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WCAP-14606

# WESTINGHOUSE SETPOINT METHODOLOGY FOR PROTECTION SYSTEMS

## AP600

April 1996

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## 1.0 INTRODUCTION

In Generic Letter 91-04,[1] the NRC has noted that uncertainty calculations for 24-month fuel cycles should be performed in a manner which results in values at a high probability and a high confidence level. The implication of this is that a statistically rigorous calculation is required. In addition, Generic Letter 91-18[2] clarifies the NRC's definition of operability. In response to these documents, Westinghouse has modified the basic uncertainty algorithm. To address the requirements for a definitive basis for drift, explicit calculations must be made to determine appropriate values for the transmitters and process racks.

The basic Westinghouse approach to an uncertainty calculation is to achieve an understanding of the plant instrumentation calibration and operability verification processes. The uncertainty algorithm resulting from this understanding can be function specific, i.e., is very likely different for two functions if their calibration or operability determination processes are different. Effort is expended to determine what parameters are dependent, statistically or functionally. Those parameters that are determined to be independent are treated accordingly. This allows the use of a Square-Root-Sum-of-the-Squares (SRSS) summation of the various components. A direct benefit of this technique is an increased margin in the total allowance. For those parameters determined to be dependent, appropriate (conservative) summation techniques are utilized. 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 to allow a clear understanding of the methodology. Also provided is a detailed example of each setpoint margin calculation demonstrating the methodology and noting how each parameter value is utilized. Values for each parameter are to be determined when the plant-specific equipment and procedures are specified. In all cases, margin must exist between the summation and the total allowance.

Section 4.0 provides a description of the methodology utilized in the determination of the AP600 Technical Specifications and an explanation of the relationship between a trip setpoint and an operability verification.

### 1.1 References / Standards


[1] Generic Letter 91-04, 1991, "Changes in Technical Specification Surveillance Intervals to Accommodate a 24 Month Fuel Cycle."

[2] Generic Letter 91-18, 1991, "Information to Licensees Regarding Two NRC Inspection Manual Sections on Resolution of Degraded and Nonconforming Conditions and on Operability."

## 2.0 COMBINATION OF UNCERTAINTY COMPONENTS

### 2.1 Methodology

The methodology used to combine the uncertainty components for a channel is an appropriate combination of those groups that are statistically and functionally independent. Those uncertainties that are not independent are conservatively treated by arithmetic summation, and then systematically combined with the independent terms.

The basic methodology used is the SRSS technique which has been utilized in other Westinghouse reports. This technique, or others of a similar nature, have been used in WCAP-10395[1] and WCAP-8567.[2] WCAP-8567 is approved by the NRC, noting acceptability of statistical techniques for the application requested. Also, various ANSI, American Nuclear Society, and Instrument Society of America (ISA) standards approve the use of probabilistic and statistical techniques in determining safety-related setpoints.[3,4] The basic methodology used in this report is essentially the same as that noted in an ISA paper presented in 1992.[5]

The relationship between the uncertainty components and the calculated uncertainty for a channel is given in Eq. 2.1,

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

where:

| | | |
|---|---|---|
| CSA | = | Channel Statistical Allowance |
| PMA | = | Process Measurement Accuracy |
| PEA | = | Primary Element Accuracy |
| SMTE | = | Sensor Measurement and Test Equipment Accuracy |
| SD | = | Sensor Drift |
| SCA | = | Sensor Calibration Accuracy |
| SPE | = | Sensor Pressure Effects |
| STE | = | Sensor Temperature Effects |
| SRA | = | Sensor Reference Accuracy |
| RMTE | = | Rack Measurement and Test Equipment Accuracy |
| RD | = | Rack Drift |
| RCA | = | Rack Calibration Accuracy |
| RTE | = | Rack Temperature Effects |
| EA | = | Environmental Allowance |
| BIAS | = | One directional, known magnitude |

As can be seen in the equation, drift and calibration accuracy allowances are treated as dependent parameters with the measurement and test equipment uncertainties. The environmental allowance is not necessarily considered dependent with all other parameters, but, as an additional degree of conservatism, is added to the statistical sum. Bias terms are

one directional with a known magnitude and are added to the statistical sum. The calibration terms are treated in the same radical based on the Generic Letter 91-04[6] requirement for general trending for a 24-month fuel cycle. Since the AP600 Design Certification will be based on a 24-month fuel cycle, it is assumed that trending will be performed for AP600. This results in a net reduction of the CSA magnitude over that which would be determined if trending was not performed.

## 2.2 Sensor Allowances

Six parameters are considered to be sensor allowances: SCA, SRA, SMTE, SD, STE, and SPE (see Table 3-33). Of these parameters, three are considered to be independent (SRA, STE and SPE), and three are considered dependent with at least one other term (SCA, SMTE and SD). SRA is the manufacturer's reference accuracy that is achievable by the device. This term is introduced to address repeatability and hysteresis concerns when only performing a single pass calibration, i.e., one up and one down.[5] STE and SPE are considered to be independent due to the manner in which the instrumentation is checked, i.e., the instrumentation is calibrated and drift determined under conditions in which pressure and temperature are assumed constant. The following scenario provides an example. Assume a sensor is placed in some position in the containment during a refueling outage. After placement, an instrument technician calibrates the sensor. This calibration is performed at ambient pressure and temperature conditions. Some time later with the plant shut down, an instrument technician checks for sensor drift. Using the same technique as for calibrating the sensor, the technician determines if the sensor has drifted. The conditions under which this determination is made are again ambient pressure and temperature. The temperature and pressure should be essentially the same at both measurements. Thus, they should have no significant impact on the drift determination, and are, therefore, independent of the drift allowance.

SCA, SMTE and SD are considered to be dependent for the same reason that STE and SPE are considered independent, i.e., due to the manner in which the instrumentation is checked. When calibrating a sensor, the sensor output is checked to determine if it is accurately representing the input. The sensor response, measured by applying known inputs and recording the sensor output, involves the calibrated accuracy of both the sensor and the measurement and test equipment (M&TE). The drift equals the difference between the as-found and the previous as-left data and, therefore, involves the actual sensor drift and calibration M&TE. The as-found calibration data indicates whether the sensor input/output relationship was within reasonable allowances over the interval since the last calibration. The combination of "as-left" calibration data and plant-specific sensor drift indicate whether it is reasonable to expect the sensor to continue to perform this function for future cycles.

The calibration accuracy and drift values are combined with the measurement and test equipment accuracy term to form the dependent relationships. A hypothetical example of the impact of this treatment for a level transmitter (sensor parameters only) is shown below:

| | | |
|---|---|---|
| SCA | = | 0.5% |
| SRA | = | 0.5% |
| SMTE | = | 0.5% |
| SPE | = | 0.5% |
| STE | = | 0.5% |
| SD | = | 1.0% |

Excerpting the sensor portion of Equation 2.1 results in:

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

- or -

$$\{(0.5 + 0.5)^2 + (0.5 + 1.0)^2 + (0.5)^2 + (0.5)^2 + (0.5)^2\}^{1/2} = 2.0\%$$

Assuming no dependencies for any of the parameters results in the following:

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

- or -

$$\{(0.5)^2 + (0.5)^2 + (1.0)^2 + (0.5)^2 + (0.5)^2 + (0.5)^2\}^{1/2} = 1.5\%$$

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

## 2.3 Rack Allowances

Four parameters, as noted in Table 3-33, are considered to be rack allowances: RCA, RMTE, RTE, and RD. Three of these parameters (RCA, RMTE, and RD) are considered to be dependent for much the same reason as outlined for sensors in Section 2.2. When calibrating or determining drift in the racks for a specific channel, the processes are performed at essentially constant temperature, i.e., ambient temperature (which is reasonably controlled). Because of this, the RTE parameter is considered to be independent of any factors for calibration or drift, however, the same cannot be said for the other rack parameters. Based on this logic, these factors have been conservatively summed to form several independent groupings (see Equation 2.1). The impact of this approach (formation of independent groups based on dependent components) is significant. For the hypothetical example of a level

transmitter channel, using the same approach outlined in Equations 2.1 and 2.2 results in the following:

RCA = 0.2%
RMTE = 0.1%
RTE = 0.25%
RD = 0.2%

Excerpting the rack portion of Equation 2.1 results in:

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

- or -

$$\{(0.1 + 0.2)^2 + (0.1 + 0.2)^2 + (0.25)^2\}^{1/2} = 0.5\%$$

Assuming no dependencies for any of the parameters yields the following less conservative results:

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

- or -

$$\{(0.2)^2 + (0.1)^2 + (0.2)^2 + (0.25)^2\}^{1/2} = 0.4\%$$

Thus, the use of Equation 2.1 is conservative for rack effects and for sensor effects. Therefore, accounting for dependencies in the treatment of these allowances provides 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 uncertainty assumptions, fluid density changes, and temperature stratification assumptions. PMA may consist of more than one independent uncertainty allowance. PEA accounts for uncertainties due to metering devices, such as elbows, venturis, and orifice plates. Thus, these parameters have been factored into Equation 2.1 as independent quantities. It should be noted that treatment as an independent parameter does not preclude determination that a PMA or PEA term should be treated as a bias. If that is determined appropriate, Equation 2.1 would be modified such that the affected term would be treated by arithmetic summation as deemed necessary.

### 2.5 Measurement and Test Equipment Accuracy

It is assumed that the equipment used for calibration and functional testing of the transmitters and racks does not meet ISA S51.1-1979[7] with regards to allowed exclusion from the calculation. This implies that test equipment without an accuracy of 10% or less of the calibration accuracy is required to be included in the uncertainty calculations of Equations 2.1 and 3.1. AP600 procedures will be written to specify the appropriate M&TE accuracy for each function. These M&TE uncertainties will be included in the calculations, as seen in the tables included in this report.

### 2.6 References / Standards


[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, 1994, "Setpoints for Nuclear Safety-Related Instrumentation Used in Nuclear Power Plants."

[5] Tuley, C. R., Williams, T. P., "The Significance of Verifying the SAMA PMC 20.1-1973 Defined Reference Accuracy for the Westinghouse Setpoint Methodology," Instrumentation, Controls and Automation in the Power Industry, Vol. 35, Proceedings of the Thirty-Fifth Power Instrumentation Symposium (2nd Annual ISA/EPRI Joint Controls and Automation Conference), Kansas City, Mo., June 1992, p. 497.

[6] Generic Letter 91-04, 1991, "Changes in Technical Specification Surveillance Intervals to Accommodate a 24-Month Fuel Cycle."

[7] Instrument Society of America Standard S51.1-1979, "Process Instrumentation Terminology."

## 3.0 PROTECTION SYSTEM SETPOINT METHODOLOGY

### 3.1 Margin Calculation

As noted in Section 2.0, Westinghouse utilizes the square root of the sum of the squares for summation of the various components of the channel uncertainty. This approach is valid where no dependency is present. Arithmetic summation is a conservative treatment when a dependency between two or more parameters exists. The equation used to determine the margin and, thus, the acceptability of the parameter values used is:

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

where:

TA = Total Allowance (which is defined as Safety Analysis Limit - Nominal Trip Setpoint)

and all other parameters are as defined for Equation 2.1.

