.

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

[ ]+a,c

(Eq. 4.4)

(Eq. 4.5)

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

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

[ ]+a,c

(Eq. 4.6)

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

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

[ ]$^{+a,c}$

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

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

## 4.3 CONCLUSION

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

TABLE 4-1

EXAMPLES OF CURRENT STS SETPOINT PHILOSOPHY

| | Power Range Neutron Flux - High | Pressurizer Pressure - High* |
|---|---|---|
| Safety Analysis Limit | 118 percent | 2410 psig |
| STS Allowable Value | 110 percent | 2380 psig |
| STS Trip Setpoint | 109 percent | 2370 psig |

TABLE 4-2

EXAMPLES OF WESTINGHOUSE STS RACK ALLOWANCE

| | Power Range Neutron Flux - High | Pressurizer Pressure - High* |
|---|---|---|
| Safety Analysis Limit | 118 percent | 2410 psig |
| STS Allowable Value (Trigger Value) | 111.2 percent | 2384 psig |
| STS Trip Setpoint | 109 percent | 2370 psig |

*With Veritrak Transmitter

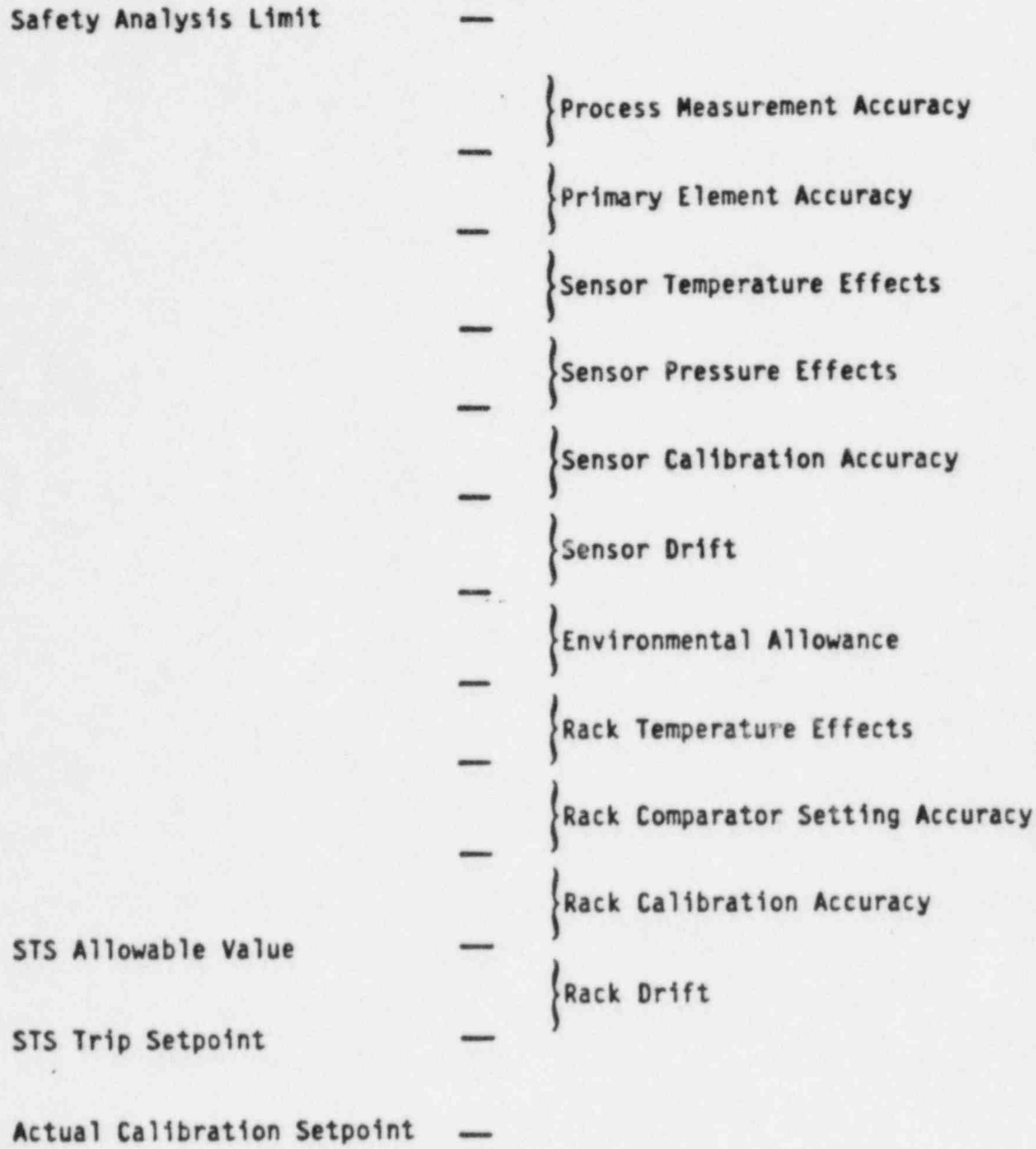


Figure 4-1 NUREG-0452 Rev. 4 Setpoint Error Breakdown

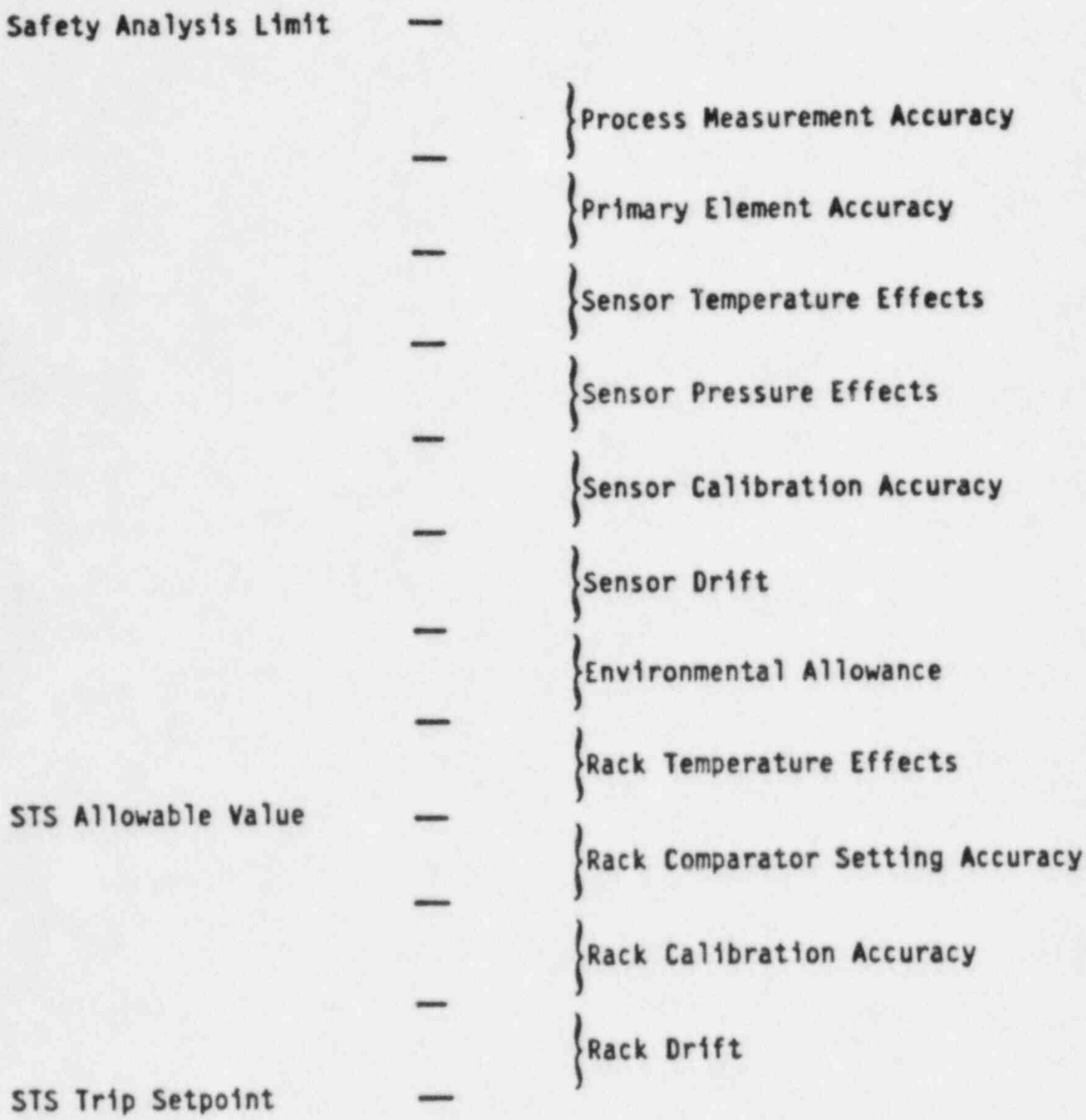


Figure 4-2 Westinghouse STS Setpoint Error Breakdown

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# APPENDIX A

## SAMPLE MILLSTONE

## 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.

(Eq. 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 of span) of rack error for the affected channel,

S = Either the "as measured" value (in percent of 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 | S | Trip Setpoint | Allowable Value |
|---|---|---|---|---|---|---|
| 1. | Manual Reactor Trip | N.A. | N.A. | N.A. | N.A. | N.A. |
| 2. | Power Range, Neutron Flux, High Setpoint | 7.5 | 4.56 | 0 | ≤ 109 percent of RTP | ≤ 111.1 percent of RTP |
| | Low Setpoint | 8.3 | 4.56 | 0 | ≤ 25 percent of RTP | ≤ 27.1 percent of RTP |
| 3. | Power Range, Neutron Flux, High Positive Rate | 1.6 | 0.50 | 0 | ≤ 5 percent of RTP with a time constant ≥ 2 seconds | ≤ 6.3 percent of RTP with a time constant ≥ 2 seconds |
| 4. | Power Range, Neutron Flux, High Negative Rate | 1.6 | 0.50 | 0 | ≤ 5 percent of RTP with a time constant ≥ 2 seconds | ≤ 6.3 percent of RTP with a time constant ≥ 2 seconds |
| 5. | Intermediate Range, Neutron Flux | 17.0 | 8.41 | 0 | ≤ 25 percent of RTP | ≤ 30.9 percent of RTP |
| 6. | Source Range, Neutron Flux | 17.0 | 10.01 | 0 | ≤ $10^5$ cps | ≤ 1.4 x $10^5$ cps |
| 7. | Overtemperature ΔT (N loop) | 8.3 | 5.90 | 1.1+1.2 | See note 1 | See note 2 |
| | (N-1 loop) | 12.0 | 5.90 | 1.1+1.2 | See note 1 | See note 2 |
| 8. | Overpower ΔT | 4.8 | 1.43 | 0.11 | See note 3 | See note 4 |
| 9. | Pressurizer Pressure - Low | 5.0 | 1.77 | 3.3 | ≥ 1885 psig | ≥ 1875 psig |
| 10. | Pressurizer Pressure - High | 5.0 | 1.77 | 3.3 | ≤ 2370 psig | ≤ 2380 psig |
| 11. | Pressurizer Water Level-High | 8.0 | 5.13 | 2.7 | ≤ 89 percent of instrument span | ≤ 90.7 percent of instrument span |
| 12. | Loss of Flow | 2.5 | 1.74 | 0.8 | ≥ 90 percent of loop design flow* | ≥ 89.3 percent of loop design flow* |

*Loop design flow = 94,600 gpm (N loop operation), 99,600 gpm (N-1 loop operation)

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

| Functional Unit | Total Allowance (TA) | Z | S | Trip Setpoint | Allowable Value |
|---|---|---|---|---|---|
| 13. Steam Generator Water Level - Low-Low | 20.5 | 18.98 | 1.75 | ≥ 23.5 percent of narrow range instrument span | ≥ 22.6 percent of narrow range instrument span |
| 14. General Warning Alarm | N.A. | N.A. | N.A. | N.A. | N.A. |
| 15. RCP Shaft - Low Speed | 3.8 | 0.5 | 0.0 | 97.8% nominal speed | 94.6% nominal speed |
| 16. Turbine Trip | | | | | |
| a. Low Fluid Oil Pressure | N.A. | N.A. | N.A. | | |
| b. Turbine Stop Valve Closure | N.A. | N.A. | N.A. | | |
| 17. Safety Injection Input from ESF | N.A. | N.A. | N.A. | N.A. | N.A. |

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

| Functional Unit | Total Allowance (TA) | Z | S | Trip Setpoint | Allowable Value |
|---|---|---|---|---|---|
| 19. Reactor Trip System Interlocks | | | | | |
| a. Intermediate Range Neutron Flux, P-6 | N.A. | N.A. | N.A. | $\geq 1 \times 10^{-10}$ amps | $\geq 6 \times 10^{-11}$ amps |
| b. Low Power Reactor Trips Block, P-7 | | | | | |
| 1. P-10 input | N.A. | N.A. | N.A. | ≤10 percent of RTP | ≤12.1 percent of RTP |
| 2. P-13 input | N.A. | N.A. | N.A. | ≤10 percent turbine impulse pressure equivalent | ≤12.1 percent turbine impulse pressure equivalent |
| c. Power Range Neutron Flux, P-8 (N loop operation) | N.A. | N.A. | N.A. | ≤37.5 percent of RTP | ≤39.6 percent of RTP |
| d. Power Range Neutron Flux, P-8 (N-1 loop operation) | N.A | N.A | N.A | ≤37.5 percent of RTP | ≤39.6 percent of RTP |
| e. Power Range Neutron Flux, P-9 | N.A. | N.A. | N.A. | ≤51 percent of RTP | ≤53.1 percent of RTP |
| f. Power Range Neutron Flux, P-10 | N.A. | N.A. | N.A. | ≥10 percent of RTP | ≥7.9 percent of RTP |
| 20. Reactor Trip Breakers | N.A. | N.A. | N.A. | N.A. | N.A. |
| 21. Automatic Trip and Interlock Logic | N.A. | N.A. | N.A. | N.A. | N.A. |

* Later

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS
NOTATION

NOTE 1: OVERTEMPERATURE ΔT $\left(\frac{1 + \tau_1 S}{1 + \tau_2 S}\right) \left(\frac{1}{1 + \tau_3 S}\right)$

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

Where:

$\Delta T$ = Measured ΔT by RTD Manifold Instrumentation;

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

$\tau_1, \tau_2$ = Time constants utilized in the lead-lag controller for ΔT, $\tau_1$ = 8 secs , $\tau_2$ = 3 secs.

