Turkey Point Units 3 and 4

LICENSE AMENDMENT REQUEST FOR EXTENDED POWER UPRATE

ATTACHMENT 12

WCAP-17070-NP, Revision 0, Westinghouse Setpoint Methodology for Protection Systems for Turkey Point Units 3 and 4 Power Uprate to 2644 MWt-Core Power

August 2010

This coversheet plus 57 pages

WCAP-17070-NP
Revision 0

August 2010

Westinghouse Setpoint Methodology for Protection Systems Turkey Point Units 3 & 4 (Power Uprate to 2644 MWt – Core Power)

Westinghouse

WCAP-17070-NP
Revision 0

Westinghouse Setpoint Methodology for Protection Systems

Turkey Point Units 3 & 4
(Power Uprate to 2644 MWt – Core Power)

D. R. Spaulding
Setpoints and Uncertainty Analysis

M. P. Drudy
Setpoints and Uncertainty Analysis

Z. C. King
Setpoints and Uncertainty Analysis

J. R. Reagan*
Setpoints and Uncertainty Analysis

August 2010

Reviewer: T. P. Williams*
Setpoints and Uncertainty Analysis

Approved: D. C. Olinski*, Acting Manager
Setpoints and Uncertainty Analysis

** Electronically Approved Records Are Authenticated in the Electronic Document Management System*

Westinghouse Electric Company LLC
P.O. Box 355
Pittsburgh, PA 15230-0355

TABLE OF CONTENTS

LIST OF TABLES

1.0 INTRODUCTION

This report has been prepared to document the instrument uncertainty calculations for the Reactor Trip System (RTS) and Engineered Safety Features Actuation System (ESFAS) trip functions identified on Table 3-11 of this report for Turkey Point Units 3 and 4 Nuclear Power Stations (FPL/FLA) for a power uprate to 2644 MWt.

This document is divided into four sections. Section 2.0 identifies the general algorithm used as a base to determine the overall instrument uncertainty for an RTS/ESFAS trip function. This approach is defined in a Westinghouse paper presented at an Instrument Society of America/Electric Power Research Institute (ISA/EPRI) conference in June, 1992(1). This approach is consistent with American National Standards Institute (ANSI), ANSI/ISA-67.04.01-2006(2). The basic uncertainty algorithm is the Square-Root-Sum-of-the-Squares (SRSS) of the applicable uncertainty terms, which is endorsed by the ISA standard. All appropriate and applicable uncertainties, as defined by a review of the plant baseline design input documentation, have been included in each RTS/ESFAS trip function uncertainty calculation. ISA-RP67.04.02-2000 (3) was utilized as a general guideline, but each uncertainty and its treatment is based on Westinghouse methods which are consistent or conservative with respect to this document. The latest version of NRC Regulatory Guide 1.105 (Revision 3(4)) endorses the 1994 version of ISA S67.04, Part I. Westinghouse has evaluated this NRC document and has determined that the RTS/ESFAS trip function uncertainty calculations contained in this report are consistent with the guidance contained in Revision 3(4). It is believed that the total channel uncertainty (Channel Statistical Allowance or CSA) represents a 95/95 value as requested in Regulatory Guide 1.105(4).

Section 3.0 of this report provides a list of the defined terms and associated acronyms used in the RTS/ESFAS trip function uncertainty calculations. Appropriate references to industry standards have been provided where applicable. Included in this section are detailed descriptions of the uncertainty terms and values for each RTS/ESFAS trip function uncertainty calculation performed by Westinghouse. Provided on each table is the function specific uncertainty algorithm which notes the appropriate combination of instrument uncertainties to determine the CSA. A summary Table (3-11) is provided which includes a listing of the Safety Analysis Limit (SAL), the Nominal Trip Setpoint (NTS), the Total Allowance (the difference between the SAL and NTS, in % span), margin, and the Allowable Value (AV). In all cases, it was determined that positive margin exists between the SAL and the NTS after accounting for the channel instrument uncertainties.

Section 4.0 provides a description of the methodology utilized in the determination of Turkey Point Units 3 and 4 Technical Specifications with regards to an explanation of the relationship between a trip setpoint and the allowable value.