This equation is appropriate when trending of transmitter calibration and drift and process rack calibration and drift values are taking place. Using Equation 2.1, Equation 3.1 may be simplified to:

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

Tables 3-1 through 3-32 list the allowances to be made for individual component uncertainties and CSA calculations for the protection functions noted in Tables 3.3.1-1 and 3.3.2-1 of the AP600 Technical Specifications. Values to be used for the uncertainty allowances will be determined when the plant-specific equipment and procedures are specified. Table 3-33 provides a summary of the Reactor Protection System / Engineered Safety Features Actuation System Channel Uncertainty Allowances for AP600. Westinghouse typically reports values in these tables to one decimal place using the conventional technique of rounding down values less than 0.05 and rounding up values greater than or equal to 0.05. Parameters reported as "0" or "---" in the tables are not applicable (i.e., have no value) for that channel.

## 3.2 Definitions For Protection System Setpoint Tolerances

To facilitate a clear understanding of the channel uncertainty values used in this report, the following definitions are noted:

- A/D

  Electronic circuit module that converts a continuously variable analog signal to a discrete digital signal via a prescriptive algorithm.

- As Found

  The condition in which a transmitter, process rack module or process instrument loop is found after a period of operation. For example, after a period of operation, a transmitter was found to deviate from the ideal condition by -0.5% of span. This would be the as-found condition.

- As Left

  The condition in which a transmitter, process rack module, or process instrument loop is left after calibration or trip setpoint verification. This condition is typically better than the calibration accuracy for that piece of equipment. For example, the permitted calibration accuracy for a transmitter is ±0.5% of span, while the worst measured deviation from the ideal condition after calibration is +0.1% of span. In this instance, if the calibration was stopped at this point (i.e., no additional efforts were made to decrease the deviation) the as-left error would be +0.1% of span.

- Channel

  The sensing and process equipment, i.e., transmitter to Central Processing Unit (CPU) trip output, for one input to the voting logic of a protection function. Westinghouse designs protection functions with voting logic made up of multiple channels, e.g., for steam generator level-low, two out of four channels must have reached the CPU trip output for a reactor trip to be initiated.

- Channel Statistical Allowance (CSA)

  The combination of the various channel uncertainties via SRSS and arithmetic summation, as appropriate. It includes both instrument (sensor and process rack) uncertainties and non-instrument related effects (process measurement accuracy). This parameter is compared with the total allowance for determination of instrument channel margin.

- Environmental Allowance (EA)

The change in a process signal (transmitter or process rack output) due to adverse environmental conditions from a limiting accident condition. Typically this value is determined from a conservative set of enveloping conditions and may represent the following:

a) temperature effects on a transmitter
b) radiation effects on a transmitter
c) seismic effects on a transmitter
d) temperature effects on a level transmitter reference leg
e) temperature effects on signal cable insulation
f) seismic effects on process racks

- Margin

The calculated difference (in percent of instrument span) between the total allowance and the channel statistical allowance.

- Nominal Trip Setpoint (NTS)

A bistable trip setpoint (analog function) or CPU trip output (digital function) in plant Technical Specifications. This value is the nominal value to which the bistable is set, as accurately as reasonably achievable (analog function) or the defined input value for the CPU trip output setpoint (digital function).

- Normalization

The process of establishing a relationship, or link, between a process parameter and an instrument channel. This is in contrast with a calibration process. A calibration process is performed with independent known values, i.e., a bistable is calibrated to change state when a specific voltage is reached. This voltage corresponds to a process parameter magnitude with the relationship established through the scaling process. A normalization process typically involves an indirect measurement, e.g., determination of steam flow via the $\Delta p$ drop across a flow restrictor. The flow coefficient is not known for this condition, effectively an orifice, therefore a mass balance between feedwater flow and steam flow can be made. With the feedwater flow known through measurement via the venturi, the steam flow is normalized.

- Primary Element Accuracy (PEA)

Uncertainty due to the use of a metering device, e.g., venturi, orifice, or pitot tube. Typically, this is a calculated or measured accuracy for the device.

- Process Loop (Instrument Process Loop)

  The process equipment for a single channel of a protection function.

- Process Measurement Accuracy (PMA)

  Allowance for non-instrument related effects that have a direct bearing on the accuracy of an instrument channel's reading, e.g., temperature stratification in a large diameter pipe, or fluid density in a pipe or vessel.

- Process Racks

  The analog or digital modules downstream of the transmitter or sensing device that condition a signal and act upon it prior to input to a voting logic system. For Westinghouse process systems, this includes all the equipment contained in the process equipment cabinets, i.e., conversion resistor, transmitter power supply, R/E, lead/lag, rate, lag functions, function generator, summator, control/protection isolator, and bistable for analog functions, or conversion resistor, transmitter power supply, signal conditioning-A/D converter, and CPU for digital functions. The go/no go signal generated by the bistable is the output of the last module in the analog process rack instrument loop and is the input to the voting logic. The CPU trip output signal is the input to the voting logic from a digital system.

- Rack Calibration Accuracy (RCA)

  The reference (calibration) accuracy, as defined by ISA Standard S51.1-1979[1] for a process loop string. Inherent in this definition is the verification of the following under a reference set of conditions; 1) conformity,[2] 2) hysteresis,[3] and 3) repeatability.[4] The Westinghouse definition of a process loop includes all modules in a specific channel. Also it is assumed that the individual modules are calibrated to a particular tolerance and that the process loop as a string is verified to be calibrated to a specific tolerance. The tolerance for the string is typically less than the arithmetic sum or SRSS of the individual module tolerances. This forces calibration of the process loop without a systematic bias in the individual module calibrations, i.e., as left values for individual modules must be compensating in sign and magnitude.

  For a Westinghouse supplied digital channel, RCA represents calibration of the signal conditioning–A/D converter providing input to the CPU. Typically there is only one module present in the digital process loop; thus, compensation between multiple modules for errors is not possible. However, for protection functions with multiple inputs, compensation between multiple modules for errors is possible. Each signal conditioning–A/D converter module is calibrated to within an accuracy of [ ]$^{+a,c}$ for functions with process rack inputs of 4 - 20 mA or 10 - 50 mA, [ ]$^{+a,c}$ for narrow range RTD inputs, or [±0.2% of span]$^{+a,c}$ for wide range RTD inputs.

- Rack Drift (RD)

  The change in input-output relationship over a period of time at reference conditions, e.g., at constant temperature. Typical values assumed for this parameter are ±1.0% of span for 30 days for analog channels and [ ]+a,c for 90 days for digital channels. An example of RD is: for an as-found value of -0.15% of span and an as-left value of +0.05% of span, the magnitude of the drift would be [ ]+a,c in the negative direction.

- Rack Measurement & Test Equipment Accuracy (RMTE)

  The accuracy of the test equipment (typically a transmitter simulator, voltage or current power supply, and DVM) used to calibrate a process loop in the racks. When the magnitude of RMTE meets the requirements of ISA S51.1-1979[5] it is considered an integral part of RCA. Magnitudes in excess of the 10:1 limit are explicitly included in Westinghouse calculations.

- Rack Temperature Effects (RTE)

  Change in input-output relationship for the process rack module string due to a change in the ambient environmental conditions (temperature, humidity, voltage and frequency) from the reference calibration conditions. It has been determined that temperature is the most significant condition, with the other parameters being second-order effects. For Westinghouse-supplied process instrumentation, a value of [ ]+a,c is used for analog channel temperature effects and [ ]+a,c is used for digital channels. It is assumed that calibration is performed at a nominal ambient temperature of +70°F with an upper extreme of +120°F (+50°F $\Delta T$) and a lower extreme of +40°F.

- Safety Analysis Limit (SAL)

  The parameter value assumed in a transient analysis or other plant operating limit at which a reactor trip or actuation function is initiated.

- Sensor Calibration Accuracy (SCA)

  The calibration accuracy for a sensor or transmitter as defined by the AP600 calibration procedures. For transmitters, this accuracy is typically ±0.25% of span to 0.5% of span. Utilizing Westinghouse recommendations for RTD cross-calibration, this accuracy is typically [ ]+a,c for the hot and cold leg RTDs.

- Sensor Drift (SD)

  The change in input-output relationship over a period of time at reference calibration conditions, e.g., at constant temperature. An example of SD is: for an as-found value of +0.5% of span and an as-left value of +0.1% of span, the magnitude of the drift would be {(+0.5) – (+0.1) = +0.4% of span} in the positive direction. For this evaluation, a maximum surveillance interval of 30 months must be assumed when projecting drift allowances.

- Sensor Measurement & Test Equipment Accuracy (SMTE)

  The accuracy of the test equipment (typically a high accuracy local readout gauge and DVM) used to calibrate a sensor or transmitter in the field or in a calibration laboratory. When the magnitude of SMTE meets the requirements of ISA S51.1-1979[5] it is considered an integral part of SCA. Magnitudes in excess of the 10:1 limit are explicitly included in Westinghouse calculations.

- Sensor Pressure Effects (SPE)

  The change in input-output relationship due to a change in the static head pressure from the calibration conditions or the accuracy to which a correction factor is introduced for the difference between calibration and operating conditions for a $\Delta p$ transmitter.

- Sensor Reference Accuracy

  The reference accuracy that is achievable by the device as specified in the manufacturer's specification sheets; reference (calibration) accuracy for a sensor or transmitter as defined by ISA S51.1-1979[1]. Inherent in this definition is the verification of the following under a reference set of conditions: 1) conformity,[2] 2) hysteresis,[3] and 3) repeatability.[4] This term is introduced into the uncertainty calculation to address repeatability concerns when performing only a single-pass calibration (i.e., one up and one down), or repeatability and hysteresis when performing a single-pass calibration in only one direction.

- Sensor Temperature Effects (STE)

  The change in input-output relationship due to a change in the ambient environmental conditions (temperature, humidity, voltage, and frequency) from the reference calibration conditions. It has been determined that temperature is the most significant condition, with the other parameters being second-order effects. It is assumed that calibration is performed at a nominal ambient temperature of +70°F with an upper extreme of +120°F and a lower extreme of +40°F.

- Span

The region for which a device is calibrated and verified to be operable, e.g., for a pressurizer pressure transmitter with a calibrated range of 1700-2500 psig would have a span of 800 psi. For pressurizer pressure, considerable suppression of the zero and turndown of the operating range is exhibited.

- SRSS

Square root of the sum of the squares, i.e.,

$$\varepsilon = \sqrt{(a)^2 + (b)^2 + (c)^2}$$

as approved for use in setpoint calculations by ISA Standard S67.04-1994[6].