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

$\tau_3$ = Time constant utilized in the lag compensator for ΔT, $\tau_3$= 0 secs.

$\Delta T_o$ = Indicated ΔT at RATED THERMAL POWER;

$K_1$ = 1.080 (N loop operation) , 1.010 (N-1 loop operation)

$K_2$ = 0.01313

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

$\tau_4, \tau_5$ = Time constants utilized in the lead-lag controller for $T_{avg}$, $\tau_4$ = 33 secs., $\tau_5$ = 4 secs.

$T$ = Average temperature °F

$\frac{1}{1 + \tau_6 S}$ = Lag compensator on measured $T_{avg}$

$\tau_6$ = Time constant utilized in the measured $T_{avg}$ lag compensator, $\tau_6$ = 0 secs.

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS NOTATION

NOTE 1: (continued)

T' = ≤ 587.1°F (Nominal $T_{avg}$ at RATED THERMAL POWER)

$K_3$ = 0.000603

P = Pressurizer pressure, psig

P' = 2235 psig (Nominal RCS operating pressure); and

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

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 $q_t - q_b$ between -30 percent and +10 percent, $f_1(\Delta I) = 0$ (where $q_t$ and $q_b$ are percent RATED THERMAL POWER in the top and bottom halves of the core respectively, and $q_t + q_b$ is total THERMAL POWER in percent of RATED THERMAL POWER);

(ii) for each percent that the magnitude of $(q_t - q_b)$ exceeds -30 percent, the ΔT trip setpoint shall be automatically reduced by 3.6 percent of its value at RATED THERMAL POWER; and

(iii) for each percent that the magnitude of $(q_t - q_b)$ exceeds +10 percent, the ΔT Trip Setpoint shall be automatically reduced by 2.0 percent of its value at RATED THERMAL POWER.

NOTE 2: The channel's maximum Trip Setpoint shall not exceed its computed trip point by more than 2.1 percent ΔT span (N loop operation), 4.1% ΔT span (N-1 loop operation).

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS NOTATION

NOTE 3: OVERPOWER ΔT $\left(\frac{1 + \tau_1 S}{1 + \tau_2 S}\right) \left(\frac{1}{1 + \tau_3 S}\right)$

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

Where: $\Delta T$ = As defined in Note 1,

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

$\tau_1$, $\tau_2$ = As defined in Note 1

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

$\tau_3$ = As defined in Note 1

$\Delta T_o$ = As defined in Note 1

$K_4$ = 1.09

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

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

$\tau_7$ = Time constant utilized in the lead-lag controller for $T_{avg}$, $\tau_7$ = 10 secs.

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

$\tau_6$ = As defined in Note 1

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS
NOTATION (Continued)

NOTE 3: (continued)

| | | |
|---|---|---|
| $K_6$ | = | 0.00129/°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, ≤ 587.1°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 Setpoint by more than 3.4 percent ΔT span.

## 2.2 LIMITING SAFETY SYSTEM SETTINGS

BASES

### 2.2.1 REACTOR TRIP SYSTEM INSTRUMENTATION SETPOINTS

The Reactor Trip Setpoint Limits specified in Table 2.2-1 are the nominal values at which the Reactor trips are set for each functional unit. The Trip Setpoints have been selected to ensure that the 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 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 2.2-1, in percent span, is the statistical summation of errors assumed in the analysis excluding those associated with the sensor and rack drift and the accuracy of their measurement. TA or Total Allowance is the difference, in percent span, between the Trip Setpoint and the value used in the analysis for Reactor Trip. R or Rack Error is the "as measured" deviation, in percent span, for the affected channel from the specified Trip

Setpoint. S or Sensor Error is either the "as measured" deviation of the sensor from its calibration point or the value specified in Table 2.2-1, in percent span, from the analysis assumptions. Use of Equation 2.2-1 allows for a sensor drift factor, an increased rack drift factor, and provides a threshold value for REPORTABLE EVENTS.

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 instrumentaton 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 of sensor drift, in excess of the allowance that is more than occasional, may be indicative of more serious problems and should warrant further investigation.

INSTRUMENTATION

3/4.3.2 ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION LIMITING CONDITION FOR OPERATION

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

APPLICABILITY: As shown in Table 3.3-3.

ACTION:

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

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

   2. Declare the channel inoperable and apply the applicable ACTION statement requirements of Table 3.3-3 until the channel is restored to OPERABLE status with its Setpoint adjusted consistent with the Trip Setpoint value.

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

Where:

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

R = The "as measured" value (in percent span) or 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.

c. With an ESFAS instrumentation channel or interlock inoperable, take the ACTION shown in Table 3.3-3.

SURVEILLANCE REQUIREMENTS

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

TABLE 3.3-4

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

| Functional Unit | Total Allowance (TA) | Z | Sensor Drift (S) | Trip Setpoint | Allowable Value |
|---|---|---|---|---|---|
| 1. Safety Injection, Reactor Trip, Feedwater Isolation, Control Room Isolation, Start Diesel Generators, Containment Cooling Fans, and Essential Service Water | | | | | |
| a. Manual Initiation | N.A. | N.A. | N.A. | N.A. | N.A. |
| b. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| c. Containment Pressure - High | 3.3 | 1.01 | 1.75 | ≤ 3.0 psig | ≤ 3.8 psig |
| d. Pressurizer Pressure - Low | 16.5 | 13.67 | 3.3 | ≥ 1877.3 psig | ≥ 1870.2 psig |
| e. Steamline Pressure - Low | 17.7 | 15.31 | 2.2 | ≥ 658.6 psig* | ≥ 644.9 psig* |

TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

| Functional Unit | Total Allowance (TA) | Z | Sensor Drift (S) | Trip Setpoint | Allowable Value |
|---|---|---|---|---|---|
| 2. Containment Spray | | | | | |
| a. Manual Initiation | N.A. | N.A. | N.A. | N.A. | N.A. |
| b. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| c. Containment Pressure - High-3 | 3.3 | 1.01 | 1.75 | ≤ 8.0 psig | ≤ 8.8 psig |
| 3. Containment Isolation | | | | | |
| a. Phase "A" Isolation | | | | | |
| 1. Manual Initiation | N.A. | N.A. | N.A. | N.A. | N.A. |
| 2. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| 3. Safety Injection | See Item 1 above for all Safety functions and requirements. | | | | |
| B. Phase "B" Isolation | | | | | |
| 1. Manual Initiation | N.A. | N.A. | N.A. | N.A. | N.A. |
| 2. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| 3. Containment Pressure - High-3 | 3.3 | 1.01 | 1.75 | ≤ 8.0 psig | ≤ 8.8 psig |

TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

| Functional Unit | Total Allowance (TA) | Z | Sensor Drift (S) | Trip Setpoint | Allowable Value |
|---|---|---|---|---|---|
| 3. Containment Isolation (continued) | | | | | |
| c. Containment Purge Isolation | | | | | |
| 1. Manual Initiation | N.A. | N.A. | N.A. | N.A. | N.A. |
| 2. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| 3. Containment Isolation Phase "A" | See Item 3.a. above for all Containment Isolation Phase "A" functions and requirements. | | | | |
| 4. Steam Line Isolation | | | | | |
| a. Manual Initiation | N.A. | N.A. | N.A. | N.A. | N.A. |
| b. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| c. Containment Pressure - High-2 | 3.3 | 1.01 | 1.75 | ≤ 3.0 psig | ≤ 3.8 psig |
| d. Steamline Pressure - Low | 17.7 | 15.31 | 2.2 | ≥ 658.6 psig* | ≥ 644.9 psig* |
| e. Negative Steam Pressure-Negative Rate - High | 5.0 | 0.50 | 0.0 | ≥ -100 psi with a time constant of 50 secs. | ≥ -122.7 psi with a time constant of 50 secs. |

## TABLE 3.3-4 (Continued)

## ENGINEERED SAFETY FEATURE 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 Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| b. Steam Generator Water Level--High-High | 3.7 | 2.33 | 1.75 | ≤ 82.0 percent of narrow range instrument span | ≤ 82.8 percent of narrow range instrument span |
| 6. Auxiliary Feedwater | | | | | |
| a. Manual Initiation | N.A. | N.A. | N.A. | N.A. | N.A. |
| b. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| c. Steam Generator Water Level--Low-Low | | | | | |
| 1. Start Motor-Driven Pumps | 20.5 | 18.98 | 1.75 | ≥ 23.5 percent of narrow range instrument span | ≥ 22.6 percent of narrow range instrument span |
| 2. Start Turbine-Driven Pump | 20.5 | 18.98 | 1.75 | ≥ 23.5 percent of narrow range instrument span | ≥ 22.6 percent of narrow range instrument span |
| d. Safety Injection Start Motor-Driven Pumps | See Item 1 above for all Safety Injection Functions and requirements | | | | |

TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

| Functional Unit | Total Allowance (TA) | Z | Sensor Drift (S) | Trip Setpoint | Allowable Value |
|---|---|---|---|---|---|
| 6. Auxiliary Feedwater (continued) | | | | | |
| e. Station Blackout Start Turbine-Driven Pump | N.A. | N.A. | N.A. | N.A. | N.A. |
| f. Trip Main Feedwater Pumps-Start Motor-Driven Pumps and Turbine-Driven Pump | N.A. | N.A. | N.A. | N.A. | N.A. |
| 7. Automatic Switchover Lo Containment Sump | | | | | |
| a. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| b. RWST Level--Low-Low | ** | ** | ** | ** | ** |
| Coincident with Safety Injection | See Item 1 above for Safety Injection functions and requirements. | | | | |
| 8. Loss of Power | | | | | |
| a. 4.16 kV Undervoltage -Loss of Voltage | ** | ** | ** | ** | ** |
| b. 4.16 kV Undervoltage -Grid Degraded Voltage | ** | ** | ** | ** | ** |
| 9. Engineered Safety Feature Actaution System Interlocks | | | | | |
| a. Pressurizer Pressure, P-11 | N.A. | N.A. | N.A. | ≤ 1985 psig | ≤ 1995 psig |
| b. Reactor Trip, P-4 | N.A. | N.A. | N.A. | N.A. | N.A. |

TABLE 3.3-4 (Continued)

TABLE NOTATION

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

** To be provided by plant.

## 3.4.3 INSTRUMENTATION

### BASES

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

The OPERABILITY of the Reactor Trip System and the Engineered Safety Features Actuation System instrumentation and interlocks ensures 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 safety 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 Features 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 3.3-1, $Z + R + S \leq TA$, the interactive effects of the errors in the rack and the sensor, and the "as measured" values of the errors are considered. Z, as specified in Table 3.3-4, in percent span, is the statistical summation of errors assumed in the analysis excluding those associated with the sensor and rack drift and the accuracy of their measurement. TA or Total Allowance is the difference, in percent span, between the Trip Setpoint and the value used in the analysis for the actuation. R or Rack Error is the "as measured" deviation, in percent span, for the affected channel from the specified Trip Setpoint. S or Sensor Error is either the "as measured" deviation of the sensor from its calibration point or the value specified in Table 3.3-4, in percent span, from the analysis assumptions.

The methodology to derive the Trip Setpoints is based upon combining all of the uncertanties 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.

WCAP-10992

# WESTINGHOUSE SETPOINT METHODOLOGY FOR PROTECTION SYSTEMS MILLSTONE NUCLEAR POWER STATION UNIT 3

November, 1985

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## 1.0 INTRODUCTION

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

The basic underlying assumption used is that several of the error components and their parameter assumptions act independently, e.g., [ ]$^{+a,c}$. This allows the use of a statistical summation of the various breakdown components instead of a strictly arithmetic summation. A direct benefit of the use of this technique is increased margin in the total allowance. For those parameter assumptions known to be interactive, the technique uses the normal, conservative approach, arithmetic summation, to form independent quantities, e.g., [ ]$^{+a,c}$. An explanation of the overall approach is provided in Section 2.0.

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

Section 4.0 notes what the current (read NRC) Technical Specifications use for setpoints and an explanation of the impact of the statistical approach on them. Detailed examples of how to determine the Technical Specification setpoint values are also provided. An Appendix is provided noting a recommended set of Technical Specifications using the plant specific data in the statistical approach. For those protection functions using both Veritrak and Rosemount transmitters, only the most limiting case is provided.

# 2.0 COMBINATION OF ERROR COMPONENTS

## 2.1 METHODOLOGY

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

The methodology used for this combination is not new. Basically it is the [ ]$^{+a,c,e}$ which has been utilized in other Westinghouse reports. This technique, or other statistical approaches of a similar nature, have been used in WCAP-10395(1) and WCAP-8567(2). It should be noted that WCAP-8567 has been approved by the NRC Staff thus noting the acceptability of statistical techniques for the application requested. It should also be recognized that ANSI, the American Nuclear Society, and the Instrument Society of America approve of the use of probabilistic techniques in determining safety-related setpoints(3)(4). Thus it can be seen that the use of statistical approaches in analysis techniques is becoming more and more widespread.