1.1 References / Standards

1. 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.

2. ANSI/ISA-67.04.01-2006, "Setpoints for Nuclear Safety-Related Instrumentation," May 2006.

3. ISA-RP67.04.02-2000, "Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation," January 2000.

4. Regulatory Guide 1.105, Revision 3, "Setpoints for Safety-Related Instrumentation," 1999.

2.0 COMBINATION OF UNCERTAINTY COMPONENTS

This section describes the Westinghouse setpoint methodology for the combination of the uncertainty components utilized for Turkey Point Units 3 and 4. The methodology used in the determination of the overall CSA, for the functions listed in Table 3-11 of this report, is in Section 2.1 below. All appropriate and applicable uncertainties, as defined by a review of Turkey Point Units 3 and 4 baseline design input documentation have been included in each RTS/ESFAS trip function CSA calculation.

2.1 Methodology

The methodology used to combine the uncertainty components for a channel is an appropriate combination of those groups which are statistically and functionally independent. Those uncertainties which 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. This technique, or others of a similar nature, has 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 (ANS), and 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 identified in a Westinghouse paper presented at an ISA/EPRI conference in June, 1992[(5)]. Differences between the algorithm presented in this paper and the equations presented in Tables 3-1 through 3-10 are due to Turkey Point Units 3 and 4 specific characteristics in design and should not be construed as differences in approach.

The generalized relationship between the uncertainty components and the calculated uncertainty for a channel is noted in Eq. 2.1:

$$CSA = \sqrt{\begin{array}{l} PMA^2 + PEA^2 + SRA^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + \\ SPE^2 + STE^2 + (RMTE + RD)^2 + (RMTE + RCA)^2 + \\ RTE^2 \end{array}} + EA + Bias \qquad \text{Eq. 2.1}$$

where,

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

Each of the above terms is defined in Section 3.2, Definitions for Protection System Setpoint Tolerances.

Eq. 2.1 is based on the following: 1) The sensor and rack measurement and test equipment uncertainties are treated as dependent parameters with their respective drift and calibration accuracy allowances. 2) While the environmental allowances are not considered statistically dependent with all other parameters, the equipment qualification testing generally results in large magnitude, non-random terms that are conservatively treated as limits of error which are added to the statistical summation. Westinghouse generally considers a term to be a limit of error if the term is a bias with an unknown sign. The term is added to the SRSS in the direction of conservatism. 3) Bias terms are one directional with known magnitudes (which may result from several sources, e.g., drift or calibration data evaluations) and are also added to the statistical summation. 4) The calibration terms are treated in the same radical with the other terms based on the assumption that general trending, i.e., drift and calibration data are evaluated on a periodic and timely basis. This evaluation should confirm that the distribution function characteristics assumed as part of treatment of the terms are still applicable. 5) Turkey Point Units 3 and 4 will monitor the "as left" and "as found" data for the sensors and process racks. This process provides performance information that results in a net reduction of the CSA magnitude (over that which would be determined if data review was not performed). Consistent with the request of Regulatory Guide 1.105[6], the CSA value from Eq. 2.1 is believed to have been determined at a 95 % probability at a 95 % confidence level (95/95).

2.2 Sensor Allowances

Seven parameters are considered to be sensor allowances: SRA, SCA, SMTE, SD, STE, SPE and EA. Three of these parameters are considered to be independent, two-sided, unverified (by plant calibration or drift determination processes), vendor supplied terms (SRA, STE and SPE). Based on vendor supplied data, typically product data sheets and qualification reports, these parameters are treated as 95/95 values unless specified otherwise by the vendor. Three of the remaining parameters are considered dependent with at least one other term, are two-sided, and are the result of the plant calibration and drift determination process (SCA, SMTE and SD).

The EA term is associated with the sensor exposure to adverse environmental conditions (elevated temperature and radiation) due to mass and energy loss from a break in the primary or secondary side piping, or adverse effects due to seismic events. Where appropriate, e.g., steamline break, only the elevated temperature term may be used for this uncertainty. The EA term magnitudes are conservatively treated as limits of error.