- Total Allowance (TA)

The absolute value of the calculated difference between the safety analysis limit and the nominal trip setpoint (SAL - NTS) in percent of instrument span. Two hypothetical examples of the calculation of TA are shown below:

  - Steam Generator Level - Low

| | |
|---|---|
| SAL | 0% of level |
| NTS | -18% of level |
| TA | \|-18% of level\| = 18% of level |

If the instrument span = 100% of level, then

$$TA = \frac{(18\%\ \text{of level}) * (100\%\ \text{of span})}{(100\%\ \text{of level})} = 18.0\%\ \text{of span}$$

  - Pressurizer Pressure - Low Trip

| | |
|---|---|
| SAL | 1800 psia |
| NTS | -1915 psia |
| TA | \|-115 psi\| = 115 psi |

If the instrument span = 800 psi, then

$$TA = \frac{(115 \text{ psia}) * (100\% \text{ of span})}{(800 \text{ psia})} = 14.4\% \text{ of span}$$

### 3.3 References/Standards


[1] Instrument Society of America Standard S51.1-1979, "Process Instrumentation Terminology," p 6, 1979.

[2] Ibid, p 8.

[3] Ibid, p 20.

[4] Ibid, p 27.

[5] Ibid, p 32.

[6] Instrument Society of America Standard S67.04-1994, "Setpoints for Nuclear Safety-Related Instrumentation," p 18, 1994.

## TABLE 3-1
## POWER RANGE, NEUTRON FLUX - HIGH & LOW SETPOINTS FOR REACTOR TRIP

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy | |
| [ ]+a,c | ±x.x |
| [ ]+a,c | ±x.x |
| [ ]+a,c | ±x.x |
| Primary Element Accuracy | 0 |
| Sensor Calibration Accuracy | |
| [ ]+a,c | 0 |
| Sensor Measurement & Test Equipment Accuracy | |
| [ ]+a,c | 0 |
| Sensor Pressure Effects | 0 |
| Sensor Temperature Effects | |
| [ ]+a,c | 0 |
| Sensor Drift | |
| [ ]+a,c | 0 |
| Environmental Allowance | 0 |
| Rack Calibration | |
| Rack Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of span (120% of Rated Thermal Power)

Channel Statistical Allowance =

[

]+a,c

**TABLE 3-2**
POWER RANGE, NEUTRON FLUX - HIGH POSITIVE RATE
FOR REACTOR TRIP AND HIGH NEGATIVE RATE FOR ROD BLOCK

| **Parameter** | **Allowance*** |
|---|---|
| Process Measurement Accuracy<br>[<br>]+a,c | 0 |
| Primary Element Accuracy | 0 |
| Sensor Calibration Accuracy<br>[<br>]+a,c | 0 |
| Sensor Measurement & Test Equipment Accuracy | 0 |
| Sensor Pressure Effects | 0 |
| Sensor Temperature Effects<br>[<br>]+a,c | 0 |
| Sensor Drift<br>[<br>]+a,c | 0 |
| Environmental Allowance | 0 |
| Rack Calibration | |
| Rack Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of span (120% of Rated Thermal Power)

Channel Statistical Allowance =

[

]+a,c

**TABLE 3-3**
INTERMEDIATE RANGE NEUTRON FLUX FOR REACTOR TRIP

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy | |
| [ ]+a,c | ±x.x |
| [ ]+a,c | +x.x |
| Primary Element Accuracy | 0 |
| Sensor Calibration Accuracy | |
| [ ]+a,c | 0 |
| Sensor Measurement & Test Equipment Accuracy | |
| [ ]+a,c | 0 |
| Sensor Pressure Effects | 0 |
| Sensor Temperature Effects | |
| [ ]+a,c | 0 |
| Sensor Drift | |
| [ ]+a,c | 0 |
| Environmental Allowance | 0 |
| Rack Calibration | |
| Rack Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of span (120% of Rated Thermal Power)

Channel Statistical Allowance =

[

]+a,c

**TABLE 3-4**
SOURCE RANGE NEUTRON FLUX FOR REACTOR TRIP

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy<br>[ ]+a,c | ±x.x |
| Primary Element Accuracy | 0 |
| Sensor Calibration Accuracy<br>[ ]+a,c | 0 |
| Sensor Measurement & Test Equipment Accuracy<br>[ ]+a,c | 0 |
| Sensor Pressure Effects | 0 |
| Sensor Temperature Effects<br>[ ]+a,c | 0 |
| Sensor Drift<br>[ ]+a,c | 0 |
| Environmental Allowance | 0 |
| Rack Calibration | |
| Rack Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of span ($1 \times 10^6$ cps)

Channel Statistical Allowance =

[ ]+a,c

## TABLE 3-5
## SOURCE RANGE NEUTRON FLUX DOUBLING FOR BORON DILUTION BLOCK

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy | |
| [ ]+a,c | ±x.x |
| [ ]+a,c | ±x.x |
| Primary Element Accuracy | 0 |
| Sensor Calibration Accuracy<br>[ ]+a,c | |
| Sensor Measurement & Test Equipment Accuracy<br>[ ]+a,c | |
| Sensor Pressure Effects | 0 |
| Sensor Temperature Effects<br>[ ]+a,c | |
| Sensor Drift<br>[ ]+a,c | |
| Environmental Allowance | 0 |
| Rack Calibration | |
| Rack Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of span ($\phi_2/\phi_1$ from 1.0 to 3.5)

Channel Statistical Allowance =

[

]+a,c

**TABLE 3-6**

OVERTEMPERATURE ΔT FOR REACTOR TRIP

**Assumes normalization of $\Delta T_o$ and T'**

| **Parameter** | **Allowance*** |
|---|---|
| Process Measurement Accuracy | |
| [ ]$^{+a,c}$ | 0 |
| [ ]$^{+a,c}$ | ±x.x |
| [ ]$^{+a,c}$ | ±x.x |
| [ ]$^{+a,c}$ | +x.x |
| [ ]$^{+a,c}$ | +x.x |
| [ ]$^{+a,c}$ | ±x.x |
| [ ]$^{+a,c}$ | 0 |
| [ ]$^{+a,c}$ | ±x.x |
| Primary Element Accuracy | 0 |
| Sensor Reference Accuracy | |
| [ ]$^{+a,c}$ | 0 |
| [ ]$^{+a,c}$ | ±x.x |
| Sensor Calibration Accuracy | |
| [ ]$^{+a,c}$ | 0 |
| [ ]$^{+a,c}$ | ±x.x |
| Sensor Measurement & Test Equipment Accuracy | |
| [ ]$^{+a,c}$ | 0 |
| [ ]$^{+a,c}$ | ±x.x |
| Sensor Pressure Effects | 0 |
| Sensor Temperature Effects | |
| [ ]$^{+a,c}$ | ±x.x |
| Sensor Drift | |
| [ ]$^{+a,c}$ | 0 |
| [ ]$^{+a,c}$ | ±x.x |
| Environmental Allowance | 0 |
| Rack Calibration Accuracy | |
| [ ]$^{+a,c}$ | 0 |
| [ ]$^{+a,c}$ | ±x.x |
| [ ]$^{+a,c}$ | ±x.x |

* In percent of ΔT span (ΔT - xxx.x°F = 150% of RTP; Pressure - 800 psi; ΔI - ±60% ΔI)

See Table 3-34 for gain and conversion calculation.

\# Number of Hot Leg RTDs used

\#\# Number of Cold Leg RTDs used

**TABLE 3-6 (continued)**
OVERTEMPERATURE ΔT FOR REACTOR TRIP
**Assumes normalization of $\Delta T_o$ and T'**

| Parameter | Allowance* |
|---|---|
| Measurement & Test Equipment Accuracy | |
| [ ]+a,c | 0 |
| [ ]+a,c | ±x.x |
| [ ]+a,c | ±x.x |
| Rack Temperature Effect | |
| [ ]+a,c | 0 |
| [ ]+a,c | ±x.x |
| [ ]+a,c | ±x.x |
| Rack Drift | |
| [ ]+a,c | 0 |
| [ ]+a,c | ±x.x |
| [ ]+a,c | ±x.x |

* In percent of ΔT span (ΔT - xxx.x°F = 150% of RTP; Pressure - 800 psi; ΔI - ±60% ΔI)

See Table 3-34 for gain and conversion calculation.
\# Number of Hot Leg RTDs used
\## Number of Cold Leg RTDs used

**TABLE 3-6 (continued)**
OVERTEMPERATURE $\Delta T$ FOR REACTOR TRIP
**Assumes normalization of $\Delta T_o$ and T'**

Channel Statistical Allowance =

+a,c

[ ]

## TABLE 3-7
## OVERPOWER ΔT FOR REACTOR TRIP
**Assumes normalization of $\Delta T_o$ and T"**

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy | |
| [ ]+a,c | 0 |
| [ ]+a,c | ±x.x |
| [ ]+a,c | +x.x |
| [ ]+a,c | +x.x |
| [ ]+a,c | 0 |
| [ ]+a,c | ±x.x |
| Primary Element Accuracy | 0 |
| Sensor Reference Accuracy | |
| [ ]+a,c | 0 |
| Sensor Calibration Accuracy | |
| [ ]+a,c | 0 |
| Sensor Measurement & Test Equipment Accuracy | |
| [ ]+a,c | 0 |
| Sensor Pressure Effects | 0 |
| Sensor Temperature Effects | 0 |
| Sensor Drift | |
| [ ]+a,c | 0 |
| Environmental Allowance | |
| [ ]+a,c | +x.x |
| Rack Calibration Accuracy | |
| [ ]+a,c | 0 |
| Rack Measurement & Test Equipment Accuracy | |
| [ ]+a,c | 0 |
| Rack Temperature Effect | |
| [ ]+a,c | 0 |
| Rack Drift | |
| [ ]+a,c | 0 |

---

* In percent of ΔT span (ΔT - xxx.x°F = 150% of RTP)

See Table 3-35 for gain calculations.
\# Number of Hot Leg RTDs used
\## Number of Cold Leg RTDs used

**TABLE 3-7 (continued)**
OVERPOWER $\Delta T$ FOR REACTOR TRIP
**Assumes normalization of $\Delta T_o$ and T"**

Channel Statistical Allowance =

+a,c

[ ]

**TABLE 3-8**
PRESSURIZER PRESSURE - LOW FOR REACTOR TRIP

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy | 0 |
| Primary Element Accuracy | 0 |
| Sensor Reference Accuracy | ±x.x |
| Sensor Calibration Accuracy | ±x.x |
| Sensor Measurement & Test Equipment Accuracy | ±x.x |
| Sensor Pressure Effects | 0 |
| Sensor Temperature Effects | ±x.x |
| Sensor Drift (30 months) | ±x.x |
| Environmental Allowance | 0 |
| Rack Calibration | |
| Rack Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of span (800 psi)

Channel Statistical Allowance =

[

]+a,c

**TABLE 3-9**
PRESSURIZER PRESSURE - HIGH FOR REACTOR TRIP

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy | 0 |
| Primary Element Accuracy | 0 |
| Sensor Reference Accuracy | ±x.x |
| Sensor Calibration Accuracy | ±x.x |
| Sensor Measurement & Test Equipment Accuracy | ±x.x |
| Sensor Pressure Effects | 0 |
| Sensor Temperature Effects | ±x.x |
| Sensor Drift (30 months) | ±x.x |
| Environmental Allowance | 0 |
| Rack Calibration | |
| Rack Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of span (800 psi)