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

[ ]$^{+a,c}$

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

where:

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

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

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

## 2.2 SENSOR ALLOWANCES

Four parameters are considered to be sensor allowances, SCA, SD, STE, and SPE (see Table 3-16). Of these four parameters, two are considered to be statistically independent, [ ]+a,c, and two are considered interactive [ ]+a,c. [ ]+a,c are considered to be independent due to the manner in which the instrumentation is checked, i.e., the instrumentation is [ ]+a,c. An example of [ ]+a,c

[ ]+a,c are considered to be interactive for the same reason that [ ]+a,c are considered independent, i.e., due to the manner in which the instrumentation is checked. [ ]+a,c. Based on this reasoning, [ ]+a,c have been added to form an independent group which is then factored into Equation 2.1. An example of the impact of this treatment is; for Pressurizer Water Level-High (Veritrak parameters only):

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

using Equation 2.1 as written gives a total of;

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

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

[ ]$^{+a,c}$ = 1.32 percent (Eq. 2.2)

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

## 2.3 RACK ALLOWANCES

Four parameters, as noted by Table 3-16, are considered to be rack allowances, RCA, RCSA, RTE, and RD. Three of these parameters are considered to be interactive (for much the same reason outlined for sensors in 2.2), [ ]$^{+a,c}$. [ ]$^{+a,c}$

[

]+a,c. Based on this logic, these three factors have been added to form an independent group. This group is then factored into Equation 2.1. The impact of this approach (formation of an independent group based on interactive components) is significant. For the same channel using the same approach outlined in Equations 2.1 and 2.2 the following results are reached:

[ ]+a,b,c

using Equation 2.1 the result is;

[ ]+a,c = 1.82 percent

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

[ ]+a,c (Eq. 2.3)

= 1.25 percent

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

## 2.4 PROCESS ALLOWANCES

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

# 3.0 PROTECTION SYSTEM SETPOINT METHODOLOGY

## 3.1 MARGIN CALCULATION

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

[ ]+a,c

(Eq. 3.1)

where:

TA = Total Allowance (Safety Analysis Limit - Nominal Trip Setpoint), and all other parameters are as defined for Equation 2.1.

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

## 3.2 DEFINITIONS FOR PROTECTION SYSTEM SETPOINT TOLERANCES

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

1. Trip Accuracy

   The tolerance band containing the highest expected value of the difference between (a) the desired trip point value of a process variable and (b) the

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

2. Process Measurement Accuracy

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

3. Actuation Accuracy

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

4. Indication Accuracy

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

5. Channel Accuracy

The accuracy of an analog channel which includes the accuracy of the primary element and/or transmitter and modules in the chain where

calibration of modules intermediate in a chain is allowed to compensate for errors in other modules of the chain. Rack environmental effects are not included here to avoid duplication due to dual inputs, however, normal environmental effects on field mounted hardware is included.

6. Sensor Allowable Deviation

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

The tolerances are as follows:

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

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

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

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

---

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

7. Rack Allowable Deviation

The tolerances are as follows:

a. Rack Calibration Accuracy

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

b. Rack Environmental Effects

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

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

d. Comparator Setting Accuracy

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

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

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

The tolerances are as follows:

(a) Fixed setpoint with a single input - [ ]$^{+a,b,c}$ 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.

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

8. Nominal Safety System Setting

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

9. Limiting Safety System Setting

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

10. Allowance for Instrument Channel Drift

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

11. Safety Analysis Limit

The setpoint value assumed in safety analyses.

12. Total Allowable Setpoint Deviation

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

## 3.3 STATISTICAL METHODOLOGY CONCLUSION

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

## 3.4 ROSEMOUNT TRANSMITTER CALCULATIONS

In addition to the Veritrak transmitters supplied by Westinghouse, Northeast Utilities Service Company has utilized Rosemount transmitters for many of the protection functions. Westinghouse has determined the instrument uncertainties for SCA, SPE, STE, and SD based on Rosemount Product Data Sheets 2388 (1153 series D), 2302 (1153 series B), and 2514 (1154) which were supplied to Westinghouse via Stone and Webster Engineering Corporaton letters NES-35935 (7/19/84), NES-32874 (8/16/83), and NES-37613 (2/18/85). In addition, Westinghouse received explicit instructions concerning the determination of the Environmental Allowance for these transmitters, NES-36886 (11/19/84), NES-37085 (12/13/84), and NES-37613 (2/18/85). Westinghouse has calculated these values in accordance with these instructions.

TABLE 3-1

POWER RANGE, NEUTRON FLUX - HIGH AND LOW SETPOINTS

| Parameter | Allowance* |
| --- | --- |
| Process Measurement Accuracy<br>[ ]+a,c | [ ]+a,c |
| Primary Element Accuracy | |
| Sensor Calibration<br>[ ]+a,c | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects<br>[ ]+a,c | |
| Sensor Drift<br>[ ]+a,c | |
| Environmental Allowance | |
| Rack Calibration<br>Rack Accuracy | |
| Comparator<br>One input | |
| Rack Temperature Effects | |
| Rack Drift | |
| Tag No.'s - N41, N42, N43, N44 | |

* In percent span (120 percent Rated Thermal Power)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-2

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

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

Tag No.'s - N41, N42, N43, N44

---

* In percent span (120 percent Rated Thermal Power)

Channel Statistical Allowance =

[ ]+a,c

## TABLE 3-3

## INTERMEDIATE RANGE, NEUTRON FLUX

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy<br>[ ] +a,c | [ ] +a,c |
| Primary Element Accuracy | |
| Sensor Calibration<br>[ ] +a,c | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects<br>[ ] +a,c | |
| Sensor Drift<br>[ ] +a,c | |
| Environmental Allowance | |
| Rack Calibration<br>Rack Accuracy | |
| Comparator<br>One input | |
| Rack Temperature Effects | |
| Rack Drift<br>5 percent of Rated Thermal Power | |

Tag No.'s - N35, N36

---

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

Channel Statistical Allowance =

[ ] +a,c

TABLE 3-4

SOURCE RANGE, NEUTRON FLUX

| Parameter | | Allowance* |
|---|---|---|
| Process Measurement Accuracy | [ ]+a,c | [ ]+a,c |
| Primary Element Accuracy | | |
| Sensor Calibration | [ ]+a,c | |
| Sensor Pressure Effects | | |
| Sensor Temperature Effects | [ ]+a,c | |
| Sensor Drift | [ ]+a,c | |
| Environmental Allowance | | |
| Rack Calibration<br>Rack Accuracy | | |
| Comparator<br>One input | | |
| Rack Temperature Effects | | |
| Rack Drift<br>$3 \times 10^4$ cps | | |
| Tag No.'s - N31, N32 | | |

* In percent span ($1 \times 10^6$ counts per second)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-5a

OVERTEMPERATURE ΔT (Veritrak Transmitter for Pressurizer Pressure)

| Parameter | Allowance* |
| --- | --- |
| Process Measurement Accuracy [ ]+a,c | [ ]+a,c |
| Primary Element Accuracy | |
| Sensor Calibration [ ]+a,c | |
| Sensor Pressure Effects ]+a,c | |
| Sensor Temperature Effects [ | |
| Sensor Drift [ ]+a,c | |
| Environmental Allowance [ ]+a,c | |
| Rack Calibration [ ]+a,c | |
| Rack Accuracy | |
| ΔT channel | |
| $T_{avg}$ channel | |
| Pressure channel | |
| ΔI channel | |
| Total | |
| ΔT channel | |
| $T_{avg}$ channel | |
| Pressure channel | |
| ΔI channel | |

TABLE 3-5a (Continued)

OVERTEMPERATURE ΔT

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

Tag No.'s - TE411A, TE411B, PT455, N41
TE421A, TE421B, PT456, N42

---

* In percent span ($T_{avg}$ - 100°F, pressure - 800 psi, power - 150 percent Rated Thermal Power, ΔT - 90.3°F, ΔI - ± 60 percent ΔI; 90.3°F span = 150 percent power)

** See Table 3-17a for gain calculations

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-5b

OVERTEMPERATURE ΔT (Rosemount Transmitter for Pressurizer Pressure)

All values are the same as Table 3-5a except:

| Parameter | Allowance* |
|---|---|
| Sensor Temperature Effects [ ]+a,c | [ ]+a,c |
| Sensor Drift [ ]+a,c | |

Tag No.'s - TE431A, TE431B, PT457, N43
TE441A, TE441B, PT458, N44

---

*In percent span (See Table 3-5b)
**See Table 3-17a for gain calculations

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-6

OVERPOWER ΔT

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy<br>[ ]+a,c | [ ]+a,c |
| Primary Element Accuracy | |
| Sensor Calibration<br>[ ]+a,c | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects | |
| Sensor Drift<br>[ ]+a,c | |
| Environmental Allowance | |
| Rack Calibration<br>[ ]+a,c | |
| Rack Accuracy<br>ΔT channel<br>$T_{avg}$ channel | |
| Total<br>ΔT channel<br>$T_{avg}$ channel | |
| Comparator<br>Two inputs | |
| Rack Temperature Effects | |
| Rack Drift<br>ΔT channel<br>$T_{avg}$ channel | |

TABLE 3-6 (Continued)

OVERPOWER ΔT

Tag No.'s - TE411A, TE411B
TE421A, TE421B
TE431A, TE431B
TE441A, TE441B

---

* In percent span ($T_{avg}$ - 100°F, pressure - 800 psi, power - 150 percent Rated Thermal Power, ΔT - 90.3°F; 90.3°F span = 150 percent power)

** See Table 3-18 for gain calculations

Channel Statistical Allowance =

[ ]+a,c

## TABLE 3-7a

### PRESSURIZER PRESSURE - LOW AND HIGH, REACTOR TRIPS (With Veritrak Transmitter)

| Parameter | Allowance* |
|---|---|
| | [ ]+a,c |
| Process Measurement Accuracy | |
| Primary Element Accuracy | |
| Sensor Calibration | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Environmental Allowance | |
| Rack Calibration | |
| Rack Accuracy | |
| Comparator | |
| One input | |
| Rack Temperature Effects | |
| Rack Drift | |
| Tag No.'s - PT455, PT456 | |

---

* In percent span (800 psi)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-7b

PRESSURIZER PRESSURE - LOW AND HIGH, REACTOR TRIPS
(With Rosemount Transmitter)

All values are the same as Table 3-7a except:

| Parameter | Allowance* |
|---|---|
| | [ ]+a,c |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Tag No.'s - PT457, PT458 | |

*In percent span (100 percent span)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-8a

PRESSURIZER WATER LEVEL - HIGH
(With Veritrak Transmitter)

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy<br>+a,c<br>[ ] | [ ]+a,c |
| Primary Element Accuracy | |
| Sensor Calibration | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Environmental Allowance | |
| Rack Calibration<br>Rack Accuracy | |
| Comparator<br>One input | |
| Rack Temperature Effects | |
| Rack Drift | |
| Tag No.'s - LT459 | |

* In percent span (100 percent span)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-8b

PRESSURIZER WATER LEVEL - HIGH
(With Rosemount Transmitter)

All values are the same as Table 3-8a except:

| Parameter | Allowance* |
|---|---|
| Sensor Pressure Effects | [ ]+a,c |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Tag No.'s - LT460, LT461 | |

*In percent span (100 percent span)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-9a

LOSS OF FLOW
(With Rosemount Transmitter)

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy<br>[ ]+a,c | [ ]+a,c |
| Primary Element Accuracy<br>[ ]+a,c | |
| Sensor Calibration<br>[ ]+a,c | |
| Sensor Pressure Effects<br>[ ]+a,c | |
| Sensor Temperature Effects<br>[ ]+a,c | |
| Sensor Drift [ ]+a,c | |
| Environmental Allowance | |
| Rack Calibration<br>Rack Accuracy [ ]+a,c | |
| Comparator<br>One input [ ]+a,c | |
| Rack Temperature Effects [ ]+a,c | |
| Rack Drift<br>1.0 percent Δp span | |

Tag No.'s - FT414, FT415, FT416, FT424, FT425, FT426
FT434, FT435, FT436, FT444, FT445, FT446

---

* In percent span (120 percent Thermal Design Flow)
Percent Δp span converted to flow span via Eq. 3-20.B

Channel Statistical Allowance =

[ ]+a,c

## TABLE 3-10a

### STEAM GENERATOR WATER LEVEL - LOW-LOW
### (With Veritrak Transmitter)

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

Tag No.'s - LT517, LT518, LT519
LT527, LT528, LT529
LT537, LT538, LT539
LT547, LT548, LT549

* In percent span (100 percent span)

** See Table 3-22 for explanation

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-10b

STEAM GENERATOR WATER LEVEL - LOW-LOW
(With Rosemount Transmitter)

All values the same as Table 3-10a except:

| Parameter | Allowance* |
|---|---|
| Sensor Pressure Effects | [ ]+a,c |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Environmental Allowance | |
| Reference Leg Heatup | |
| Tag No.'s - LT551, LT552, LT553, LT554 | |

* In percent span (100 percent span)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-11

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

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy | [ ]+a,c |
| Primary Element Accuracy | |
| Sensor Calibration | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Environmental Allowance | |
| Rack Calibration<br>Rack Accuracy | |
| Comparator<br>One input | |
| Rack Temperature Effects | |
| Rack Drift<br>(0.6 psig) | |

Tag No.'s - PT934, PT935, PT936, PT937

* In percent span (60 psig)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-12a

PRESSURIZER PRESSURE - LOW, SAFETY INJECTION
(With Veritrak Transmitter)

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

Tag No.'s - PT455, PT456

---

* In percent span (800 psi)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-12b

PRESSURIZER PRESSURE - LOW, SAFETY INJECTION
(With Rosemount Transmitter)

All values are the same as Table 3-12a except:

| Parameter | Allowance* |
| --- | --- |
| Sensor Temperature Effects | [ ]+a,c |
| Sensor Drift | |
| Environmental Allowance | |
| Tag No.'s - PT457, PT458 | |

---

* In percent span (800 psi)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-13

STEAMLINE PRESSURE - LOW

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

Tag No.'s - PT514, PT515, PT516
PT524, PT525, PT526
PT534, PT535, PT536
PT544, PT545, PT546

* In percent span (1300 psig)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-14

NEGATIVE STEAMLINE PRESSURE RATE - HIGH

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

Tag No.'s - PT514, PT515, PT516
PT524, PT525, PT526
PT534, PT535, PT536
PT544, PT545, PT546

---

* In percent span (1300 psig)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-15a

STEAM GENERATOR WATER LEVEL - HIGH-HIGH
(With Veritrak Transmitter)

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

Tag No.'s - LT517, LT518, LT519
LT527, LT528, LT529
LT537, LT538, LT539
LT547, LT548, LT549

* In percent span (100 percent span)

** See Table 3-19 for explanation

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-15b

STEAM GENERATOR WATER LEVEL - HIGH-HIGH
(With Rosemount Transmitter)

All values are the same as Table 3-15a except:

| Parameter | Allowance* |
|---|---|
| | [ ]+a,c |
| Sensor Pressure Effects | |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Tag No.'s - LT551, LT552, LT553, LT554 | |

* In percent span (100 percent span)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-17a

OVERTEMPERATURE ΔT GAIN CALCULATIONS
(Veritrak Transmitter for Pressurizer Pressure)

The equation for Overtemperature ΔT is:

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

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

As an example to show calculational methodology and conservatism for Millstone Unit 3;

$K_1$ (nominal) = 1.08 TS trip setpoint

$K_1$ (max) = [ ]$^{+a,c}$

$K_2$ = 0.0131

$K_3$ = 0.000603

vessel ΔT = 60.2°F

positive f(ΔI) penalty function gain = 2.0 percent FP/percent ΔI

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

[ ]$^{+a,c}$

[ ]+a,c

---

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

** 1.5 is ΔT instrument span, equivalent to 150 percent Rated Thermal Power.

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TABLE 3-17b

OVERTEMPERATURE ΔT GAIN CALCULATIONS
(Rosemount Transmitter for Pressurizer Pressure)

All values noted in Table 3-17a are the same except:

[ ]+a,c

TABLE 3-18

OVERPOWER ΔT GAIN CALCULATIONS

The equation for Overpower ΔT is:

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

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

For Millstone Unit 3:

| | | |
|---|---|---|
| $K_4$ (nominal) | = | 1.09 TS trip setpoint |
| $K_4$ (max) | = | [ ]+a,c |
| $K_6$ | = | 0.00129 |
| vessel ΔT | = | 60.2°F |

[ ]+a,c

[ ]+a,c

---

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

## TABLE 3-19

## STEAM GENERATOR LEVEL DENSITY VARIATIONS

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

INDICATED LEVEL (50 Percent Power Calibration)

| | 0 percent | 10 percent | 70 percent | 100 percent |
|---|---|---|---|---|

[ ]+a,c

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

## TABLE 3-20

## ΔP MEASUREMENTS EXPRESSED IN FLOW UNITS

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

+a,c

Error in flow units is:

[ ]$^{+a,c}$

Equation 3-20.B is used to express errors in percent full span in this document.