SRA is the manufacturer's reference accuracy that is achievable by the device. This term is introduced to address repeatability and hysteresis effects when performing only a single pass calibration, i.e., one up and one down[5,7]. 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. For example, assume a sensor is placed in some position in the containment during a refueling outage. After placement, an instrument technician calibrates the sensor at ambient pressure and temperature conditions. Some time later with the plant shutdown, an instrument technician checks for sensor drift using the same technique as was previously used for calibrating the sensor. The conditions under which this drift 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 and SD are considered to be dependent with SMTE due to the manner in which the instrumentation is evaluated. A transmitter is calibrated by providing a known process input (measured with a high accuracy gauge) and evaluating the electrical output with a digital multimeter (DMM) or digital voltmeter (DVM). The gauge and DVM accuracies form the SMTE terms. The transmitter response is known, at best, to within the accuracy of the measured input and measured output. Thus the calibration accuracy (SCA) is functionally dependent with the measurement and test equipment (SMTE). Since the gauge and DVM are independent of each other (they operate on two different physical principles), the two SMTE terms may be combined by SRSS prior to addition with the SCA term. Transmitter drift is determined using the same process used to perform a transmitter calibration.

That is, a known process input (measured with a high accuracy gauge) is provided and the subsequent electrical output is measured with a DMM or DVM. In most cases the same measurement and test equipment is used for both calibration and drift determination. Thus the drift value (SD) is functionally dependent with the measurement and test equipment (SMTE) and is treated in the same manner as SMTE and SCA.

While the data is gathered in the same manner, SD is independent of SCA in that they are two different parameters. SCA is the difference between the "as left" value and the desired value. SD is the difference between the "as found" value of the current calibration and the "as left" value of the previous calibration. It is assumed that a mechanistic cause and effect relationship between SCA and SD is not demonstrated and that any data evaluation will determine the distribution function characteristics for both SCA and SD and confirm that SD is random and independent of SCA.

2.3 Rack Allowances

Four parameters are considered to be rack allowances: RCA, RMTE, RTE and RD. RRA is the manufacturer's reference accuracy that is achievable by the process rack instrument string. This term is introduced to address repeatability and hysteresis effects when performing only a single pass calibration, i.e., one up and one down[5]. Review of a sample of Turkey Point Units 3 and 4 specific calibration procedures has concluded that the calibration tolerance identified in the procedures is sufficient to encompass "as left" deviation and the hysteresis and repeatability effects without an additional allowance. Thus this term has been included in the RCA term in the uncertainty calculations. RTE is considered to be an independent, two-sided, unverified (by plant calibration or drift determination processes), vendor supplied parameter. The process racks are located in an area with ambient temperature control, making consistency with the rack evaluation temperature easy to achieve. Based on Westinghouse Eagle process rack data and Hagan rack data, this parameter is treated as a 95/95 value.

RCA and RD are considered to be two-sided terms dependent with RMTE. The functional dependence is due to the manner in which the process racks are evaluated. To calibrate or determine drift for the process rack portion of a channel, a known input (in the form of a voltage, current or resistance) is provided and the point at which the trip bistable changes state is measured. The input parameter is either measured by the use of a DMM or DVM (for a current or voltage signal) or is known to some degree of precision by use of precision equipment, e.g., a precision decade box for a resistance input. For simple channels, only a DMM or DVM is necessary to measure the input and the state change is noted by a light or similar device. For more complicated channels, multiple DVMs may be used or a DVM in conjunction with a decade box. The process rack response is known at best to within the accuracy of the measured input and indicated output. Thus the calibration accuracy (RCA) is functionally dependent with the measurement and test equipment (RMTE).

In those instances where multiple pieces of measurement and test equipment are utilized, the uncertainties are combined via SRSS when appropriate.

The RCA term represents the total calibration uncertainty for the channels which are calibrated as a single string. Drift for the process racks is determined using the same process used to perform the rack calibration and in most cases utilizes the same measurement and test equipment. Thus the drift value (RD) is also functionally dependent with the measurement and test equipment (RMTE) and is treated in the same manner as RMTE and RCA.