Channel Statistical Allowance =

[

]$^{+a,c}$

**TABLE 3-10**

PRESSURIZER WATER LEVEL - HIGH 1 & 2 FOR CVS ISOLATION AND HIGH 3 FOR REACTOR TRIP

| **Parameter** | **Allowance** |
|---|---|
| Process Measurement Accuracy | 0 |
| Primary Element Accuracy | 0 |
| Sensor Reference Accuracy | ±x.x |
| Sensor Calibration Accuracy | ±x.x |
| Sensor Measurement & Test Equipment Accuracy | ±x.x |
| Sensor Pressure Effects | ±x.x |
| Sensor Temperature Effects | ±x.x |
| Sensor Drift (30 months) | ±x.x |
| Environmental Allowance | 0 |
| Bias | |
| [ ]$^{+a,c}$ | +x.x |
| [ ]$^{+a,c}$ | +x.x |
| Rack Calibration | |
| Rack Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

---

* In percent of span (100% of level)

Channel Statistical Allowance =

[

]$^{+a,c}$

**TABLE 3-11**
LOSS OF FLOW FOR REACTOR TRIP
Pitot Tube

| **Parameter** | **Allowance*** |
|---|---|
| Process Measurement Accuracy | |
| [ ]+a,c | ±x.x |
| [ ]+a,c | ±x.x |
| Primary Element Accuracy | |
| [ ]+a,c | ±x.x |
| [ ]+a,c | ±x.x |
| Sensor Reference Accuracy [ ]+a,c | ±x.x |
| Sensor Calibration Accuracy | |
| [ ]+a,c | 0 |
| Sensor Measurement & Test Equipment Accuracy | |
| [ ]+a,c | 0 |
| Sensor Pressure Effects | |
| [ ]+a,c | 0 |
| Sensor Temperature Effects | |
| [ ]+a,c | 0 |
| Sensor Drift (30 months)[ ]+a,c | ±x.x |
| Environmental Allowance | 0 |
| Rack Calibration | |
| Rack Accuracy [ ]+a,c | ±x.x |
| Measurement & Test Equipment Accuracy [ ]+a,c | ±x.x |
| Rack Temperature Effect [ ]+a,c | ±x.x |
| Rack Drift [ ]+a,c | ±x.x |

* In percent of flow span (120% flow). Percent of $\Delta p$ span coverted to flow span via Equation 3-36.8, with $F_{max}$ = 120% and $F_N$ = 100%.

Channel Statistical Allowance =

[

]+a,c

**TABLE 3-12**
**STEAM GENERATOR NARROW RANGE WATER LEVEL - LOW FOR REACTOR TRIP, STEAM GENERATOR BLOWDOWN SYSTEM ISOLATION, AND PRHR**

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy | |
| [ ]+a,c | x.x |
| [ ]+a,c | x.x |
| [ ]+a,c | x.x |
| Primary Element Accuracy | 0 |
| Sensor Reference Accuracy | ±x.x |
| Sensor Calibration Accuracy | ±x.x |
| Sensor Measurement & Test Equipment Accuracy | ±x.x |
| Sensor Pressure Effects | ±x.x |
| Sensor Temperature Effects | ±x.x |
| Sensor Drift (30 months) | ±x.x |
| Environmental Allowance | |
| [ ]+a,c | x.x |
| [ ]+a,c | x.x |
| [ ]+a,c | x.x |
| Rack Calibration | |
| Rack Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of span (100% of narrow range level)

Channel Statistical Allowance =

[ ]+a,c

**TABLE 3-13**
REACTOR COOLANT PUMP SPEED - LOW FOR REACTOR TRIP
Magnetic Sensor

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy | ±x.x |
| Primary Element Accuracy | 0 |
| Sensor Calibration Accuracy | 0 |
| Sensor Measurement & Test Equipment Accuracy | 0 |
| Sensor Pressure Effects | 0 |
| Sensor Temperature Effects | 0 |
| Sensor Drift (30 months) | 0 |
| Environmental Allowance | 0 |
| Rack Calibration | |
| Rack Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of span (120% of rated speed)

Channel Statistical Allowance =

[

]+a,c

**TABLE 3-14**
REACTOR COOLANT PUMP BEARING WATER TEMPERATURE - HIGH FOR REACTOR TRIP AND TRIP OF AFFECTED RCP

| Parameter | Allowance |
|---|---|
| Process Measurement Accuracy | |
| [ ]+a,c | 0 |
| Primary Element Accuracy | 0 |
| Sensor Calibration Accuracy | |
| [ ]+a,c | 0 |
| Sensor Reference Accuracy | ±x.x |
| Sensor Measurement & Test Equipment Accuracy | |
| [ ]+a,c | 0 |
| Sensor Pressure Effects | 0 |
| Sensor Temperature Effects | 0 |
| Sensor Drift (30 months) | ±x.x |
| Environmental Allowance | 0 |
| Rack Calibration | |
| Rack Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of span (380°F)

Channel Statistical Allowance =

[

]+a,c

**TABLE 3-15**
CONTAINMENT PRESSURE - HIGH 1 FOR SAFEGUARDS ACTUATION AND STEAM LINE ISOLATION, AND HIGH 2 FOR CONTAINMENT COOLING

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy | 0 |
| Primary Element Accuracy | 0 |
| Sensor Reference Accuracy | ±x.x |
| Sensor Calibration Accuracy | ±x.x |
| Sensor Measurement & Test Equipment Accuracy | ±x.x |
| Sensor Pressure Effects | 0 |
| Sensor Temperature Effects | ±x.x |
| Sensor Drift (30 months) | ±x.x |
| Environmental Allowance | 0 |
| Rack Calibration | |
| Rack Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of span (15 psi)

Channel Statistical Allowance =

[

]+a,c

**TABLE 3-16**
PRESSURIZER PRESSURE - LOW FOR SAFEGUARDS ACTUATION

| Parameter | | Allowance* |
|---|---|---|
| Process Measurement Accuracy | | 0 |
| Primary Element Accuracy | | 0 |
| Sensor Reference Accuracy | | ±x.x |
| Sensor Calibration Accuracy | | ±x.x |
| Sensor Measurement & Test Equipment Accuracy | | ±x.x |
| Sensor Pressure Effects | | 0 |
| Sensor Temperature Effects | | ±x.x |
| Sensor Drift (30 months) | | ±x.x |
| Environmental Allowance | | |
| [ | ]+a,c | +x.x |
| [ ]+a,c | | +x.x |
| Rack Calibration | | |
| Rack Accuracy | | ±x.x |
| Measurement & Test Equipment Accuracy | | ±x.x |
| Rack Temperature Effect | | ±x.x |
| Rack Drift | | ±x.x |

* In percent of span (800 psi)

Channel Statistical Allowance =

[

]+a,c

**TABLE 3-17**
STEAM LINE PRESSURE - LOW FOR SAFEGUARDS ACTUATION
AND STEAM LINE ISOLATION ON OUTSIDE CONTAINMENT BREAK

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy | 0 |
| Primary Element Accuracy | 0 |
| Sensor Reference Accuracy | ±x.x |
| Sensor Calibration Accuracy | ±x.x |
| Sensor Measurement & Test Equipment Accuracy | ±x.x |
| Sensor Pressure Effects | 0 |
| Sensor Temperature Effects | ±x.x |
| Sensor Drift (30 months) | ±x.x |
| Environmental Allowance | |
| [ ]+a,c | +x.x |
| [ ]+a,c | +x.x |
| Rack Calibration | |
| Rack Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of span (1200 psi)

Channel Statistical Allowance =

[

]+a,c

**TABLE 3-18**
STEAM LINE PRESSURE - LOW FOR SAFEGUARDS ACTUATION
AND STEAM LINE ISOLATION ON INSIDE CONTAINMENT BREAK

| **Parameter** | **Allowance*** |
|---|---|
| Process Measurement Accuracy | 0 |
| Primary Element Accuracy | 0 |
| Sensor Reference Accuracy | ±x.x |
| Sensor Calibration Accuracy | ±x.x |
| Sensor Measurement & Test Equipment Accuracy | ±x.x |
| Sensor Pressure Effects | 0 |
| Sensor Temperature Effects | ±x.x |
| Sensor Drift (30 months) | ±x.x |
| Environmental Allowance | 0 |
| Rack Calibration | |
| Rack Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of span (1200 psi)

Channel Statistical Allowance =

[

]+a,c

**TABLE 3-19**
NEGATIVE STEAM LINE PRESSURE RATE - HIGH FOR STEAM LINE ISOLATION

| Parameter | | Allowance |
|---|---|---|
| Process Measurement Accuracy | | 0 |
| Primary Element Accuracy | | 0 |
| Sensor Reference Accuracy | | |
| [ | ]+a,c | 0 |
| Sensor Calibration Accuracy | | |
| [ | ]+a,c | 0 |
| Sensor Measurement & Test Equipment Accuracy | | 0 |
| Sensor Pressure Effects | | 0 |
| Sensor Temperature Effects | | |
| [ | ]+a,c | 0 |
| Sensor Drift | | |
| [ | ]+a,c | 0 |
| Environmental Allowance | | 0 |
| Rack Calibration | | |
| Rack Accuracy | | ±x.x |
| Measurement & Test Equipment Accuracy | | ±x.x |
| Rack Temperature Effect | | ±x.x |
| Rack Drift | | ±x.x |

* In percent of span (1200 psi)

Channel Statistical Allowance =

[

]+a,c

**TABLE 3-20**
Tcold - LOW FOR SAFEGUARDS ACTUATION, STEAM LINE ISOLATION, AND STARTUP FEEDWATER ISOLATION

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy<br>[ ]+a,c | +x.x |
| Primary Element Accuracy | 0 |
| Sensor Reference Accuracy<br>[ ]+a,c | ±x.x |
| Sensor Calibration Accuracy<br>[ ]+a,c | ±x.x |
| Sensor Measurement & Test Equipment Accuracy | 0 |
| Sensor Pressure Effects | 0 |
| Sensor Temperature Effects | 0 |
| Sensor Drift (30 months)<br>[ ]+a,c | ±x.x |
| Environmental Allowance<br>[ ]+a,c | +x.x |
| Rack Calibration Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of Tcold span (120°F)

Channel Statistical Allowance =

[

]+a,c

**TABLE 3-21**
Thot - HIGH FOR CMT ACTUATION AND RCP TRIP

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy | |
| [ ]+a,c | ±x.x |
| [ ]+a,c | |
| Primary Element Accuracy | 0 |
| Sensor Reference Accuracy | |
| [ ]+a,c | ±x.x |
| Sensor Calibration Accuracy | |
| [ ]+a,c | ±x.x |
| Sensor Measurement & Test Equipment Accuracy | 0 |
| Sensor Pressure Effects | 0 |
| Sensor Temperature Effects | 0 |
| Sensor Drift (30 months) | |
| [ ]+a,c | ±x.x |
| Environmental Allowance | 0 |
| Rack Calibration Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of span (120°F)
\# Number of hot leg RTDs used