TABLE 3-21

RCP SHAFT - LOW SPEED

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

Tag No.'s - SE475, SE476, SE477, SE478

* In percent span (100% nominal rotation speed)

Channel Statistical Allowance =

[ ]+a,c

# 4.0 TECHNICAL SPECIFICATION USAGE

## 4.1 CURRENT USE

The Standardized Technical Specifications (STS) as used for Westinghouse type plant designs (see NUREG-0452, Revision 4) utilizes a two column format for the RPS and ESF system. This format recognizes that the setpoint channel breakdown, as presented in Figure 4-1, allows for a certain amount of rack drift. The intent of this format is to reduce the number of Licensee Event Reports (LERs) in the area of instrumentation setpoint drift. It appears that this approach has been successful in achieving its goal. However, the approach utilized is fairly simplistic [

]$^{+a,c}$

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

]$^{+a,c}$ and allows for a more flexible approach in reporting LERs. Also of significant benefit to the plant is the incorporation of sensor drift parameters on an 18 month basis (or more often if necessary).

## 4.2 WESTINGHOUSE STATISTICAL SETPOINT METHODOLOGY FOR STS SETPOINTS

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

### 4.2.1 RACK ALLOWANCE

The first item that will be covered is the interactive effects. When an instrument technician looks for [ $]^{+a,c}$ he is seeing more than that. This interaction has been noted several times and is handled in Equations 2.1 and 3.1 [

$]^{+a,c}$. To provide a conservative "trigger value", the difference between the STS trip setpoint and the STS allowable value is determined by two methods. The first is simply the values used in the [ $]^{+a,c}$.
The second [ $]^{+a,c}$ as follows:

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

where:

[ $]^{+a,c}$

The smaller of the trigger values should be used for comparison with the "as measured" [ ]$^{+a,c}$ value. As long as the "as measured" value is smaller, the channel is well within the accuracy allowance. If the "as measured" value exceeds the "trigger value", the actual numbers should be used in the calculation described in Section 4.2.3.

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

### 4.2.2 INCLUSION OF "AS MEASURED" SENSOR ALLOWANCE

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

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

where:

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

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

and all other parameters are as defined in Equation 4.1.

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

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

where:

[ ] +a,c

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

4.2.3 IMPLEMENTATION OF THE WESTINGHOUSE SETPOINT METHODOLOGY

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

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

[ ] +a,c

[ ]+a,c

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

Now assume that one bistable has "drifted" more than that allowed by the STS for 31 day surveillance. According to ACTION statement "A", the plant staff must verify that Equation 2.2-1 is met. Going to Table 2.2-1, the following values are noted: Z = 2.18 and the Total Allowance (TA) = 8.0. Assume that the "as measured" rack setpoint value is 4.5 percent high and the "as measured" sensor value is 1.5 percent. Equation 2.2-1 looks like:

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

$$2.18 + 4.5 + 1.5 \leq 8.0$$

$$8.2 > 8.0$$

As can be seen, 8.2 percent is not less than 8.0 percent thus, the plant staff must follow ACTION statement "B" (declare channel inoperable and place in the "tripped" condition). It should be noted that if the plant staff had not measured the sensor drift, but instead used the value of S in Table 2.2-1 then the sum of Z + R + S would also be greater than 8.0 percent. In fact, almost

anytime the "as measured" value for rack drift is greater than T (the "trigger value"), use of S in Table 2.2-1 will result in the sum of Z + R + S being greater than TA and requiring the reporting of the case of the NRC.

If the sum of R + S was about 0.3 percent less, e.g., R = 4.1 percent, S = 1.3 percent thus, R + S = 5.4 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.

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

[ ] +a,c

(Eq. 4.4)

(Eq. 4.5)

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

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

[ ] +a,c

(Eq. 4.6)

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

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

[ ]+a,c

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

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

## 4.3 CONCLUSION

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

TABLE 4-1

EXAMPLES OF CURRENT STS SETPOINT PHILOSOPHY

| | Power Range Neutron Flux - High | Pressurizer Pressure - High* |
|---|---|---|
| Safety Analysis Limit | 118 percent | 2410 psig |
| STS Allowable Value | 110 percent | 2380 psig |
| STS Trip Setpoint | 109 percent | 2370 psig |

TABLE 4-2

EXAMPLES OF WESTINGHOUSE STS RACK ALLOWANCE

| | Power Range Neutron Flux - High | Pressurizer Pressure - High* |
|---|---|---|
| Safety Analysis Limit | 118 percent | 2410 psig |
| STS Allowable Value (Trigger Value) | 111.2 percent | 2384 psig |
| STS Trip Setpoint | 109 percent | 2370 psig |

*With Veritrak Transmitter

Safety Analysis Limit —

} Process Measurement Accuracy

} Primary Element Accuracy

} Sensor Temperature Effects

} Sensor Pressure Effects

} Sensor Calibration Accuracy

} Sensor Drift

} Environmental Allowance

} Rack Temperature Effects

} Rack Comparator Setting Accuracy

} Rack Calibration Accuracy

STS Allowable Value —

} Rack Drift

STS Trip Setpoint —

Actual Calibration Setpoint —

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

Safety Analysis Limit —

Process Measurement Accuracy

Primary Element Accuracy

Sensor Temperature Effects

Sensor Pressure Effects

Sensor Calibration Accuracy

Sensor Drift

Environmental Allowance

Rack Temperature Effects

STS Allowable Value —

Rack Comparator Setting Accuracy

Rack Calibration Accuracy

Rack Drift

STS Trip Setpoint —

Figure 4-2 Westinghouse STS Setpoint Error Breakdown

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# APPENDIX A

## SAMPLE MILLSTONE

## 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.

(Eq. 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 of span) of rack error for the affected channel,

S = Either the "as measured" value (in percent of 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 | S | Trip Setpoint | Allowable Value |
|---|---|---|---|---|---|---|
| 1. | Manual Reactor Trip | N.A. | N.A. | N.A. | N.A. | N.A. |
| 2. | Power Range, Neutron Flux, High Setpoint | 7.5 | 4.56 | 0 | ≤ 109 percent of RTP | ≤ 111.1 percent of RTP |
| | Low Setpoint | 8.3 | 4.56 | 0 | ≤ 25 percent of RTP | ≤ 27.1 percent of RTP |
| 3. | Power Range, Neutron Flux, High Positive Rate | 1.6 | 0.50 | 0 | ≤ 5 percent of RTP with a time constant ≥ 2 seconds | ≤ 6.3 percent of RTP with a time constant ≥ 2 seconds |
| 4. | Power Range, Neutron Flux, High Negative Rate | 1.6 | 0.50 | 0 | ≤ 5 percent of RTP with a time constant ≥ 2 seconds | ≤ 6.3 percent of RTP with a time constant ≥ 2 seconds |
| 5. | Intermediate Range, Neutron Flux | 17.0 | 8.41 | 0 | ≤ 25 percent of RTP | ≤ 30.9 percent of RTP |
| 6. | Source Range, Neutron Flux | 17.0 | 10.01 | 0 | ≤ $10^5$ cps | ≤ 1.4 x $10^5$ cps |
| 7. | Overtemperature ΔT (N loop) | 8.3 | 5.90 | 1.1+1.2 | See note 1 | See note 2 |
| | (N-1 loop) | 12.0 | 5.90 | 1.1+1.2 | See note 1 | See note 2 |
| 8. | Overpower ΔT | 4.8 | 1.43 | 0.11 | See note 3 | See note 4 |
| 9. | Pressurizer Pressure - Low | 5.0 | 1.77 | 3.3 | ≥ 1885 psig | ≥ 1875 psig |
| 10. | Pressurizer Pressure - High | 5.0 | 1.77 | 3.3 | ≤ 2370 psig | ≤ 2380 psig |
| 11. | Pressurizer Water Level-High | 8.0 | 5.13 | 2.7 | ≤ 89 percent of instrument span | ≤ 90.7 percent of instrument span |
| 12. | Loss of Flow | 2.5 | 1.74 | 0.8 | ≥ 90 percent of loop design flow* | ≥ 89.3 percent of loop design flow* |

*Loop design flow = 94,600 gpm (N loop operation), 99,600 gpm (N-1 loop operation)

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

| Functional Unit | Total Allowance (TA) | Z | S | Trip Setpoint | Allowable Value |
|---|---|---|---|---|---|
| 13. Steam Generator Water Level - Low-Low | 20.5 | 18.98 | 1.75 | ≥ 23.5 percent of narrow range instrument span | ≥ 22.6 percent of narrow range instrument span |
| 14. General Warning Alarm | N.A. | N.A. | N.A. | N.A. | N.A. |
| 15. RCP Shaft - Low Speed | 3.8 | 0.5 | 0.0 | 97.8% nominal speed | 94.6% nominal speed |
| 16. Turbine Trip | | | | | |
| a. Low Fluid Oil Pressure | N.A. | N.A. | N.A. | | |
| b. Turbine Stop Valve Closure | N.A. | N.A. | N.A. | | |
| 17. Safety Injection Input from ESF | N.A. | N.A. | N.A. | N.A. | N.A. |

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

| Functional Unit | Total Allowance (TA) | Z | S | Trip Setpoint | Allowable Value |
|---|---|---|---|---|---|
| 19. Reactor Trip System Interlocks | | | | | |
| a. Intermediate Range Neutron Flux, P-6 | N.A. | N.A. | N.A. | $\geq 1 \times 10^{-10}$ amps | $\geq 6 \times 10^{-11}$ amps |
| b. Low Power Reactor Trips Block, P-7 | | | | | |
| 1. P-10 input | N.A. | N.A. | N.A. | ≤10 percent of RTP | ≤12.1 percent of RTP |
| 2. P-13 input | N.A. | N.A. | N.A. | ≤10 percent turbine impulse pressure equivalent | ≤12.1 percent turbine impulse pressure equivalent |
| c. Power Range Neutron Flux, P-8 (N loop operation) | N.A. | N.A. | N.A. | ≤37.5 percent of RTP | ≤39.6 percent of RTP |
| d. Power Range Neutron Flux, P-8 (N-1 loop operation) | N.A | N.A | N.A | ≤37.5 percent of RTP | ≤39.6 percent of RTP |
| e. Power Range Neutron Flux, P-9 | N.A. | N.A. | N.A. | ≤51 percent of RTP | ≤53.1 percent of RTP |
| f. Power Range Neutron Flux, P-10 | N.A. | N.A. | N.A. | ≥10 percent of RTP | ≥7.9 percent of RTP |
| 20. Reactor Trip Breakers | N.A. | N,A. | N.A. | N.A. | N.A. |
| 21. Automatic Trip and Interlock Logic | N.A. | N.A. | N.A. | N.A. | N.A. |

* Later

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS
NOTATION

NOTE 1: OVERTEMPERATURE ΔT $\left(\frac{1 + \tau_1 S}{1 + \tau_2 S}\right) \left(\frac{1}{1 + \tau_3 S}\right)$

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

Where:

$\Delta T$ = Measured ΔT by RTD Manifold Instrumentation;

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

$\tau_1$, $\tau_2$ = Time constants utilized in the lead-lag controller for ΔT, $\tau_1$ = 8 secs., $\tau_2$ = 3 secs.

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

$\tau_3$ = Time constant utilized in the lag compensator for ΔT, $\tau_3$= 0 secs.

$\Delta T_o$ = Indicated ΔT at RATED THERMAL POWER;

$K_1$ = 1.080 (N loop operation) , 1.010 (N-1 loop operation)

$K_2$ = 0.01313

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

$\tau_4$, $\tau_5$ = Time constants utilized in the lead-lag controller for $T_{avg}$, $\tau_4$ = 33 secs., $\tau_5$ = 4 secs.

T = Average temperature °F

$\frac{1}{1 + \tau_6 S}$ = Lag compensator on measured $T_{avg}$

$\tau_6$ = Time constant utilized in the measured $T_{avg}$ lag compensator, $\tau_6$ = 0 secs.