While the data is gathered in the same manner, RD is independent of RCA in that they are different parameters. RCA is the difference between the "as left" value and the desired value. RD is the difference between the "as found" of the current calibration and the "as left" values of the previous calibration. The RD term represents the drift for all process rack modules in an instrument string, regardless of the channel complexity. For multiple instrument strings there may be multiple RD terms, e.g., Overtemperature ΔT. It is assumed that a mechanistic cause and effect relationship between RCA and RD is not demonstrated and that any data evaluation will determine the distribution function characteristics for both RCA and RD and will confirm that RD is random and independent of RCA.

2.4 Process Allowances

The PMA and PEA parameters are considered to be independent of both sensor and rack parameters. The PMA terms provide allowances for the non-instrument related effects; e.g., neutron flux, calorimetric power uncertainty assumptions and fluid density changes. There may be more than one independent PMA uncertainty allowance for a channel if warranted. The PEA term typically accounts for uncertainties due to metering devices, such as elbows, venturis, and orifice plates. In this report, this type of uncertainty is limited in application by Westinghouse to RCS Flow (Cold Leg Elbow Taps), high steam flow, and steam flow / feedwater flow mismatch. In these applications, the PEA term has been determined to be independent of the sensors and process racks. 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, Eq. 2.1 would be modified such that the affected term would be treated by arithmetic summation with appropriate determination and application of the sign of the uncertainty.

2.5 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. ANSI/ISA-67.04.01-2006, "Setpoints for Nuclear Safety-Related Instrumentation," May 2006.

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. Regulatory Guide 1.105 Revision 3, "Setpoints for Safety Related Instrumentation," 1999.

7. ANSI/ISA-51.1-1979 (R1993), "Process Instrumentation Terminology," Reaffirmed May 26, 1995, p. 61.

3.0 PROTECTION SYSTEM SETPOINT METHODOLOGY

This section contains a list of defined terms used in the Turkey Point Units 3 and 4 RTS/ESFAS trip function uncertainty calculations. Also included in this section are detailed tables and a summary table of the uncertainty terms and values for each calculation that Westinghouse performed. It was determined that in all cases sufficient margin exists between the nominal trip setpoint and the safety analysis limit after accounting for uncertainties.

3.1 Instrument Channel Uncertainty Calculations

Tables 3-1 through 3-10 provide individual component uncertainties and CSA calculations for the protection functions noted in Tables 2.2-1 and Table 3.3-3 of Turkey Point Units 3 and 4 Technical Specifications. Table 3-11 of this report provides a summary of the Reactor Trip System / Engineered Safety Features Actuation System Channel Uncertainty Allowances for Turkey Point Units 3 and 4. This table lists the Safety Analysis Limit, Nominal Trip Setpoint, and Allowable Value (in engineering units), and Channel Statistical Allowance, Margin, Total Allowance and uncertainty terms (in % span). Westinghouse reports the values in Tables 3-1 through 3-10 and Table 3-11 to one decimal place using the technique of rounding down values less than 0.05 % span and rounding up values greater than or equal to 0.05 % span. Parameters reported as "0.0" have been identified as having a value of ≤ 0.04 % span. 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

For the channel uncertainty values used in this report, the following definitions are provided in alphabetical order:

- 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 one cycle of operation, a Steam Generator Level transmitter's output at 50 % span was measured to be 12.05 mA. 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 bistable trip setpoint verification. This condition is typically better than the calibration accuracy for that piece of equipment. For example, the calibration point for a Steam Generator Level transmitter at 50 % span is 12.0 ± 0.04 mA. A measured "as left" condition of 12.03 mA would satisfy this calibration tolerance. 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 + 0.03 mA or + 0.19 % span, assuming a 16 mA (4 to 20 mA) instrument span.

- Channel

  The sensing and process equipment, i.e., transmitter to bistable, 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. 2 out of 3 Steam Generator Level - Low-Low channels for one steam generator must have their bistables in the tripped condition for a Reactor Trip to be initiated.

- Channel Statistical Allowance (**CSA**)

  The combination of the various channel uncertainties via SRSS and algebraic techniques. It includes instrument (sensor and process rack) uncertainties and non-instrument related effects (Process Measurement Accuracy), see Eq. 2.1. 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 or seismic event. Typically this value is determined from a conservative set of enveloping conditions and may represent the following:

  · Temperature effects on a transmitter
  · Radiation effects on a transmitter
  · Seismic effects on a transmitter
  · Temperature effects on a level transmitter reference leg
  · Temperature effects on signal cable insulation
  · Seismic effects on process racks

- Margin

    The calculated difference (in % instrument span) between the Total Allowance (TA) and the CSA.