Channel Statistical Allowance =

[ ]+a,c

**TABLE 3-22**
**STEAM GENERATOR NARROW RANGE WATER LEVEL - HIGH 2 FOR REACTOR TRIP, TURBINE TRIP, MAIN FEEDWATER ISOLATION, STARTUP FEEDWATER ISOLATION, AND CVS ISOLATION**

| Parameter | Allowance |
|---|---|
| Process Measurement Accuracy | |
| [ ]+a,c | +x.x |
| [ ]+a,c | +x.x |
| [ ]+a,c | +x.x |
| Primary Element Accuracy | 0 |
| Sensor Reference Accuracy | ±x.x |
| Sensor Calibration Accuracy | ±x.x |
| Sensor Measurement & Test Equipment Accuracy | ±x.x |
| Sensor Pressure Effects | ±x.x |
| Sensor Temperature Effects | ±x.x |
| Sensor Drift (30 months) | ±x.x |
| Environmental Allowance | 0 |
| Rack Calibration | |
| Rack Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of span (100% of narrow range level)

Channel Statistical Allowance =

[ ]+a,c

**TABLE 3-23**
STARTUP FEEDWATER FLOW - LOW FOR PRHR ACTUATION
Orifice Plate

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy | 0 |
| Primary Element Accuracy | |
| [ ]+a,c | ±x.x |
| [ ]+a,c | ±x.x |
| Sensor Reference Accuracy | |
| [ ]+a,c | ±x.x |
| Sensor Calibration Accuracy | |
| [ ]+a,c | ±x.x |
| Sensor Measurement & Test Equipment Accuracy | |
| [ ]+a,c | ±x.x |
| Sensor Pressure Effects | |
| [ ]+a,c | ±x.x |
| Sensor Temperature Effects | |
| [ ]+a,c | ±x.x |
| Sensor Drift (30 months) | |
| [ ]+a,c | ±x.x |
| Environmental Allowance | 0 |
| Rack Calibration | |
| Rack Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of startup feedwater flow span (1000 gpm)

Channel Statistical Allowance =

[

]+a,c

**TABLE 3-24**
STEAM GENERATOR WIDE RANGE WATER LEVEL - LOW
FOR PRHR ACTUATION

| **Parameter** | **Allowance** |
|---|---|
| Process Measurement Accuracy | |
| [ ]+a,c | +x.x |
| [ ]+a,c | +x.x |
| [ ]+a,c | +x.x |
| Primary Element Accuracy | 0 |
| Sensor Reference Accuracy | ±x.x |
| Sensor Calibration Accuracy | ±x.x |
| Sensor Measurement & Test Equipment Accuracy | ±x.x |
| Sensor Pressure Effects | ±x.x |
| Sensor Temperature Effects | ±x.x |
| Sensor Drift (30 months) | ±x.x |
| Environmental Allowance | |
| [ ]+a,c | +x.x |
| [ ]+a,c | +x.x |
| [ ]+a,c | +x.x |
| Rack Calibration | |
| Rack Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of span (100% of wide range level)

Channel Statistical Allowance =

[

]+a,c

**TABLE 3-25**
PRESSURIZER WATER LEVEL - LOW 2 FOR CMT ACTUATION,
RCP TRIP, AND PURIFICATION LINE ISOLATION

| Parameter | Allowance |
|---|---|
| Process Measurement Accuracy | 0 |
| Primary Element Accuracy | 0 |
| Sensor Reference Accuracy | ±x.x |
| Sensor Calibration Accuracy | ±x.x |
| Sensor Measurement & Test Equipment Accuracy | ±x.x |
| Sensor Pressure Effects | ±x.x |
| Sensor Temperature Effects | ±x.x |
| Sensor Drift (30 months) | ±x.x |
| Environmental Allowance | 0 |
| Bias | |
| [ ]+a,c | +x.x |
| [ ]+a,c | +x.x |
| Rack Calibration | |
| Rack Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of span (100% of level)

Channel Statistical Allowance =

[

]+a,c

**TABLE 3-26**
CORE MAKEUP TANK LEVEL - LOW 1 & 2 FOR ADS STAGES
Heated Junction Thermocouples

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy [ ]+a,c | ±x.x |
| Primary Element Accuracy | 0 |
| Sensor Reference Accuracy | ±x.x |
| Sensor Calibration Accuracy | 0 |
| Sensor Measurement & Test Equipment Accuracy | 0 |
| Sensor Pressure Effects | 0 |
| Sensor Temperature Effects | ±x.x |
| Sensor Drift | 0 |
| Environmental Allowance | 0 |
| Rack Calibration | |
| Rack Accuracy | 0 |
| Measurement & Test Equipment Accuracy | 0 |
| Rack Temperature Effect | 0 |
| Rack Drift | 0 |

* In percent of span (100% of tank volume)

Channel Statistical Allowance =

[

]+a,c

**TABLE 3-27**
RCS PRESSURE - LOW FOR ADS STAGE 4 ACTUATION

| Parameter | Allowance |
|---|---|
| Process Measurement Accuracy | 0 |
| Primary Element Accuracy | 0 |
| Sensor Reference Accuracy | ±x.x |
| Sensor Calibration Accuracy | ±x.x |
| Sensor Measurement & Test Equipment Accuracy | ±x.x |
| Sensor Pressure Effects | 0 |
| Sensor Temperature Effects | ±x.x |
| Sensor Drift (30 months) | ±x.x |
| Environmental Allowance | +x.x |
| Rack Calibration | |
| Rack Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of span (3300 psi)

Channel Statistical Allowance =

[

]+a,c

**TABLE 3-28**
RCS Tavg - LOW 1 FOR MAIN FEEDWATER CONTROL VALVE CLOSURE
AND LOW 2 FOR MAIN FEEDWATER PUMP TRIP, ISOLATION VALVE CLOSURE
AND STEAM DUMP BLOCK

| **Parameter** | **Allowance*** |
|---|---|
| Process Measurement Accuracy | |
| [ ]+a,c | ±x.x |
| [ ]+a,c | |
| [ ]+a,c | +x.x |
| Primary Element Accuracy | 0 |
| Sensor Reference Accuracy | ±x.x |
| Sensor Calibration Accuracy | ±x.x |
| Sensor Measurement & Test Equipment Accuracy | 0 |
| Sensor Pressure Effects | 0 |
| Sensor Temperature Effects | 0 |
| Sensor Drift (30 months) | ±x.x |
| Environmental Allowance | 0 |
| Rack Calibration Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of span (100°F)
\# Number of hot leg RTDs used
\## Number of cold leg RTDs used

**TABLE 3-28 (continued)**
RCS Tavg - LOW 1 FOR MAIN FEEDWATER CONTROL VALVE CLOSURE
AND LOW 2 FOR MAIN FEEDWATER PUMP TRIP AND ISOLATION VALVE CLOSURE
AND STEAM DUMP BLOCK

Channel Statistical Allowance =

+a,c

[ ]

**TABLE 3-29**

HOT LEG WATER LEVEL - LOW FOR OPENING IRWST INJECTION LINE VALVES

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy | ±x.x |
| Primary Element Accuracy | 0 |
| Sensor Reference Accuracy | ±x.x |
| Sensor Calibration Accuracy | ±x.x |
| Sensor Measurement & Test Equipment Accuracy | ±x.x |
| Sensor Pressure Effects | ±x.x |
| Sensor Temperature Effects | ±x.x |
| Sensor Drift (30 months) | ±x.x |
| Environmental Allowance | 0 |
| Rack Calibration | |
| Rack Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of span (100% of level)

Channel Statistical Allowance =

[

]+a,c

**TABLE 3-30**
IRWST WATER LEVEL - LOW 3
FOR OPENING ALL IRWST CONTAINMENT RECIRCULATION VALVES

| Parameter | Allowance* |
|---|---|
| Process Measurement Accuracy | ±x.x |
| Primary Element Accuracy | 0 |
| Sensor Reference Accuracy | ±x.x |
| Sensor Calibration Accuracy | ±x.x |
| Sensor Measurement & Test Equipment Accuracy | ±x.x |
| Sensor Pressure Effects | ±x.x |
| Sensor Temperature Effects | ±x.x |
| Sensor Drift (30 months) | ±x.x |
| Environmental Allowance | 0 |
| Rack Calibration | |
| Rack Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of span (100% of level)

Channel Statistical Allowance =

[

]+a,c

**TABLE 3-31**
SPENT FUEL POOL WATER LEVEL - LOW FOR SPENT FUEL POOL ISOLATION

| **Parameter** | **Allowance*** |
|---|---|
| Process Measurement Accuracy | ±x.x |
| Primary Element Accuracy | 0 |
| Sensor Reference Accuracy | ±x.x |
| Sensor Calibration Accuracy | ±x.x |
| Sensor Measurement & Test Equipment Accuracy | ±x.x |
| Sensor Pressure Effects | ±x.x |
| Sensor Temperature Effects | ±x.x |
| Sensor Drift (30 months) | ±x.x |
| Environmental Allowance | 0 |
| Rack Calibration | |
| Rack Accuracy | ±x.x |
| Measurement & Test Equipment Accuracy | ±x.x |
| Rack Temperature Effect | ±x.x |
| Rack Drift | ±x.x |

* In percent of span (41 ft.)

Channel Statistical Allowance =

[

]+a,c

**TABLE 3-32**
BATTERY CHARGER VOLTAGE LOW FOR ADS STAGES 1,2, & 3,
MAIN CONTROL ROOM ISOLATION AND AIR SUPPLY INITIATION, AND OPEN
IRWST CONTAINMENT RECIRCULATION VALVES IN SERIES WITH CHECK VALVES

| **Parameter** | **Allowance*** |
|---|---|
| Process Measurement Accuracy | 0 |
| Primary Element Accuracy | ±x.x |
| Sensor Reference Accuracy | ±x.x |
| Sensor Calibration Accuracy | ±x.x |
| Sensor Measurement & Test Equipment Accuracy | ±x.x |
| Sensor Pressure Effects | 0 |
| Sensor Temperature Effects | ±x.x |
| Sensor Drift (30 months) | ±x.x |
| Environmental Allowance | 0 |
| Rack Calibration | |
| Rack Accuracy | 0 |
| Measurement & Test Equipment Accuracy | 0 |
| Rack Temperature Effect | 0 |
| Rack Drift | 0 |

* In percent of span (150 V)

Channel Statistical Allowance =

[

]+a,c

TAB[illegible]

REACTOR TRIP SYSTEM / E[illegible]