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS NOTATION

NOTE 1: (continued)

| | | |
|---|---|---|
| T' | = | ≤ 587.1°F (Nominal $T_{avg}$ at RATED THERMAL POWER) |
| $K_3$ | = | 0.000603 |
| P | = | Pressurizer pressure, psig |
| P' | = | 2235 psig (Nominal RCS operating pressure); and |
| S | = | Laplace transform operator, $sec^{-1}$; |

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 $q_t - q_b$ between -30 percent and +10 percent, $f_1(\Delta I) = 0$ (where $q_t$ and $q_b$ are percent RATED THERMAL POWER in the top and bottom halves of the core respectively, and $q_t + q_b$ is total THERMAL POWER in percent of RATED THERMAL POWER);

(ii) for each percent that the magnitude of $(q_t - q_b)$ exceeds -30 percent, the ΔT trip setpoint shall be automatically reduced by 3.6 percent of its value at RATED THERMAL POWER; and

(iii) for each percent that the magnitude of $(q_t - q_b)$ exceeds +10 percent, the ΔT Trip Setpoint shall be automatically reduced by 2.0 percent of its value at RATED THERMAL POWER.

NOTE 2: The channel's maximum Trip Setpoint shall not exceed its computed trip point by more than 2.1 percent ΔT span (N loop operation), 4.1% ΔT span (N-1 loop operation).

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS NOTATION

NOTE 3: OVERPOWER $\Delta T \quad \left(\frac{1 + \tau_1 S}{1 + \tau_2 S}\right) \left(\frac{1}{1 + \tau_3 S}\right)$

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

Where: $\Delta T$ = As defined in Note 1,

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

$\tau_1$, $\tau_2$ = As defined in Note 1

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

$\tau_3$ = As defined in Note 1

$\Delta T_o$ = As defined in Note 1

$K_4$ = 1.09

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

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

$\tau_7$ = Time constant utilized in the lead-lag controller for $T_{avg}$, $\tau_7$ = 10 secs.

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

$\tau_6$ = As defined in Note 1

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS
NOTATION (Continued)

NOTE 3: (continued)

$K_6$ = 0.00129/°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, ≤ 587.1°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 Setpoint by more than 3.4 percent ΔT span.

## 2.2 LIMITING SAFETY SYSTEM SETTINGS

BASES

### 2.2.1 REACTOR TRIP SYSTEM INSTRUMENTATION SETPOINTS

The Reactor Trip Setpoint Limits specified in Table 2.2-1 are the nominal values at which the Reactor trips are set for each functional unit. The Trip Setpoints have been selected to ensure that the 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 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 2.2-1, in percent span, is the statistical summation of errors assumed in the analysis excluding those associated with the sensor and rack drift and the accuracy of their measurement. TA or Total Allowance is the difference, in percent span, between the Trip Setpoint and the value used in the analysis for Reactor Trip. R or Rack Error is the "as measured" deviation, in percent span, for the affected channel from the specified Trip

Setpoint. S or Sensor Error is either the "as measured" deviation of the sensor from its calibration point or the value specified in Table 2.2-1, in percent span, from the analysis assumptions. Use of Equation 2.2-1 allows for a sensor drift factor, an increased rack drift factor, and provides a threshold value for REPORTABLE EVENTS.

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 instrumentaton 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 of sensor drift, in excess of the allowance that is more than occasional, may be indicative of more serious problems and should warrant further investigation.

INSTRUMENTATION

## 3/4.3.2 ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION LIMITING CONDITION FOR OPERATION

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

APPLICABILITY: As shown in Table 3.3-3.

ACTION:

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

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

   2. Declare the channel inoperable and apply the applicable ACTION statement requirements of Table 3.3-3 until the channel is restored to OPERABLE status with its Setpoint adjusted consistent with the Trip Setpoint value.

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

Where:

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

R = The "as measured" value (in percent span) or 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.

c. With an ESFAS instrumentation channel or interlock inoperable, take the ACTION shown in Table 3.3-3.

SURVEILLANCE REQUIREMENTS

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

TABLE 3.3-4

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

| Functional Unit | Total Allowance (TA) | Z | Sensor Drift (S) | Trip Setpoint | Allowable Value |
|---|---|---|---|---|---|
| 1. Safety Injection, Reactor Trip, Feedwater Isolation, Control Room Isolation, Start Diesel Generators, Containment Cooling Fans, and Essential Service Water | | | | | |
| a. Manual Initiation | N.A. | N.A. | N.A. | N.A. | N.A. |
| b. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| c. Containment Pressure - High | 3.3 | 1.01 | 1.75 | ≤ 3.0 psig | ≤ 3.8 psig |
| d. Pressurizer Pressure - Low | 16.5 | 13.67 | 3.3 | ≥ 1877.3 psig | ≥ 1870.2 psig |
| e. Steamline Pressure - Low | 17.7 | 15.31 | 2.2 | ≥ 658.6 psig* | ≥ 644.9 psig* |

TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

| Functional Unit | Total Allowance (TA) | Z | Sensor Drift (S) | Trip Setpoint | Allowable Value |
|---|---|---|---|---|---|
| 2. Containment Spray | | | | | |
| a. Manual Initiation | N.A. | N.A. | N.A. | N.A. | N.A. |
| b. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| c. Containment Pressure - High-3 | 3.3 | 1.01 | 1.75 | ≤ 8.0 psig | ≤ 8.8 psig |
| 3. Containment Isolation | | | | | |
| a. Phase "A" Isolation | | | | | |
| 1. Manual Initiation | N.A. | N.A. | N.A. | N.A. | N.A. |
| 2. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| 3. Safety Injection | See Item 1 above for all Safety functions and requirements. | | | | |
| B. Phase "B" Isolation | | | | | |
| 1. Manual Initiation | N.A. | N.A. | N.A. | N.A. | N.A. |
| 2. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| 3. Containment Pressure - High-3 | 3.3 | 1.01 | 1.75 | ≤ 8.0 psig | ≤ 8.8 psig |

TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

| Functional Unit | Total Allowance (TA) | Z | Sensor Drift (S) | Trip Setpoint | Allowable Value |
|---|---|---|---|---|---|
| 3. Containment Isolation (continued) | | | | | |
| c. Containment Purge Isolation | | | | | |
| 1. Manual Initiation | N.A. | N.A. | N.A. | N.A. | N.A. |
| 2. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| 3. Containment Isolation Phase "A" | See Item 3.a. above for all Containment Isolation Phase "A" functions and requirements. | | | | |
| 4. Steam Line Isolation | | | | | |
| a. Manual Initiation | N.A. | N.A. | N.A. | N.A. | N.A. |
| b. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| c. Containment Pressure - High-2 | 3.3 | 1.01 | 1.75 | ≤ 3.0 psig | ≤ 3.8 psig |
| d. Steamline Pressure - Low | 17.7 | 15.31 | 2.2 | ≥ 658.6 psig* | ≥ 644.9 psig* |
| e. Negative Steam Pressure-Negative Rate - High | 5.0 | 0.50 | 0.0 | ≥ -100 psi with a time constant of 50 secs. | ≥ -122.7 psi with a time constant of 50 secs. |

TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURE 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 Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| b. Steam Generator Water Level--High-High | 3.7 | 2.33 | 1.75 | ≤ 82.0 percent of narrow range instrument span | ≤ 82.8 percent of narrow range instrument span |
| 6. Auxiliary Feedwater | | | | | |
| a. Manual Initiation | N.A. | N.A. | N.A. | N.A. | N.A. |
| b. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| c. Steam Generator Water Level--Low-Low | | | | | |
| 1. Start Motor-Driven Pumps | 20.5 | 18.98 | 1.75 | ≥ 23.5 percent of narrow range instrument span | ≥ 22.6 percent of narrow range instrument span |
| 2. Start Turbine-Driven Pump | 20.5 | 18.98 | 1.75 | ≥ 23.5 percent of narrow range instrument span | ≥ 22.6 percent of narrow range instrument span |
| d. Safety Injection Start Motor-Driven Pumps | See Item 1 above for all Safety Injection Functions and requirements | | | | |

TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

| Functional Unit | Total Allowance (TA) | Z | Sensor Drift (S) | Trip Setpoint | Allowable Value |
|---|---|---|---|---|---|
| 6. Auxiliary Feedwater (continued) | | | | | |
| e. Station Blackout Start Turbine-Driven Pump | N.A. | N.A. | N.A. | N.A. | N.A. |
| f. Trip Main Feedwater Pumps-Start Motor-Driven Pumps and Turbine-Driven Pump | N.A. | N.A. | N.A. | N.A. | N.A. |
| 7. Automatic Switchover Lo Containment Sump | | | | | |
| a. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| b. RWST Level--Low-Low | ** | ** | ** | ** | ** |
| Coincident with Safety Injection | See Item 1 above for Safety Injection functions and requirements. | | | | |
| 8. Loss of Power | | | | | |
| a. 4.16 kV Undervoltage -Loss of Voltage | ** | ** | ** | ** | ** |
| b. 4.16 kV Undervoltage -Grid Degraded Voltage | ** | ** | ** | ** | ** |
| 9. Engineered Safety Feature Actaution System Interlocks | | | | | |
| a. Pressurizer Pressure, P-11 | N.A. | N.A. | N.A. | ≤ 1985 psig | ≤ 1995 psig |
| b. Reactor Trip, P-4 | N.A. | N.A. | N.A. | N.A. | N.A. |

TABLE 3.3-4 (Continued)

TABLE NOTATION

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

** To be provided by plant.

## 3.4.3 INSTRUMENTATION

## BASES

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

The OPERABILITY of the Reactor Trip System and the Engineered Safety Features Actuation System instrumentation and interlocks ensures 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 safety 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 Features 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 3.3-1, $Z + R + S \leq TA$, the interactive effects of the errors in the rack and the sensor, and the "as measured" values of the errors are considered. Z, as specified in Table 3.3-4, in percent span, is the statistical summation of errors assumed in the analysis excluding those associated with the sensor and rack drift and the accuracy of their measurement. TA or Total Allowance is the difference, in percent span, between the Trip Setpoint and the value used in the analysis for the actuation. R or Rack Error is the "as measured" deviation, in percent span, for the affected channel from the specified Trip Setpoint. S or Sensor Error is either the "as measured" deviation of the sensor from its calibration point or the value specified in Table 3.3-4, in percent span, from the analysis assumptions.

The methodology to derive the Trip Setpoints is based upon combining all of the uncertanties 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.

WCAP-10992

# WESTINGHOUSE SETPOINT METHODOLOGY FOR PROTECTION SYSTEMS MILLSTONE NUCLEAR POWER STATION UNIT 3

November, 1985

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# 1.0 INTRODUCTION

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

The basic underlying assumption used is that several of the error components and their parameter assumptions act independently, e.g., [ ]$^{+a,c}$. This allows the use of a statistical summation of the various breakdown components instead of a strictly arithmetic summation. A direct benefit of the use of this technique is increased margin in the total allowance. For those parameter assumptions known to be interactive, the technique uses the normal, conservative approach, arithmetic summation, to form independent quantities, e.g., [ ]$^{+a,c}$. An explanation of the overall approach is provided in Section 2.0.

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

Section 4.0 notes what the current (read NRC) Technical Specifications use for setpoints and an explanation of the impact of the statistical approach on them. Detailed examples of how to determine the Technical Specification setpoint values are also provided. An Appendix is provided noting a recommended set of Technical Specifications using the plant specific data in the statistical approach. For those protection functions using both Veritrak and Rosemount transmitters, only the most limiting case is provided.

# 2.0 COMBINATION OF ERROR COMPONENTS

## 2.1 METHODOLOGY

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

The methodology used for this combination is not new. Basically it is the [ ]+a,c,e which has been utilized in other Westinghouse reports. This technique, or other statistical approaches of a similar nature, have been used in WCAP-10395(1) and WCAP-8567(2). It should be noted that WCAP-8567 has been approved by the NRC Staff thus noting the acceptability of statistical techniques for the application requested. It should also be recognized that ANSI, the American Nuclear Society, and the Instrument Society of America approve of the use of probabilistic techniques in determining safety-related setpoints(3)(4). Thus it can be seen that the use of statistical approaches in analysis techniques is becoming more and more widespread.

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

[ ]+a,c

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

where:

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

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

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

## 2.2 SENSOR ALLOWANCES

Four parameters are considered to be sensor allowances, SCA, SD, STE, and SPE (see Table 3-16). Of these four parameters, two are considered to be statistically independent, [ ]$^{+a,c}$, and two are considered interactive [ ]$^{+a,c}$. [ ]$^{+a,c}$ are considered to be independent due to the manner in which the instrumentation is checked, i.e., the instrumentation is [ ]$^{+a,c}$. An example of $^{+a,c}$

[ ]

[ ]$^{+a,c}$ are considered to be interactive for the same reason that [ ]$^{+a,c}$ are considered independent, i.e., due to the manner in which the instrumentation is checked. [ ]$^{+a,c}$. Based on this reasoning, [ ]$^{+a,c}$ have been added to form an independent group which is then factored into Equation 2.1. An example of the impact of this treatment is; for Pressurizer Water Level-High (Veritrak parameters only):

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

using Equation 2.1 as written gives a total of;

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

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

[ ]$^{+a,c}$ (Eq. 2.2) = 1.32 percent

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

## 2.3 RACK ALLOWANCES

Four parameters, as noted by Table 3-16, are considered to be rack allowances, RCA, RCSA, RTE, and RD. Three of these parameters are considered to be interactive (for much the same reason outlined for sensors in 2.2), [ ]$^{+a,c}$. [ ]$^{+a,c}$

[

]$^{+a,c}$. Based on this logic, these three factors have been added to form an independent group. This group is then factored into Equation 2.1. The impact of this approach (formation of an independent group based on interactive components) is significant. For the same channel using the same approach outlined in Equations 2.1 and 2.2 the following results are reached:

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

using Equation 2.1 the result is;

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

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

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

= 1.25 percent

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

## 2.4 PROCESS ALLOWANCES

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

# 3.0 PROTECTION SYSTEM SETPOINT METHODOLOGY

## 3.1 MARGIN CALCULATION

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

[ ] +a,c

(Eq. 3.1)

where:

TA = Total Allowance (Safety Analysis Limit - Nominal Trip Setpoint), and all other parameters are as defined for Equation 2.1.