ACTUATION SYSTEM CHANN[illegible]

| | | | | SENSOR | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | PROTECTION CHANNEL | PROCESS MEASUREMENT ACCURACY (1) | PRIMARY ELEMENT ACCURACY (1) | CALIBRATION ACCURACY (1) | REFERENCE ACCURACY (1) | MEASUREMENT & TEST EQUIPMENT ACCURACY (1) | PRESSURE EFFECTS (1) | TEMPERATURE EFFECTS (1) |
| 1 | POWER RANGE, NEUTRON FLUX - HIGH SETPOINT, REACTOR TRIP | X (4), X (5) & X (6) | — | (7) | — | (7) | — | (7) |
| 2 | POWER RANGE, NEUTRON FLUX - LOW SETPOINT, REACTOR TRIP | X (4), X (5) & X (6) | — | (7) | — | (7) | — | (7) |
| 3 | POWER RANGE, NEUTRON FLUX - HIGH POSITIVE RATE, REACTOR TRIP AND HIGH NEGATIVE RATE, ROD BLOCK, | (8) | — | (8) | — | (8) | — | (8) |
| 4 | INTERMEDIATE RANGE, NEUTRON FLUX, REACTOR TRIP | X (10) & X (11) | — | (12) | — | (12) | — | (12) |
| 5 | SOURCE RANGE, NEUTRON FLUX, REACTOR TRIP | X (13) | — | (12) | — | (12) | — | (12) |
| 6 | SOURCE RANGE, NEUTRON FLUX DOUBLING, BORON DILUTION BLOCK | X (14) & X (15) | | (8) | — | (8) | — | (8) |
| 7 | OVERTEMPERATURE ΔT, REACTOR TRIP | | | | | | | |
| | ΔT CHANNEL | X (16), X(21), &X(34) | — | — | — | — | — | — |
| | PRESSURIZER PRESSURE CHANNEL | — | — | X | X | X | — | X |
| | ΔI CHANNEL | X (17) & X (18) | — | — | — | — | — | — |
| | TAVG CHANNEL | X(21) | — | — | — | — | — | — |
| 8 | OVERPOWER ΔT, REACTOR TRIP — ΔT CHANNEL | X (16), X(21), & X(34) | — | — | — | — | — | — |
| | TAVG CHANNEL | X(21) | — | — | — | — | — | — |
| 9 | PRESSURIZER PRESSURE - LOW, REACTOR TRIP | — | — | X | X | X | — | X |
| 10 | PRESSURIZER PRESSURE - HIGH, REACTOR TRIP | — | — | X | X | X | — | X |
| 11 | PRESSURIZER LEVEL - HIGH-3, REACTOR TRIP | | | | | | | |
| | ΔP CHANNEL | — | — | X | X | X | X | X |
| | Tref COMPENSATION CHANNEL | — | — | — | — | — | — | — |
| | PRESSURE COMPENSATION CHANNEL | — | — | — | X | — | — | — |
| 12 | LOSS OF FLOW, REACTOR TRIP | X (22) & X (23) | X (24) & X (25) | (26) | X | (26) | (26) | (26) |
| 13 | STEAM GENERATOR NR LEVEL - LOW, REACTOR TRIP, STEAM GENERATOR BLOWDOWN ISOLATION, AND PRHR | X (27), X(35), & X(36) | — | X | X | X | X | X |
| 14 | RCP SPEED - LOW, REACTOR TRIP | X | — | — | — | — | — | — |
| 15 | RCP BEARING WATER TEMPERATURE - HIGH, REACTOR TRIP AND TRIP OF AFFECTED RCP | (28) | — | (28) | X | (28) | — | — |
| 16 | CONTAINMENT PRESSURE - HIGH-1, S SIGNAL, SLI | — | — | X | X | X | — | X |
| 17 | CONTAINMENT PRESSURE - HIGH-2, CONTAINMENT COOLING | — | — | X | X | X | — | X |
| 18 | PRESSURIZER PRESSURE - LOW, S SIGNAL | — | — | X | X | X | — | X |
| 19 | STEAM LINE PRESSURE - LOW, S SIGNAL & SLI (OUTSIDE CONTAINMENT BREAK) | — | — | X | X | X | — | X |
| 20 | STEAM LINE PRESSURE - LOW, S SIGNAL & SLI (INSIDE CONTAINMENT BREAK) | — | — | X | X | X | — | X |
| 21 | STEAM LINE PRESSURE NEGATIVE RATE - HIGH, SLI | — | — | (8) | (8) | (8) | — | (8) |
| 22 | Tcold - LOW, S SIGNAL, SLI, SFW ISOLATION FOR CVS MALFUNCTION | X (42) | — | X | X | — | — | — |
| 23 | Tcold - LOW, S SIGNAL, SLI, SFW ISOLATION FOR STEAM LINE BREAK | X (42) | — | X | X | — | — | — |
| 24 | Thot HIGH, CMT ACTUATION, RCP TRIP | X (34) & X(43) | — | X | X | — | — | — |
| 25 | STEAM GENERATOR NR LEVEL - HIGH 2, REACTOR TRIP, TURBINE TRIP,MAIN FW ISOLATION, STARTUP FW ISOLATION,CVS ISOLATION | X (29), X(35) & X(36) | — | X | X | X | X | X |
| 26 | REACTOR COOLANT SYSTEM TEMPERATURE TAVG–LOW-1, MAIN FW CONTROL VALVE CLOSURE | X (42), X (43), & X (34) | — | X | X | — | — | — |
| 27 | REACTOR COOLANT SYSTEM TEMPERATURE TAVG–LOW-2, MAIN FW PUMP TRIP, MAIN FW ISOLATION, BLOCK STEAM DUMP | X (42), X (43), & X (34) | — | X | X | — | — | — |
| 28 | STARTUP FEEDWATER FLOW - LOW, ACTUATE PRHR | — | X (30) & X (31) | X | X | X | X | X |

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GINEERED SAFETY FEATURES
EL UNCERTAINTY ALLOWANCES
P600

| | | INSTRUMENT RACK | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | |
| T | ENVIRONMENTAL ALLOWANCE/ COMPENSATION CHANNEL ERRORS (1) | CALIBRATION ACCURACY (1) | MEASUREMENT & TEST EQUIPMENT ACCURACY (1) | TEMPERATURE EFFECTS (1) | DRIFT (1) | INSTRUMENT SPAN | SAFETY ANALYSIS LIMIT (2) | NOMINAL TRIP SETPOINT (3) | TOTAL ALLOWANCE (1) | CHANNEL STATISTICAL ALLOWANCE (1) | MARGIN (1) | |
| | — | X | X | X | X | 120% RTP | 118% RTP | X% RTP | X | X | X | 1 |
| | — | X | X | X | X | 120% RTP | 35% RTP | X% RTP | X | X | X | 2 |
| | — | X | X | X | X | 120% RTP | (9) | X% RTP/X SEC | — | X | — | 3 |
| | — | X | X | X | X | 120% RTP | (9) | X% RTP | — | X | — | 4 |
| | — | X | X | X | X | 1.0E+6 CPS | (9) | (X E+X) CPS | — | X | — | 5 |
| | — | X | X | X | X | 2.5 X φ | 1.6 X φ | X φ | X | X | X | 6 |
| | —<br>—<br>—<br>— | —<br>X<br>X<br>— | —<br>X<br>X<br>— | —<br>X<br>X<br>— | —<br>X<br>X<br>— | 150% RTP<br>800 PSI<br>±60 % ΔI | FUNCTION (19) | FUNCTION (20) | X | X | X | 7 |
| | X(39) | —<br>— | —<br>— | —<br>— | —<br>— | 150% RTP | FUNCTION (19) | FUNCTION (20) | X | X | X | 8 |
| | — | X | X | X | X | 800 PSI | 1785 PSIC | X PSIG | X | X | X | 9 |
| | — | X | X | X | X | 800 PSI | 2445 PSIG | X PSIG | X | X | X | 10 |
| | —<br>X<br>X | X<br>—<br>— | X<br>—<br>— | X<br>—<br>— | X<br>—<br>— | 100% LEVEL SPAN | (9) | X% SPAN | — | X | — | 11 |
| | — | X | X | X | X | 120% FLOW | 87% FLOW | X% FLOW | X | X | X | 12 |
| | X(37), X(38), & X(39) | X | X | X | X | 100% LEVEL SPAN | (40) | X% SPAN | X | X | X | 13 |
| | — | X | X | X | X | 120% NOMINAL SPEED | 90% NOMINAL SPEED | X% NOMINAL SPEED | X | X | X | 14 |
| | — | X | X | X | X | 380 °F | (9) | X °F ABOVE FULL POWER TEMPERATURE | — | X | — | 15 |
| | — | X | X | X | X | 15 PSI | 8 PSI | X PSI | X | X | X | 16 |
| | — | X | X | X | X | 15 PSI | 8 PSI | X PSI | X | X | X | 17 |
| | X(44) & X(39) | X | X | X | X | 800 PSI | 1685 PSIG | X PSIG | X | X | X | 18 |
| | X(37) & X(39) | X | X | X | X | 1200 PSI | 405 PSIG | X PSIG | X | X | X | 19 |
| | — | X | X | X | X | 1200 PSI | 525 PSIG | X PSIG | X | X | X | 20 |
| | — | X | X | X | X | 1200 PSI | (9) | X PSI/X SEC | — | X | — | 21 |
| | — | X | X | X | X | 120 °F | 510 °F | X °F | X | X | X | 22 |
| | X(39) | X | X | X | X | 120 °F | 470 °F | X °F | X | X | X | 23 |
| | — | X | X | X | X | 120 °F | (9) | X °F | — | X | — | 24 |
| | — | X | X | X | X | 100% LEVEL SPAN | 95% SPAN | X% SPAN | X | X | X | 25 |
| | — | X | X | X | X | 100 °F | (9) | X °F | — | X | — | 26 |
| | — | X | X | X | X | 100 °F | 542 °F | X °F | X | X | X | 27 |
| | — | X | X | X | X | 1000 GPM | (9) | X GPM | — | X | — | 28 |

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TAI

REACTOR TRIP SYSTEM / E

ACTUATION SYSTEM CHANN

| | PROTECTION CHANNEL | 1 | 2 | SENSOR 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| | | PROCESS MEASUREMENT ACCURACY (1) | PRIMARY ELEMENT ACCURACY (1) | CALIBRATION ACCURACY (1) | REFERENCE ACCURACY (1) | MEASUREMENT & TEST EQUIPMENT ACCURACY (1) | PRESSURE EFFECTS (1) | TEMPERATURE EFFECTS (1) |
| 29 | STEAM GENERATOR WR LEVEL - LOW, ACTUATE PRHR | X (27), X(35), & X(36) | — | X | X | X | X | X |
| 30 | PRESSURIZER LEVEL - LOW 2, ACTUATE CMT, RCP TRIP, PURIFICATION LINE ISOLATION | | | | | | | |
| | ΔP CHANNEL | — | — | X | X | X | X | X |
| | Tref COMPENSATION CHANNEL | — | — | — | — | — | — | — |
| | PRESSURE COMPENSATION CHANNEL | — | — | — | — | — | — | — |
| 31 | PRESSURIZER LEVEL - HIGH 1, CVS ISOLATION | | | | | | | |
| | ΔP CHANNEL | — | — | X | X | X | X | X |
| | Tref COMPENSATION CHANNEL | — | — | | — | — | — | — |
| | PRESSURE COMPENSATION CHANNEL | — | — | — | — | — | — | — |
| 32 | PRESSURIZER LEVEL - HIGH 2, CVS ISOLATION | | | | | | | |
| | ΔP CHANNEL | — | — | X | X | X | X | X |
| | Tref COMPENSATION CHANNEL | — | — | — | — | — | — | — |
| | PRESSURE COMPENSATION CHANNEL | — | — | — | — | — | — | — |
| 33 | CMT WATER LEVEL - LOW 1, ADS STAGES 1,2 &3 | X (32) | — | — | [illegible] | — | — | X (33) |
| 34 | CMT WATER LEVEL - LOW 2, ADS STAGE 4 | X (32) | — | — | X | — | — | X (33) |
| 35 | RCS HOT LEG LEVEL - LOW , OPEN IRWST INJECTION LINE VALVES | X | — | X | X | X | X | X |
| 36 | IRWST WATER LEVEL - LOW 3, OPEN IRWST CONTAINMENT RECIRCULATION VALVES | X | — | X | X | X | X | X |
| 37 | SPENT FUEL POOL WATER LEVEL - LOW, SPENT FUEL POOL ISOLATION | X | — | X | X | X | X | X |
| 38 | RCS PRESSURE - LOW, ADS STAGE 4 | — | — | X | X | X | — | X |
| 39 | BATTERY CHARGER INPUT VOLTAGE LOW FOR ADS STAGES 1, 2 & 3, MAIN CONTROL ROOM ISOLATION | — | X | X | X | X | — | X |

NOTES:

1. ALL VALUES IN PERCENT OF SPAN.
2. AS NOTED IN CHAPTER 15 OF THE SSAR.
3. AS CALCULATED USING THE APPROVED METHODOLOGY.
4. [POWER CALORIMETRIC ALLOWANCE]a,c
5. [NEUTRON FLUX - DOWNCOMER WATER DENSITY, RADIAL POWER REDISTRIBUTION]a,c
6. [ALLOWED MISMATCH BETWEEN NIS AND POWER CALORIMETRIC]a,c
7. [INCLUDED IN CALORIMETRIC ALLOWANCE IN PROCESS MEASUREMENT ACCURACY]a,c
8. [USE OF A RATE (DERIVATIVE) ELIMINATES SENSOR STEADY STATE ERRORS]a,c
9. NOT USED IN THE SAFETY ANALYSIS.
10. [POWER CALORIMETRIC ALLOWANCE, RADIAL POWER REDISTRIBUTION]a,c
11. [ROD SHADOWING EFFECT, TREATED AS A BIAS]a,c
12. INCLUDED IN [PROCESS MEASUREMENT ACCURACY]a,c
13. [DOWNCOMER WATER DENSITY, RADIAL POWER REDISTRIBUTION, AND DETECTOR GAS BURNUP]a,c
14. [ICRR CURVE APPLICABILITY]a,c
15. [SIGNAL NOISE]a,c
16. [POWER CALORIMETRIC]a,c
17. INCORE / EXCORE f(ΔI) COMPARISON AS NOTED IN PLANT TECHNICAL SPECIFICATIONS
18. [INCORE FLUX MAP f(ΔI) UNCERTAINTY]a,c
19. AS NOTED IN SSAR
20. AS NOTED IN TABLE 3.3.1-1 OF AP600 TECHNICAL SPECIFICATIONS
21. [CORE BURNDOWN EFFECTS - TREATED AS A BIAS]a,c
22. [DENSITY EFFECTS]a,c
23. [PRECISION FLOW CALORIMETRIC UNCERTAINTY]a,c
24. [PITOT TUBE ACCURACY ALLOWANCE]a,c
25. [HYDRAULIC NOISE EFFECT]a,c
26. [NORMALIZATION OF PITOT TUBES TO PRECISION FLOW CALORIMETRIC ELIMINATES SENSOR CALIBRATION, TEMPERATURE, AND PRESSURE ERRORS]a,c
27. [STEAM GENERATOR DOWNCOMER SUBCOOLING EFFECT - TREATED AS A BIAS]a,c
28. [ELIMINATED BY NORMALIZATION]a,c
29. [STEAM GENERATOR FLUID VELOCITY EFFECT - TREATED AS A BIAS]a,c
30. [ORIFICE PLATE FLOW COEFFICIENT ERROR ALLOWANCE]a,c

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NGINEERED SAFETY FEATURES
EL UNCERTAINTY ALLOWANCES
P600

| | | INSTRUMENT RACK | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | |
| FT | ENVIRONMENTAL ALLOWANCE/ COMPENSATION CHANNEL ERRORS (1) | CALIBRATION ACCURACY (1) | MEASUREMENT & TEST EQUIPMENT ACCURACY (1) | TEMPERATURE EFFECTS (1) | DRIFT (1) | INSTRUMENT SPAN | SAFETY ANALYSIS LIMIT (2) | NOMINAL TRIP SETPOINT (3) | TOTAL ALLOWANCE (1) | CHANNEL STATISTICAL ALLOWANCE (1) | MARGIN (1) | |
| | X(37), X(38), & X(39) | X | X | X | X | 100% LEVEL SPAN | (44) | X% SPAN | X | X | X | 29 |
| | —<br>X<br>X | X<br>—<br>— | X<br>—<br>— | X<br>—<br>— | X<br>—<br>— | 100% LEVEL SPAN | 1% LEVEL SPAN | X% SPAN | X | X | X | 30 |
| | —<br>X<br>X | X<br>—<br>— | X<br>—<br>— | X<br>—<br>— | X<br>—<br>— | 100% LEVEL SPAN | (9) | X% SPAN | — | X | — | 31 |
| | —<br>X<br>X | X<br>—<br>— | X<br>—<br>— | X<br>—<br>— | X<br>—<br>— | 100% LEVEL SPAN | 741% LEVEL SPAN | X% SPAN | X | X | X | 32 |
| | — | — | — | — | — | 100% TANK VOLUME | 67.5% SPAN | X% SPAN | X | X | X | 33 |
| | — | — | — | — | — | 100% TANK VOLUME | 20 % SPAN | X% SPAN | X | X | X | 34 |
| | — | X | X | X | X | 100% LEVEL | 0% SPAN | X% SPAN | X | X | X | 35 |
| | — | X | X | X | X | 100% TANK LEVEL | (9) | X% SPAN | — | X | — | 36 |
| | — | X | X | X | X | 100% TANK LEVEL | (9) | X% SPAN | — | X | — | 37 |
| | X | X | X | X | X | 3300 PSI | 100 PSIG | X PSIG | X | X | X | 38 |
| | — | — | — | — | — | 150 VOLTS | (9) | X VOLTS | — | X | — | 39 |

31. [ALLOWANCE FOR ORIFICE PLATE INSTALLATION CONFIGURATION][a,b,c]
32. [ALLOWANCE FOR FROTHING AT WATER/STEAM INTERFACE][a,b,c]
33. [ALLOWANCE FOR EXPANSION/CONTRACTION OF PROBE][a,b,c]
34. [LOSS OF HOT LEG RTD][a,b,c]
35. [PROCESS PRESSURE VARIATIONS - TREATED AS A BIAS][a,b,c]
36. [REFERENCE LEG TEMPERATURE VARIATIONS - TREATED AS A BIAS][a,b,c]
37. [TRANSMITTER ELEVATED TEMPERATURE EFFECT][a,b,c]
38. [REFERENCE LEG HEATUP][a,b,c]
39. [CABLE IR DEGRADATION][a,b,c]
40. [45,000 LBM CONVERTED TO % NR LEVEL SPAN][a,b,c]
41. [TRANSMITTER ELEVATED TEMPERATURE AND RADIATION EFFECT][a,b,c]
42. [COLD LEG TEMPERATURE STREAMING - TREATED AS A BIAS][a,b,c]
43. [HOT LEG TEMPERATURE STREAMING][a,b,c]
44. [25,000 LBM CONVERTED TO % WR LEVEL SPAN][a,b,c]



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## TABLE 3-34
OVERTEMPERATURE $\Delta T$ CALCULATIONS

- The equation for Overtemperature $\Delta T$:

$$\Delta T \frac{(1 + \tau_4 S)}{(1 + \tau_5 S)} \leq \Delta T_0 \{K_1 - K_2 \frac{(1 + \tau_1 S)}{(1 + \tau_2 S)} (T - T') + K_3 (P - P') - f_1 (\Delta I)\}$$

| | | |
|---|---|---|
| $K_1$ (nominal) | = | x.xx Technical Specification value |
| $K_1$ (max) | = | [ ]+a,c |
| $K_2$ | = | 0.03/°F |
| $K_3$ | = | 0.002/psi |
| Vessel $\Delta T$ | = | xx.x°F |
| $\Delta I$ gain | = | 4.915% RTP/% of $\Delta I$ |

- Full power $\Delta T$ calculation:

$\Delta T$ span = [ ]+a,c
$\Delta T$ span_power = 150% of RTP

- Process Measurement Accuracy Calculations:*

[ ]+a,c

[ ]+a,c

[ ]+a,c

---

* Presumes normalization of $\Delta T_o$ and $T^1$ to as-found full power indicated values

**TABLE 3-34 (continued)**
OVERTEMPERATURE ΔT CALCULATIONS

ΔI - Incore / Excore Mismatch

[

]+a,c

ΔI - Incore Map Delta-I

[

]+a,c

- Pressure Channel Uncertainties

| | | |
|---|---|---|
| Gain | = | [ ]+a,c |
| SCA | = | (gain)(x.x% of pressure span) = x.x% of ΔT span |
| SRA | = | (gain)(x.x% of pressure span) = x.x% of ΔT span |
| SMTE | = | (gain)(x.x% of pressure span) = x.x% of ΔT span |
| STE | = | (gain)(x.x% of pressure span) = x.x% of ΔT span |
| SD | = | (gain)(x.x% of pressure span) = x.x% of ΔT span |
| RCA | = | (gain)(x.x% of pressure span) = x.x% of ΔT span |
| RMTE | = | (gain)(x.x% of pressure span) = x.x% of ΔT span |
| RD | = | (gain)(x.x% of pressure span) = x.x% of ΔT span |

**TABLE 3-34 (continued)**
OVERTEMPERATURE ΔT CALCULATIONS

- ΔI Channel Uncertainties

| | | |
|---|---|---|
| Gain | = | [ ]+a,c |
| RCA | = | (gain)(x.x% of ΔI span) = x.x% of ΔT span |
| RMTE | = | (gain)(x.x% of ΔI span) = x.x% of ΔT span |
| RD | = | (gain)(x.x% of ΔI span) = x.x% of ΔT span |

- Total Allowance

[ ]+a,c

## TABLE 3-35
OVERPOWER ΔT CALCULATIONS

- The equation for Overpower ΔT:

$$\Delta T \frac{(1 + \tau_4 S)}{(1 + \tau_5 S)} \leq \Delta T_0 \{K_4 - K_5(\frac{\tau_3 S}{(1 + \tau_3 S)}) T - K_6[T \quad T''] - f_2 (\Delta I) \}$$

$K_4$ (nominal) = x.xx Technical Specification value
$K_4$ (max) = [ )]$^{+a,c}$
$K_5$ = 0.0 for decreasing average temperature
$K_5$ = 0.02 for increasing average temperature
$K_6$ = 0.00219/°F
Vessel ΔT = xx.x°F

- Full power ΔT calculation:

ΔT span = [ ]$^{+a,c}$
ΔT span_power = 150% of RTP

- Process Measurement Accuracy Calculations:*

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

- Total Allowance

[ ]$^{+a,c}$

---

* Presumes normalization of $\Delta T_0$ and T" to as-found full power indicated values

## TABLE 3-36
## 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% of 100 inches ΔP = ±1.5 inches anywhere in the span. Because $F^2 = f(\Delta P)$ the same cannot be said for flow accuracies. When it is more convenient to express the accuracy of a transmitter in flow terms, the following method is used:

$$(F_N)^2 = \Delta P_N$$

where N = Nominal Flow

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

thus

$$\partial F_N = \frac{\partial \Delta P_N}{2F_N} \qquad \text{Eq. 3-36.1}$$

Error at a point (not in percent) is:

$$\frac{\partial F_N}{F_N} = \frac{\partial \Delta P_N}{2(F_N)^2} = \frac{\partial \Delta P_N}{2\Delta P_N} \qquad \text{Eq. 3-36.2}$$

and

$$\frac{\Delta P_N}{\Delta P_{max}} = \frac{(F_N)^2}{(F_{max})^2} \qquad \text{Eq. 3-36.3}$$

where max = maximum flow and the transmitter ΔP error is:

$$\frac{\partial \Delta P_N}{\Delta P_{max}}(100) = \text{percent error in full scale } \Delta P \ (\%\ \varepsilon\ \text{FS}\ \Delta P) \qquad \text{Eq. 3-36.4}$$

therefore:

$$\frac{\partial F_N}{F_N} = \frac{\Delta P_{max}\left[\frac{\%\ \varepsilon\ \text{FS}\ \Delta P}{100}\right]}{2\Delta P_{max}\left[\frac{F_N}{F_{max}}\right]^2} = \left[\frac{\%\ \varepsilon\ \text{FS}\ \Delta P}{(2)(100)}\right]\left[\frac{F_{max}}{F_N}\right]^2 \qquad \text{Eq. 3-36.5}$$

Error in flow units is:

$$\partial F_N = F_N\left[\frac{\%\ \varepsilon\ \text{FS}\ \Delta P}{(2)(100)}\right]\left[\frac{F_{max}}{F_N}\right]^2 \qquad \text{Eq. 3-36.6}$$

Error in percent of nominal flow is:

$$\frac{\partial F_N}{F_N}(100) = \left[\frac{\%\ \varepsilon\ FS\ \Delta P}{2}\right]\left[\frac{F_{max}}{F_N}\right]^2 \qquad \text{Eq. 3-36.7}$$

Error in percent of full span is:

$$\frac{\partial F_N}{F_{max}}(100) = \left[\frac{F_N}{F_{max}}\right]\left[\frac{\%\ \varepsilon\ FS\ \Delta P}{(2)(100)}\right]\left[\frac{F_{max}}{F_N}\right]^2(100)$$

$$= \left[\frac{\%\ \varepsilon\ FS\ \Delta P}{2}\right]\left[\frac{F_{max}}{F_N}\right] \qquad \text{Eq. 3-36.8}$$

Equation 3-36.8 is used to express errors in percent of full span in this document.

## 4.0 APPLICATION OF THE SETPOINT METHODOLOGY

### 4.1 Uncertainty Calculation Basic Assumptions and Premises

The equations noted in Sections 2 and 3 are based on several basic assumptions about the manner in which calibration procedures and drift determinations will be performed for AP600:

1) instrument technicians will make reasonable attempts to achieve the Nominal Trip Setpoint as an as-left condition at the start of each process rack's surveillance interval

2) instrument technicians will make reasonable attempts to achieve a nominal as-left condition at the start of each sensor/transmitter's surveillance interval

3) process rack drift will be evaluated (probability distribution function characteristics and drift magnitude) over multiple surveillance intervals

4) sensor/transmitter drift will be trended over the fuel cycle and evaluated (probability distribution function characteristics and drift magnitude) over multiple fuel cycles

5) process rack calibration accuracy will be evaluated (probability distribution function characteristics and drift magnitude) over multiple surveillance intervals

6) sensor/transmitter calibration accuracy will be evaluated (probability distribution function characteristics and drift magnitude) over multiple surveillance intervals, and

7) sensor/transmitters are calibrated using a one up and one down pass utilizing multiple calibration points (minimum 5 points, as recommended by ISA51.1[1])

It should be noted for (1) and (2) that it is not necessary for the instrument technician to recalibrate a device or channel if the as-left condition is not exactly at the nominal condition but is within the plus or minus of nominal as-left procedural tolerance. As noted above, the uncertainty calculations assume that the as-left tolerance (conservative and non-conservative direction) is satisfied on a reasonable statistical basis, not that the nominal condition is satisfied exactly. The as-left condition for the RPS/ESFAS process rack channels and sensor/transmitters for AP600 should be statistically evaluated over multiple calibration cycles. This evaluation must show that the SCA and RCA parameter values included in the plant-specific uncertainty calculations are satisfied on the basis of at least a 95% probability / 95% confidence level. For those instances where non-conservative biases in calibration are noted, the biases must be factored into the uncertainty calculations. Calibration biases for sensor/transmitters are considered as non-conservative since sensor/transmitter signals are used for both control and protection and could be considered significant for control purposes. It is, therefore, necessary for the plant to periodically reverify the continued validity of these results. This prevents the institution of non-conservative biases due to a procedural basis without the plant staff's knowledge and appropriate treatment.

In summary, a sensor/transmitter or a process rack channel is considered to be calibrated when the two-sided as-left calibration procedural tolerance is satisfied. An instrument technician may decide to recalibrate if near the extremes of the as-left procedural tolerance, but it is not required. Recalibration is explicitly required any time the as-found condition of the device or channel is outside of the as-left procedural tolerance. A device or channel may not be left outside the as-left tolerance without declaring the channel inoperable and appropriate action taken. Thus, an as-left tolerance may be considered as an outer limit for the purposes of calibration and instrument uncertainty calculations.

In determining the drift allowances for AP600, drift data (as-found – as-left) for similar sensor/transmitters and process racks from other plants will need to be evaluated, along with vendor specifications, until AP600-specific data becomes available. Multiple surveillance intervals will be evaluated to determine the appropriate values for drift for a surveillance interval of 30 months (for sensor/transmitters) and 3 months (for digital process rack modules). The SD and RD parameter values to be used as allowances should satisfy on the basis of a 95% probability / 95% confidence level for the projected surveillance intervals. Generic Letter 91-04[2] requires that drift be tracked or trended on a periodic basis. The equations used in Sections 2 and 3, assume that drift data is evaluated for continuation of the validity of the basic characteristics determined by the Westinghouse evaluation. This assumption has a significantly beneficial effect on the basic uncertainty equations utilized, i.e., it results in a reduction in the CSA magnitude.

## 4.2 Sensor/Transmitter Operability Determination Program and Criteria

Generic Letter 91-04, Enclosure 2, requires that the assumptions of the setpoint evaluations be appropriately reflected in plant surveillance procedures and that a program be in place to monitor and assess the effects of increased calibration surveillance intervals on instrument drift and its effect on safety. The program should ensure that existing procedures provide data for evaluating the effects of increased calibration intervals. The data should confirm that the estimated errors for instrument drift with increased calibration intervals are within projected limits. This requirement to monitor instrument drift is consistent with the format of the uncertainty equations noted in Sections 2 and 3 of this WCAP, whereby calibration accuracy and drift are treated as two statistically independent parameters. An implication of this format is that equipment performance should be evaluated based not only on the capability of the equipment to be calibrated, but also on continued equipment performance which is consistent with the drift allowances based on historical performance and incorporated in the uncertainty calculations.

A set of criteria must be selected to be used for equipment operability determination which is controlled by plant procedures and processes, as opposed to the plant Technical Specifications. The principle criterion for sensor/transmitter operability, as a first pass parameter, is drift (as-found - as-left) determined to be within SD, where SD is the 95/95 drift value determined for that specific device, e.g., a pressurizer pressure transmitter. This would require the instrument technician to record both the as-left and as-found conditions and

perform a calculation in the field. This field calculation may be determined to be impracticable at this time since it would require having the as-left value for that device at the time of drift determination and becomes a records availability/control problem. A less rigorous alternate first pass criterion is the use of a fixed magnitude, two-sided as-found tolerance about the nominal value. A reasonable value for this tolerance is SMTE + SD, where SD is again the 95/95 drift value and SMTE is as defined in the uncertainty calculations and identified in the AP600 procedures. This criterion can then be incorporated into plant, function specific calibration and drift procedures as the defined as-found tolerance about the desired, nominal value.

A second criterion is the ability to calibrate the sensor/transmitter within the two-sided as-left tolerance. If the device is found outside the SMTE + SD (or as-found) criterion, the drift characteristics should be evaluated incorporating the previous experience for that specific device. The response time characteristics may also be evaluated on a qualitative and, if necessary, a quantitative basis. Monitoring the sensor/transmitter response with the average of its peer devices, utilizing data available online, periodically over the entire cycle can be an additional check on operability. This additional check provides a reasonable substitute for the use of a relative SD term (as recommended in the Westinghouse paper presented at the ISA/EPRI conference of June 1994[3]). When an appropriate acceptance criterion is utilized, it then allows the use of SMTE + SD as a first-pass operability criterion. The acceptance criterion is a relative deviation of ±0.5% of span from the beginning of cycle difference value. A relative shift of this magnitude has been determined to be an appropriate indication of device drift warranting further investigation.

It is believed that a systematic sensor/transmitter program of drift and calibration review is acceptable as a set of first pass criteria. More elaborate evaluation and more frequent online monitoring may be included, as necessary, if the drift is found to be excessive or the device is found difficult to calibrate. To provide additional confidence in the evaluation process, AP600 must utilize a function indication match criterion at the beginning of each cycle to determine the acceptability of the calibration process for the transmitter and that portion of the channel encompassed through the indicator. Based on the above, it is believed that the total program proposed for AP600 will provide a more comprehensive evaluation of operability than a simple determination of an acceptable as-found condition.

### 4.3 Process Rack Operability Determination Program and Criteria

A program has been determined to define operability criteria for the digital process racks. Assuming that the process racks are self-checking, the critical parameter is the ability of the process racks to be calibrated within the rack calibration accuracy. These values will be found in the AP600 plant calibration procedures as the as-left calibration accuracy, and must be consistent with the digital card/channel analog input verification test criteria. The channel will be considered inoperable if it cannot be returned to within the rack calibration accuracy regardless of the as-found value.

### 4.4 References/Standards


[1] Instrument Society of America Standard S51.1-1979, "Process Instrumentation Terminology," p 33, 1979.

[2] Generic Letter 91-04, 1991, "Changes in Technical Specification Surveillance Intervals to Accommodate a 24-month Fuel Cycle."

[3] Tuley, C. R., Williams, T. P., "The Allowable Value in the Westinghouse Setpoint Methodology - Fact or Fiction?," presented at the Thirty-Seventh Power Instrumentation Symposium (4th Annual ISA/EPRI Joint Controls and Automation Conference), Orlando, Fl., June 1994.