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

## 3.2 DEFINITIONS FOR PROTECTION SYSTEM SETPOINT TOLERANCES

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

1. Trip Accuracy

The tolerance band containing the highest expected value of the difference between (a) the desired trip point value of a process variable and (b) the

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

2. Process Measurement Accuracy

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

3. Actuation Accuracy

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

4. Indication Accuracy

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

5. Channel Accuracy

The accuracy of an analog channel which includes the accuracy of the primary element and/or transmitter and modules in the chain where

calibration of modules intermediate in a chain is allowed to compensate for errors in other modules of the chain. Rack environmental effects are not included here to avoid duplication due to dual inputs, however, normal environmental effects on field mounted hardware is included.

6. Sensor Allowable Deviation

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

The tolerances are as follows:

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

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

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

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

---

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

7. Rack Allowable Deviation

The tolerances are as follows:

a. Rack Calibration Accuracy

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

b. Rack Environmental Effects

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

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

d. Comparator Setting Accuracy

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

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

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

The tolerances are as follows:

(a) Fixed setpoint with a single input - [ ]$^{+a,b,c}$ 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.

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

8. Nominal Safety System Setting

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

9. Limiting Safety System Setting

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

10. Allowance for Instrument Channel Drift

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

11. Safety Analysis Limit

The setpoint value assumed in safety analyses.

12. Total Allowable Setpoint Deviation

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

### 3.3 STATISTICAL METHODOLOGY CONCLUSION

The Westinghouse setpoint methodology results in a value with a 95 percent probability with a high confidence level. With the exception of Process Measurement Accuracy, Rack Drift and Sensor Drift, all uncertainties assumed are the extremes of the ranges of the various parameters, i.e., are better than $2\sigma$ 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.

### 3.4 ROSEMOUNT TRANSMITTER CALCULATIONS

In addition to the Veritrak transmitters supplied by Westinghouse, Northeast Utilities Service Company has utilized Rosemount transmitters for many of the protection functions. Westinghouse has determined the instrument uncertainties for SCA, SPE, STE, and SD based on Rosemount Product Data Sheets 2388 (1153 series D), 2302 (1153 series B), and 2514 (1154) which were supplied to Westinghouse via Stone and Webster Engineering Corporaton letters NES-35935 (7/19/84), NES-32874 (8/16/83), and NES-37613 (2/18/85). In addition, Westinghouse received explicit instructions concerning the determination of the Environmental Allowance for these transmitters, NES-36886 (11/19/84), NES-37085 (12/13/84), and NES-37613 (2/18/85). Westinghouse has calculated these values in accordance with these instructions.

## TABLE 3-1

## POWER RANGE, NEUTRON FLUX - HIGH AND LOW SETPOINTS

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy<br>[ ] +a,c | [ ] +a,c |
| Primary Element Accuracy | |
| Sensor Calibration<br>[ ] +a,c | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects<br>[ ] +a,c | |
| Sensor Drift<br>[ ] +a,c | |
| Environmental Allowance | |
| Rack Calibration<br>Rack Accuracy | |
| Comparator<br>One input | |
| Rack Temperature Effects | |
| Rack Drift | |
| Tag No.'s - N41, N42, N43, N44 | |

* In percent span (120 percent Rated Thermal Power)

Channel Statistical Allowance =

[ ] +a,c

TABLE 3-2

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

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy [ ]+a,c | [ ]+a,c |
| Primary Element Accuracy | |
| Sensor Calibration [ ]+a,c | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects [ ]+a,c | |
| Sensor Drift [ ]+a,c | |
| Environmental Allowance | |
| Rack Calibration<br>Rack Accuracy | |
| Comparator<br>One input | |
| Rack Temperature Effects | |
| Rack Drift | |
| Tag No.'s - N41, N42, N43, N44 | |

* In percent span (120 percent Rated Thermal Power)

Channel Statistical Allowance =

[ ]+a,c

## TABLE 3-3

## INTERMEDIATE RANGE, NEUTRON FLUX

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy<br>[ ]+a,c | [ ]+a,c |
| Primary Element Accuracy | |
| Sensor Calibration<br>[ ]+a,c | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects<br>[ ]+a,c | |
| Sensor Drift<br>[ ]+a,c | |
| Environmental Allowance | |
| Rack Calibration<br>Rack Accuracy | |
| Comparator<br>One input | |
| Rack Temperature Effects | |
| Rack Drift<br>5 percent of Rated Thermal Power | |
| Tag No.'s - N35, N36 | |

---

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

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-4

SOURCE RANGE, NEUTRON FLUX

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy [ ]+a,c | [ ]+a,c |
| Primary Element Accuracy | |
| Sensor Calibration [ ]+a,c | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects [ ]+a,c | |
| Sensor Drift [ ]+a,c | |
| Environmental Allowance | |
| Rack Calibration<br>Rack Accuracy | |
| Comparator<br>One input | |
| Rack Temperature Effects | |
| Rack Drift<br>$3 \times 10^4$ cps | |
| Tag No.'s - N31, N32 | |

* In percent span ($1 \times 10^6$ counts per second)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-5a

OVERTEMPERATURE ΔT (Veritrak Transmitter for Pressurizer Pressure)

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy [ ]+a,c | [ ]+a,c |
| Primary Element Accuracy | |
| Sensor Calibration [ ]+a,c | |
| Sensor Pressure Effects ]+a,c | |
| Sensor Temperature Effects [ | |
| Sensor Drift [ ]+a,c | |
| Environmental Allowance [ ]+a,c | |
| Rack Calibration [ ]+a,c | |
| Rack Accuracy | |
| ΔT channel | |
| $T_{avg}$ channel | |
| Pressure channel | |
| ΔI channel | |
| Total | |
| ΔT channel | |
| $T_{avg}$ channel | |
| Pressure channel | |
| ΔI channel | |

TABLE 3-5a (Continued)

OVERTEMPERATURE ΔT

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

Tag No.'s - TE411A, TE411B, PT455, N41
TE421A, TE421B, PT456, N42

---

* In percent span ($T_{avg}$ - 100°F, pressure - 800 psi, power - 150 percent Rated Thermal Power, ΔT - 90.3°F, ΔI - ± 60 percent ΔI; 90.3°F span = 150 percent power)

** See Table 3-17a for gain calculations

Channel Statistical Allowance =

[ ] +a,c

TABLE 3-5b

OVERTEMPERATURE ΔT (Rosemount Transmitter for Pressurizer Pressure)

All values are the same as Table 3-5a except:

| Parameter | Allowance* |
|---|---|
| Sensor Temperature Effects<br>[ ]+a,c | [ ]+a,c |
| Sensor Drift<br>[ ]+a,c | |

Tag No.'s - TE431A, TE431B, PT457, N43
TE441A, TE441B, PT458, N44

---

*In percent span (See Table 3-5b)
**See Table 3-17a for gain calculations

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-6

OVERPOWER ΔT

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy [ ]$^{+a,c}$ | [ ]$^{+a,c}$ |
| Primary Element Accuracy | |
| Sensor Calibration [ ]$^{+a,c}$ | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects | |
| Sensor Drift [ ]$^{+a,c}$ | |
| Environmental Allowance | |
| Rack Calibration [ ]$^{+a,c}$ | |
| Rack Accuracy | |
| ΔT channel | |
| $T_{avg}$ channel | |
| Total | |
| ΔT channel | |
| $T_{avg}$ channel | |
| Comparator | |
| Two inputs | |
| Rack Temperature Effects | |
| Rack Drift | |
| ΔT channel | |
| $T_{avg}$ channel | |

TABLE 3-6 (Continued)

OVERPOWER ΔT

Tag No.'s - TE411A, TE411B
TE421A, TE421B
TE431A, TE431B
TE441A, TE441B

---

* In percent span ($T_{avg}$ - 100°F, pressure - 800 psi, power - 150 percent Rated Thermal Power, ΔT - 90.3°F; 90.3°F span = 150 percent power)

** See Table 3-18 for gain calculations

Channel Statistical Allowance =

[ ] +a,c

TABLE 3-7a

PRESSURIZER PRESSURE - LOW AND HIGH, REACTOR TRIPS
(With Veritrak Transmitter)

| Parameter | Allowance* |
|---|---|
| | +a,c |
| Process Measurement Accuracy | |
| Primary Element Accuracy | |
| Sensor Calibration | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Environmental Allowance | |
| Rack Calibration<br>Rack Accuracy | |
| Comparator<br>One input | |
| Rack Temperature Effects | |
| Rack Drift | |
| Tag No.'s - PT455, PT456 | |

* In percent span (800 psi)

Channel Statistical Allowance =

+a,c

TABLE 3-7b

PRESSURIZER PRESSURE - LOW AND HIGH, REACTOR TRIPS
(With Rosemount Transmitter)

All values are the same as Table 3-7a except:

| Parameter | Allowance* |
|---|---|
| Sensor Temperature Effects | [ ]+a,c |
| Sensor Drift | |
| Tag No.'s - PT457, PT458 | |

*In percent span (100 percent span)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-8a

PRESSURIZER WATER LEVEL - HIGH
(With Veritrak Transmitter)

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy [ ]+a,c | [ ]+a,c |
| Primary Element Accuracy | |
| Sensor Calibration | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Environmental Allowance | |
| Rack Calibration<br>Rack Accuracy | |
| Comparator<br>One input | |
| Rack Temperature Effects | |
| Rack Drift | |
| Tag No.'s - LT459 | |

* In percent span (100 percent span)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-8b

PRESSURIZER WATER LEVEL - HIGH
(With Rosemount Transmitter)

All values are the same as Table 3-8a except:

| Parameter | Allowance* |
|---|---|
| Sensor Pressure Effects | [ ]+a,c |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Tag No.'s - LT460, LT461 | |

*In percent span (100 percent span)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-9a

LOSS OF FLOW
(With Rosemount Transmitter)

| Parameter | Allowance* |
| --- | --- |
| Process Measurement Accuracy [ ]+a,c | [ ]+a,c |
| Primary Element Accuracy [ ]+a,c | |
| Sensor Calibration [ ]+a,c | |
| Sensor Pressure Effects [ ]+a,c | |
| Sensor Temperature Effects [ ]+a,c | |
| Sensor Drift [ ]+a,c | |
| Environmental Allowance | |
| Rack Calibration<br>Rack Accuracy [ ]+a,c | |
| Comparator<br>One input [ ]+a,c | |
| Rack Temperature Effects [ ]+a,c | |
| Rack Drift<br>1.0 percent Δp span | |

Tag No.'s - FT414, FT415, FT416, FT424, FT425, FT426
FT434, FT435, FT436, FT444, FT445, FT446

---

* In percent span (120 percent Thermal Design Flow)
Percent Δp span converted to flow span via Eq. 3-20.8

Channel Statistical Allowance = [ ]+a,c

## TABLE 3-10a

### STEAM GENERATOR WATER LEVEL - LOW-LOW
(With Veritrak Transmitter)

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

Tag No.'s - LT517, LT518, LT519
LT527, LT528, LT529
LT537, LT538, LT539
LT547, LT548, LT549

---

* In percent span (100 percent span)

** See Table 3-22 for explanation

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-10b

STEAM GENERATOR WATER LEVEL - LOW-LOW
(With Rosemount Transmitter)

All values the same as Table 3-10a except:

| Parameter | Allowance* |
| --- | --- |
| Sensor Pressure Effects | [ ]+a,c |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Environmental Allowance | |
| Reference Leg Heatup | |
| Tag No.'s - LT551, LT552, LT553, LT554 | |

* In percent span (100 percent span)

Channel Statistical Allowance =

[ ]+a,c

## TABLE 3-11

## CONTAINMENT PRESSURE - HIGH, HIGH-HIGH, HIGH-HIGH-HIGH

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy | $[\ ]^{+a,c}$ |
| Primary Element Accuracy | |
| Sensor Calibration | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Environmental Allowance | |
| Rack Calibration<br>Rack Accuracy | |
| Comparator<br>One input | |
| Rack Temperature Effects | |
| Rack Drift<br>(0.6 psig) | |

Tag No.'s - PT934, PT935, PT936, PT937

---

* In percent span (60 psig)

Channel Statistical Allowance =

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

TABLE 3-12a

PRESSURIZER PRESSURE - LOW, SAFETY INJECTION
(With Veritrak Transmitter)

| Parameter | Allowance* |
|---|---|
| | [ ]+a,c |
| Process Measurement Accuracy | |
| Primary Element Accuracy | |
| Sensor Calibration | |
| Sensor Pressure Effects | |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Environmental Allowance | |
| Rack Calibration | |
| Rack Accuracy | |
| Comparator | |
| One input | |
| Rack Temperature Effects | |
| Rack Drift | |
| Tag No.'s - PT455, PT456 | |

* In percent span (800 psi)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-12b

PRESSURIZER PRESSURE - LOW, SAFETY INJECTION
(With Rosemount Transmitter)

All values are the same as Table 3-12a except:

| Parameter | Allowance* |
| --- | --- |
| Sensor Temperature Effects | [ ]+a,c |
| Sensor Drift | |
| Environmental Allowance | |
| Tag No.'s - PT457, PT458 | |

* In percent span (800 psi)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-13

STEAMLINE PRESSURE - LOW

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

Tag No.'s - PT514, PT515, PT516
PT524, PT525, PT526
PT534, PT535, PT536
PT544, PT545, PT546

---

* In percent span (1300 psig)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-14

NEGATIVE STEAMLINE PRESSURE RATE - HIGH

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

Tag No.'s - PT514, PT515, PT516
PT524, PT525, PT526
PT534, PT535, PT536
PT544, PT545, PT546

---

* In percent span (1300 psig)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-15a

STEAM GENERATOR WATER LEVEL - HIGH-HIGH
(With Veritrak Transmitter)

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

Tag No.'s - LT517, LT518, LT519
LT527, LT528, LT529
LT537, LT538, LT539
LT547, LT548, LT549

---

* In percent span (100 percent span)

** See Table 3-19 for explanation

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-15b

STEAM GENERATOR WATER LEVEL - HIGH-HIGH
(With Rosemount Transmitter)

All values are the same as Table 3-15a except:

| Parameter | Allowance* |
|---|---|
| Sensor Pressure Effects | [ ]+a,c |
| Sensor Temperature Effects | |
| Sensor Drift | |
| Tag No.'s - LT551, LT552, LT553, LT554 | |

* In percent span (100 percent span)

Channel Statistical Allowance =

[ ]+a,c

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TABLE 3-17a

OVERTEMPERATURE ΔT GAIN CALCULATIONS
(Veritrak Transmitter for Pressurizer Pressure)

The equation for Overtemperature ΔT is:

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

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

As an example to show calculational methodology and conservatism for Millstone Unit 3;

$K_1$ (nominal) = 1.08 TS trip setpoint
$K_1$ (max) = [ ]+a,c
$K_2$ = 0.0131
$K_3$ = 0.000603
vessel ΔT = 60.2°F
positive f(ΔI) penalty function gain = 2.0 percent FP/percent ΔI

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

[ ]+a,c

[ ] +a,c

---

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

** 1.5 is ΔT instrument span, equivalent to 150 percent Rated Thermal Power.

TABLE 3-17b

OVERTEMPERATURE ΔT GAIN CALCULATIONS
(Rosemount Transmitter for Pressurizer Pressure)

All values noted in Table 3-17a are the same except:

[ ]+a,c

TABLE 3-18

OVERPOWER ΔT GAIN CALCULATIONS

The equation for Overpower ΔT is:

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

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

For Millstone Unit 3:

| | | |
|---|---|---|
| $K_4$ (nominal) | = | 1.09 TS trip setpoint |
| $K_4$ (max) | = | [ ]+a,c |
| $K_6$ | = | 0.00129 |
| vessel ΔT | = | 60.2°F |

[ ]+a,c

[ ]+a,c

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

## TABLE 3-19

## STEAM GENERATOR LEVEL DENSITY VARIATIONS

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

INDICATED LEVEL (50 Percent Power Calibration)

| 0 percent | 10 percent | 70 percent | 100 percent |
|---|---|---|---|

+a,c

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

TABLE 3-20

ΔP MEASUREMENTS EXPRESSED IN FLOW UNITS

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

[ ]+a,c

Error in flow units is:

[ ] +a,c

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

TABLE 3-21

RCP SHAFT - LOW SPEED

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

Tag No.'s - SE475, SE476, SE477, SE478

* In percent span (100% nominal rotation speed)

Channel Statistical Allowance =

[ ]+a,c

# 4.0 TECHNICAL SPECIFICATION USAGE

## 4.1 CURRENT USE

The Standardized Technical Specifications (STS) as used for Westinghouse type plant designs (see NUREG-0452, Revision 4) utilizes a two column format for the RPS and ESF system. This format recognizes that the setpoint channel breakdown, as presented in Figure 4-1, allows for a certain amount of rack drift. The intent of this format is to reduce the number of Licensee Event Reports (LERs) in the area of instrumentation setpoint drift. It appears that this approach has been successful in achieving its goal. However, the approach utilized is fairly simplistic [

]$^{+a,c}$

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

]$^{+a,c}$ and allows for a more flexible approach in reporting LERs. Also of significant benefit to the plant is the incorporation of sensor drift parameters on an 18 month basis (or more often if necessary).

## 4.2 WESTINGHOUSE STATISTICAL SETPOINT METHODOLOGY FOR STS SETPOINTS

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

### 4.2.1 RACK ALLOWANCE

The first item that will be covered is the interactive effects. When an instrument technician looks for [ ]$^{+a,c}$ he is seeing more than that. This interaction has been noted several times and is handled in Equations 2.1 and 3.1 [

]$^{+a,c}$. To provide a conservative "trigger value", the difference between the STS trip setpoint and the STS allowable value is determined by two methods. The first is simply the values used in the [ ].$^{+a,c}$
The second [ ]$^{+a,c}$ as follows:

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

where:

[ ]$^{+a,c}$

The smaller of the trigger values should be used for comparison with the "as measured" [ ]$^{+a,c}$ value. As long as the "as measured" value is smaller, the channel is well within the accuracy allowance. If the "as measured" value exceeds the "trigger value", the actual numbers should be used in the calculation described in Section 4.2.3.

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

4.2.2 INCLUSION OF "AS MEASURED" SENSOR ALLOWANCE

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

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

where:

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

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

and all other parameters are as defined in Equation 4.1.

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

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

where:

[ ] +a,c

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

### 4.2.3 IMPLEMENTATION OF THE WESTINGHOUSE SETPOINT METHODOLOGY

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

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

[ ] +a,c

[ ]+a,c

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

Now assume that one bistable has "drifted" more than that allowed by the STS for 31 day surveillance. According to ACTION statement "A", the plant staff must verify that Equation 2.2-1 is met. Going to Table 2.2-1, the following values are noted: Z = 2.18 and the Total Allowance (TA) = 8.0. Assume that the "as measured" rack setpoint value is 4.5 percent high and the "as measured" sensor value is 1.5 percent. Equation 2.2-1 looks like:

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

$$2.18 + 4.5 + 1.5 \leq 8.0$$

$$8.2 > 8.0$$

As can be seen, 8.2 percent is not less than 8.0 percent thus, the plant staff must follow ACTION statement "B" (declare channel inoperable and place in the "tripped" condition). It should be noted that if the plant staff had not measured the sensor drift, but instead used the value of S in Table 2.2-1 then the sum of Z + R + S would also be greater than 8.0 percent. In fact, almost

anytime the "as measured" value for rack drift is greater than T (the "trigger value"), use of S in Table 2.2-1 will result in the sum of Z + R + S being greater than TA and requiring the reporting of the case of the NRC.

If the sum of R + S was about 0.3 percent less, e.g., R = 4.1 percent, S = 1.3 percent thus, R + S = 5.4 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.

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

[ ]+a,c

(Eq. 4.4)

(Eq. 4.5)

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

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

[ ]+a,c

(Eq. 4.6)

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

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

[ ]+a,c

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

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

## 4.3 CONCLUSION

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

## TABLE 4-1

## EXAMPLES OF CURRENT STS SETPOINT PHILOSOPHY

| | Power Range Neutron Flux - High | Pressurizer Pressure - High* |
|---|---|---|
| Safety Analysis Limit | 118 percent | 2410 psig |
| STS Allowable Value | 110 percent | 2380 psig |
| STS Trip Setpoint | 109 percent | 2370 psig |

## TABLE 4-2

## EXAMPLES OF WESTINGHOUSE STS RACK ALLOWANCE

| | Power Range Neutron Flux - High | Pressurizer Pressure - High* |
|---|---|---|
| Safety Analysis Limit | 118 percent | 2410 psig |
| STS Allowable Value (Trigger Value) | 111.2 percent | 2384 psig |
| STS Trip Setpoint | 109 percent | 2370 psig |

*With Veritrak Transmitter

Safety Analysis Limit —

- Process Measurement Accuracy
- Primary Element Accuracy
- Sensor Temperature Effects
- Sensor Pressure Effects
- Sensor Calibration Accuracy
- Sensor Drift
- Environmental Allowance
- Rack Temperature Effects
- Rack Comparator Setting Accuracy
- Rack Calibration Accuracy

STS Allowable Value —

- Rack Drift

STS Trip Setpoint —

Actual Calibration Setpoint —

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

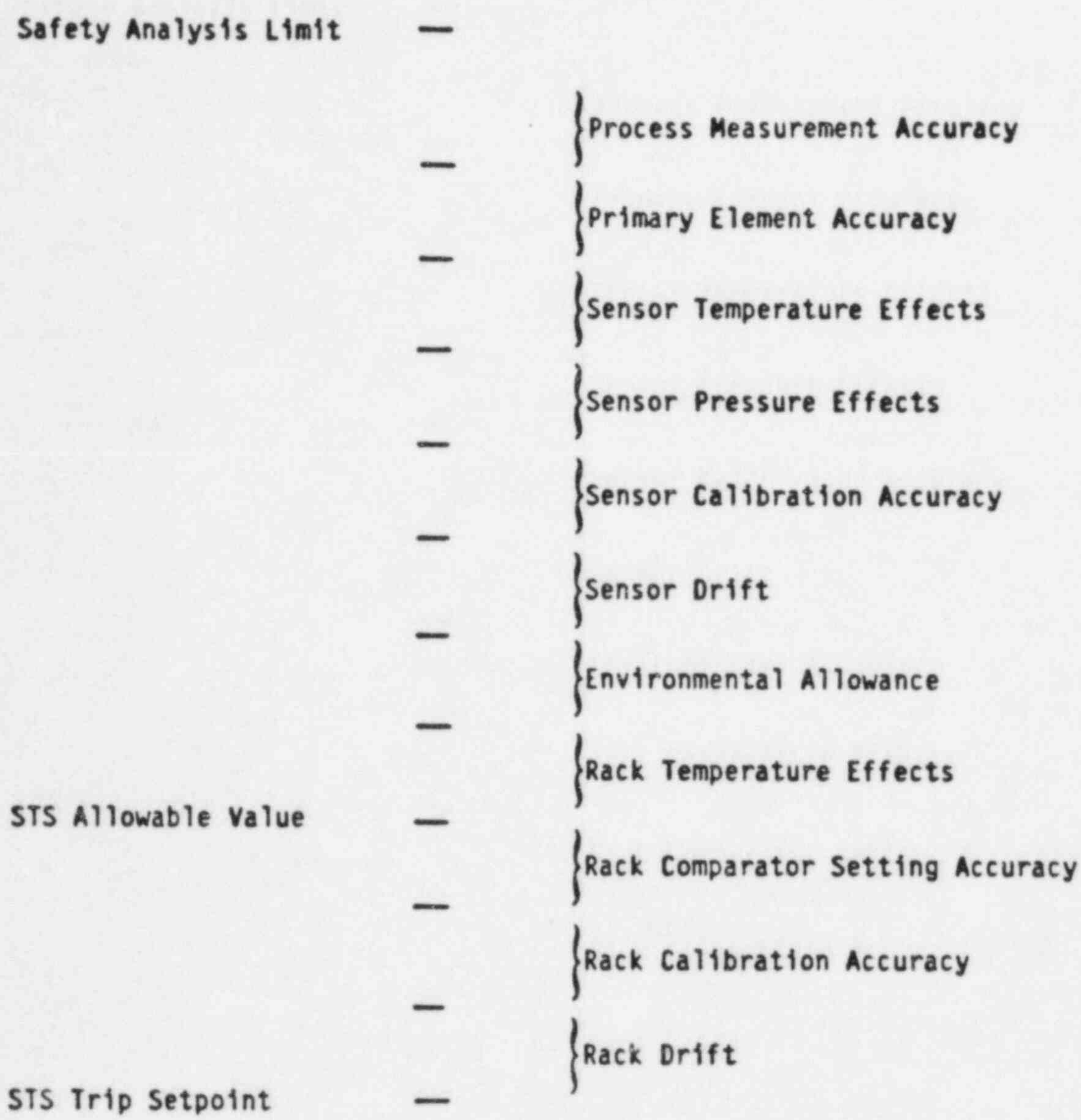


Figure 4-2 Westinghouse STS Setpoint Error Breakdown

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# APPENDIX A

## SAMPLE MILLSTONE

## 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.

(Eq. 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 of span) of rack error for the affected channel,

S = Either the "as measured" value (in percent of 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 | S | Trip Setpoint | Allowable Value |
|---|---|---|---|---|---|
| 1. Manual Reactor Trip | N.A. | N.A. | N.A. | N.A. | N.A. |
| 2. Power Range, Neutron Flux, High Setpoint | 7.5 | 4.56 | 0 | ≤ 109 percent of RTP | ≤ 111.1 percent of RTP |
| Low Setpoint | 8.3 | 4.56 | 0 | ≤ 25 percent of RTP | ≤ 27.1 percent of RTP |
| 3. Power Range, Neutron Flux, High Positive Rate | 1.6 | 0.50 | 0 | ≤ 5 percent of RTP with a time constant ≥ 2 seconds | ≤ 6.3 percent of RTP with a time constant ≥ 2 seconds |
| 4. Power Range, Neutron Flux, High Negative Rate | 1.6 | 0.50 | 0 | ≤ 5 percent of RTP with a time constant ≥ 2 seconds | ≤ 6.3 percent of RTP with a time constant ≥ 2 seconds |
| 5. Intermediate Range, Neutron Flux | 17.0 | 8.41 | 0 | ≤ 25 percent of RTP | ≤ 30.9 percent of RTP |
| 6. Source Range, Neutron Flux | 17.0 | 10.01 | 0 | ≤ $10^5$ cps | ≤ 1.4 x $10^5$ cps |
| 7. Overtemperature ΔT (N loop) | 8.3 | 5.90 | 1.1+1.2 | See note 1 | See note 2 |
| (N-1 loop) | 12.0 | 5.90 | 1.1+1.2 | See note 1 | See note 2 |
| 8. Overpower ΔT | 4.8 | 1.43 | 0.11 | See note 3 | See note 4 |
| 9. Pressurizer Pressure - Low | 5.0 | 1.77 | 3.3 | ≥ 1885 psig | ≥ 1875 psig |
| 10. Pressurizer Pressure - High | 5.0 | 1.77 | 3.3 | ≤ 2370 psig | ≤ 2380 psig |
| 11. Pressurizer Water Level-High | 8.0 | 5.13 | 2.7 | ≤ 89 percent of instrument span | ≤ 90.7 percent of instrument span |
| 12. Loss of Flow | 2.5 | 1.74 | 0.8 | ≥ 90 percent of loop design flow* | ≥ 89.3 percent of loop design flow* |

*Loop design flow = 94,600 gpm (N loop operation), 99,600 gpm (N-1 loop operation)

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

| Functional Unit | Total Allowance (TA) | Z | S | Trip Setpoint | Allowable Value |
|---|---|---|---|---|---|
| 13. Steam Generator Water Level - Low-Low | 20.5 | 18.98 | 1.75 | ≥ 23.5 percent of narrow range instrument span | ≥ 22.6 percent of narrow range instrument span |
| 14. General Warning Alarm | N.A. | N.A. | N.A. | N.A. | N.A. |
| 15. RCP Shaft - Low Speed | 3.8 | 0.5 | 0.0 | 97.8% nominal speed | 94.6% nominal speed |
| 16. Turbine Trip | | | | | |
| a. Low Fluid Oil Pressure | N.A. | N.A. | N.A. | | |
| b. Turbine Stop Valve Closure | N.A. | N.A. | N.A. | | |
| 17. Safety Injection Input from ESF | N.A. | N.A. | N.A. | N.A. | N.A. |

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

| Functional Unit | Total Allowance (TA) | Z | S | Trip Setpoint | Allowable Value |
|---|---|---|---|---|---|
| 19. Reactor Trip System Interlocks | | | | | |
| a. Intermediate Range Neutron Flux, P-6 | N.A. | N.A. | N.A. | ≥1 x $10^{-10}$ amps | ≥6 x $10^{-11}$ amps |
| b. Low Power Reactor Trips Block, P-7 | | | | | |
| 1. P-10 input | N.A. | N.A. | N.A. | ≤10 percent of RTP | ≤12.1 percent of RTP |
| 2. P-13 input | N.A. | N.A. | N.A. | ≤10 percent turbine impulse pressure equivalent | ≤12.1 percent turbine impulse pressure equivalent |
| c. Power Range Neutron Flux, P-8 (N loop operation) | N.A. | N.A. | N.A. | ≤37.5 percent of RTP | ≤39.6 percent of RTP |
| d. Power Range Neutron Flux, P-8 (N-1 loop operation) | N.A | N.A | N.A | ≤37.5 percent of RTP | ≤39.6 percent of RTP |
| e. Power Range Neutron Flux, P-9 | N.A. | N.A. | N.A. | ≤51 percent of RTP | ≤53.1 percent of RTP |
| f. Power Range Neutron Flux, P-10 | N.A. | N.A. | N.A. | ≥10 percent of RTP | ≥7.9 percent of RTP |
| 20. Reactor Trip Breakers | N.A. | N.A. | N.A. | N.A. | N.A. |
| 21. Automatic Trip and Interlock Logic | N.A. | N.A. | N.A. | N.A. | N.A. |

* Later

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS
NOTATION

NOTE 1: OVERTEMPERATURE ΔT $\left(\frac{1 + \tau_1 S}{1 + \tau_2 S}\right) \left(\frac{1}{1 + \tau_3 S}\right)$

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

Where:

| | | |
|---|---|---|
| $\Delta T$ | = | Measured ΔT by RTD Manifold Instrumentation; |
| $\frac{1 + \tau_1 S}{1 + \tau_2 S}$ | = | Lead-lag compensator on measured ΔT |
| $\tau_1$, $\tau_2$ | = | Time constants utilized in the lead-lag controller for ΔT, $\tau_1$ = 8 secs., $\tau_2$ = 3 secs. |
| $\frac{1}{1 + \tau_3 S}$ | = | Lag compensator on measured ΔT |
| $\tau_3$ | = | Time constant utilized in the lag compensator for ΔT, $\tau_3$= 0 secs. |
| $\Delta T_o$ | = | Indicated ΔT at RATED THERMAL POWER; |
| $K_1$ | = | 1.080 (N loop operation) , 1.010 (N-1 loop operation) |
| $K_2$ | = | 0.01313 |
| $\frac{1 + \tau_4 S}{1 + \tau_5 S}$ | = | The function generated by the lead-lag controller for $T_{avg}$ dynamic compensation; |
| $\tau_4$, $\tau_5$ | = | Time constants utilized in the lead-lag controller for $T_{avg}$, $\tau_4$ = 33 secs., $\tau_5$ = 4 secs. |
| T | = | Average temperature °F |
| $\frac{1}{1 + \tau_6 S}$ | = | Lag compensator on measured $T_{avg}$ |
| $\tau_6$ | = | Time constant utilized in the measured $T_{avg}$ lag compensator, $\tau_6$ = 0 secs. |

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS NOTATION

NOTE 1: (continued)

T' = $\leq$ 587.1°F (Nominal $T_{avg}$ at RATED THERMAL POWER)

$K_3$ = 0.000603

P = Pressurizer pressure, psig

P' = 2235 psig (Nominal RCS operating pressure); and

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

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 $q_t - q_b$ between -30 percent and +10 percent, $f_1(\Delta I) = 0$ (where $q_t$ and $q_b$ are percent RATED THERMAL POWER in the top and bottom halves of the core respectively, and $q_t + q_b$ is total THERMAL POWER in percent of RATED THERMAL POWER);

(ii) for each percent that the magnitude of $(q_t - q_b)$ exceeds -30 percent, the ΔT trip setpoint shall be automatically reduced by 3.6 percent of its value at RATED THERMAL POWER; and

(iii) for each percent that the magnitude of $(q_t - q_b)$ exceeds +10 percent, the ΔT Trip Setpoint shall be automatically reduced by 2.0 percent of its value at RATED THERMAL POWER.

NOTE 2: The channel's maximum Trip Setpoint shall not exceed its computed trip point by more than 2.1 percent ΔT span (N loop operation), 4.1% ΔT span (N-1 loop operation).

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS NOTATION

NOTE 3: OVERPOWER ΔT $\left(\frac{1 + \tau_1 S}{1 + \tau_2 S}\right) \left(\frac{1}{1 + \tau_3 S}\right)$

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

Where: $\Delta T$ = As defined in Note 1,

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

$\tau_1$, $\tau_2$ = As defined in Note 1

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

$\tau_3$ = As defined in Note 1

$\Delta T_o$ = As defined in Note 1

$K_4$ = 1.09

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

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

$\tau_7$ = Time constant utilized in the lead-lag controller for $T_{avg}$, $\tau_7$ = 10 secs.

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

$\tau_6$ = As defined in Note 1

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS
NOTATION (Continued)

NOTE 3: (continued)

$K_6$ = 0.00129/°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, ≤ 587.1°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 Setpoint by more than 3.4 percent ΔT span.

## 2.2 LIMITING SAFETY SYSTEM SETTINGS

### BASES

### 2.2.1 REACTOR TRIP SYSTEM INSTRUMENTATION SETPOINTS

The Reactor Trip Setpoint Limits specified in Table 2.2-1 are the nominal values at which the Reactor trips are set for each functional unit. The Trip Setpoints have been selected to ensure that the 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 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 2.2-1, in percent span, is the statistical summation of errors assumed in the analysis excluding those associated with the sensor and rack drift and the accuracy of their measurement. TA or Total Allowance is the difference, in percent span, between the Trip Setpoint and the value used in the analysis for Reactor Trip. R or Rack Error is the "as measured" deviation, in percent span, for the affected channel from the specified Trip

Setpoint. S or Sensor Error is either the "as measured" deviation of the sensor from its calibration point or the value specified in Table 2.2-1, in percent span, from the analysis assumptions. Use of Equation 2.2-1 allows for a sensor drift factor, an increased rack drift factor, and provides a threshold value for REPORTABLE EVENTS.

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 instrumentaton 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 of sensor drift, in excess of the allowance that is more than occasional, may be indicative of more serious problems and should warrant further investigation.

INSTRUMENTATION

3/4.3.2 ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION LIMITING CONDITION FOR OPERATION

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

APPLICABILITY: As shown in Table 3.3-3.

ACTION:

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

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

   2. Declare the channel inoperable and apply the applicable ACTION statement requirements of Table 3.3-3 until the channel is restored to OPERABLE status with its Setpoint adjusted consistent with the Trip Setpoint value.

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

Where:

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

R = The "as measured" value (in percent span) or 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.

c. With an ESFAS instrumentation channel or interlock inoperable, take the ACTION shown in Table 3.3-3.

SURVEILLANCE REQUIREMENTS

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

## TABLE 3.3-4

## ENGINEERED SAFETY FEATURE ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

| Functional Unit | Total Allowance (TA) | Z | Sensor Drift (S) | Trip Setpoint | Allowable Value |
|---|---|---|---|---|---|
| 1. Safety Injection, Reactor Trip, Feedwater Isolation, Control Room Isolation, Start Diesel Generators, Containment Cooling Fans, and Essential Service Water | | | | | |
| a. Manual Initiation | N.A. | N.A. | N.A. | N.A. | N.A. |
| b. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| c. Containment Pressure - High | 3.3 | 1.01 | 1.75 | ≤ 3.0 psig | ≤ 3.8 psig |
| d. Pressurizer Pressure - Low | 16.5 | 13.67 | 3.3 | ≥ 1877.3 psig | ≥ 1870.2 psig |
| e. Steamline Pressure - Low | 17.7 | 15.31 | 2.2 | ≥ 658.6 psig* | ≥ 644.9 psig* |

TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

| Functional Unit | Total Allowance (TA) | Z | Sensor Drift (S) | Trip Setpoint | Allowable Value |
|---|---|---|---|---|---|
| 2. Containment Spray | | | | | |
| a. Manual Initiation | N.A. | N.A. | N.A. | N.A. | N.A. |
| b. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| c. Containment Pressure - High-3 | 3.3 | 1.01 | 1.75 | ≤ 8.0 psig | ≤ 8.8 psig |
| 3. Containment Isolation | | | | | |
| a. Phase "A" Isolation | | | | | |
| 1. Manual Initiation | N.A. | N.A. | N.A. | N.A. | N.A. |
| 2. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| 3. Safety Injection | See Item 1 above for all Safety functions and requirements. | | | | |
| B. Phase "B" Isolation | | | | | |
| 1. Manual Initiation | N.A. | N.A. | N.A. | N.A. | N.A. |
| 2. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| 3. Containment Pressure - High-3 | 3.3 | 1.01 | 1.75 | ≤ 8.0 psig | ≤ 8.8 psig |

TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

| Functional Unit | Total Allowance (TA) | Z | Sensor Drift (S) | Trip Setpoint | Allowable Value |
|---|---|---|---|---|---|
| 3. Containment Isolation (continued) | | | | | |
| c. Containment Purge Isolation | | | | | |
| 1. Manual Initiation | N.A. | N.A. | N.A. | N.A. | N.A. |
| 2. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| 3. Containment Isolation Phase "A" | See Item 3.a. above for all Containment Isolation Phase "A" functions and requirements. | | | | |
| 4. Steam Line Isolation | | | | | |
| a. Manual Initiation | N.A. | N.A. | N.A. | N.A. | N.A. |
| b. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| c. Containment Pressure - High-2 | 3.3 | 1.01 | 1.75 | ≤ 3.0 psig | ≤ 3.8 psig |
| d. Steamline Pressure - Low | 17.7 | 15.31 | 2.2 | ≥ 658.6 psig* | ≥ 644.9 psig* |
| e. Negative Steam Pressure-Negative Rate - High | 5.0 | 0.50 | 0.0 | ≥ -100 psi with a time constant of 50 secs. | ≥ -122.7 psi with a time constant of 50 secs. |

TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURE 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 Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| b. Steam Generator Water Level--High-High | 3.7 | 2.33 | 1.75 | ≤ 82.0 percent of narrow range instrument span | ≤ 82.8 percent of narrow range instrument span |
| 6. Auxiliary Feedwater | | | | | |
| a. Manual Initiation | N.A. | N.A. | N.A. | N.A. | N.A. |
| b. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| c. Steam Generator Water Level--Low-Low | | | | | |
| 1. Start Motor-Driven Pumps | 20.5 | 18.98 | 1.75 | ≥ 23.5 percent of narrow range instrument span | ≥ 22.6 percent of narrow range instrument span |
| 2. Start Turbine-Driven Pump | 20.5 | 18.98 | 1.75 | ≥ 23.5 percent of narrow range instrument span | ≥ 22.6 percent of narrow range instrument span |
| d. Safety Injection Start Motor-Driven Pumps | See Item 1 above for all Safety Injection Functions and requirements | | | | |

TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

| Functional Unit | Total Allowance (TA) | Z | Sensor Drift (S) | Trip Setpoint | Allowable Value |
|---|---|---|---|---|---|
| 6. Auxiliary Feedwater (continued) | | | | | |
| e. Station Blackout Start Turbine-Driven Pump | N.A. | N.A. | N.A. | N.A. | N.A. |
| f. Trip Main Feedwater Pumps-Start Motor-Driven Pumps and Turbine-Driven Pump | N.A. | N.A. | N.A. | N.A. | N.A. |
| 7. Automatic Switchover Lo Containment Sump | | | | | |
| a. Automatic Actuation Logic and Actuation Relays | N.A. | N.A. | N.A. | N.A. | N.A. |
| b. RWST Level--Low-Low | ** | ** | ** | ** | ** |
| Coincident with Safety Injection | See Item 1 above for Safety Injection functions and requirements. | | | | |
| 8. Loss of Power | | | | | |
| a. 4.16 kV Undervoltage -Loss of Voltage | ** | ** | ** | ** | ** |
| b. 4.16 kV Undervoltage -Grid Degraded Voltage | ** | ** | ** | ** | ** |
| 9. Engineered Safety Feature Actaution System Interlocks | | | | | |
| a. Pressurizer Pressure, P-11 | N.A. | N.A. | N.A. | ≤ 1985 psig | ≤ 1995 psig |
| b. Reactor Trip, P-4 | N.A. | N.A. | N.A. | N.A. | N.A. |

TABLE 3.3-4 (Continued)

TABLE NOTATION

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

** To be provided by plant.

## 3.4.3 INSTRUMENTATION

### BASES

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

The OPERABILITY of the Reactor Trip System and the Engineered Safety Features Actuation System instrumentation and interlocks ensures 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 safety 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 Features 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 3.3-1, $Z + R + S \leq TA$, the interactive effects of the errors in the rack and the sensor, and the "as measured" values of the errors are considered. Z, as specified in Table 3.3-4, in percent span, is the statistical summation of errors assumed in the analysis excluding those associated with the sensor and rack drift and the accuracy of their measurement. TA or Total Allowance is the difference, in percent span, between the Trip Setpoint and the value used in the analysis for the actuation. R or Rack Error is the "as measured" deviation, in percent span, for the affected channel from the specified Trip Setpoint. S or Sensor Error is either the "as measured" deviation of the sensor from its calibration point or the value specified in Table 3.3-4, in percent span, from the analysis assumptions.

The methodology to derive the Trip Setpoints is based upon combining all of the uncertanties 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.