    Margin = TA - CSA

- Nominal Trip Setpoint (**NTS**)

    A bistable trip setpoint in plant procedures. This value is the nominal value to which the bistable is set, as accurately as reasonably achievable.

- 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 ΔP drop across a flow restrictor. The flow coefficient for this device, (effectively an orifice which has not been calibrated in a laboratory setting), is not known. Therefore a mass balance between Feedwater Flow and Steam Flow must be made. The mass Feedwater Flow is known through measurement via the ΔP across the venturi, Feedwater Pressure and Feedwater Temperature. Presuming no mass losses prior to the measurement of the Steam Flow, the mass Steam Flow can be claimed to equal the mass Feedwater Flow. Measurement of the Steam Flow ΔP and the Steam Pressure (to correct for density) can then be utilized to translate to a volumetric flow.

- Primary Element Accuracy (**PEA**)

    Uncertainty due to the use of a metering device. In Westinghouse calculations, this parameter is limited to use on a venturi, orifice, elbow or potential transformer. 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 which have a direct bearing on the accuracy of an instrument channel's reading, e.g., temperature stratification in a large diameter pipe, fluid density in a pipe or vessel.

- Process Racks

  The analog modules downstream of the transmitter or sensing device, which condition a signal and act upon it prior to input to a voting logic system. For Hagan analog process systems, this includes all the equipment contained in the process equipment cabinets, e.g., conversion resistor, loop power supply, lead/lag, rate, lag functions, function generator, summator, control/protection isolator, and bistable. 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.

- Rack Calibration Accuracy (**RCA**)

  Rack calibration accuracy is defined as the two-sided calibration tolerance of the process racks.

  It is assumed that the individual modules in a loop 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 is typically less than the arithmetic sum or SRSS of the individual module tolerances. This forces calibration of the process loop in such a manner as to exclude a systematic bias in the individual module calibrations, i.e., as left values for individual modules must be compensating in sign and magnitude when considered as an instrument string.

  Review of a sample of Turkey Point Units 3 and 4 specific calibration procedures concluded that the calibration process and the identified RCA allowance is sufficient to encompass the as left deviation and the hysteresis and repeatability effects without an additional RRA allowance.

- Rack Drift (**RD**)

The change in input-output relationship over a period of time at reference conditions, e.g., at constant temperature. For example, assume that a Water Level channel at 50 % span (presuming a 1 to 5 V span) has an "as found" value of 3.01 V for the current calibration and an "as left" value of 2.99 V from the previous calculation. The magnitude of the drift would be {(3.01 – 2.99)(100/4) = + 0.5 % span} in the positive direction. For Turkey Point Units 3 and 4 plant specific surveillance procedures, Florida Power and Light will implement an additional requirement to compare the as found to the previous as left value to determine if drift allowance assumptions were exceeded since the last calibration activity.

- 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 SAMA Standard PMC 20.1-1973(9) or ANSI/ISA-51.1-1979 (R1993)(10) it is considered an integral part of RCA. Uncertainties due to M&TE that are 10 times more accurate than the device being calibrated are considered insignificant and are not included in the uncertainty calculations.

- Rack Reference Accuracy (**RRA**)

Rack Reference Accuracy is the reference accuracy, as defined by SAMA Standard PMC 20.1-1973(1) for a process loop string. It is defined as the reference accuracy or accuracy rating that is achievable by the instrument string as specified in the manufacturer's specification sheets. Inherent in this definition is the verification of the following under a reference set of conditions; 1) conformity(2) or (6), 2) hysteresis(3) or (7) and 3) repeatability(4) or (8). An equivalent to the SAMA definition of reference accuracy is the ANSI/ISA-51.1-1979 (R1993)(5) term "accuracy rating," specifically as applied to Note 2 and Note 3.

Review of a sample of Turkey Point Units 3 and 4 specific calibration procedures and calibration assumptions concludes that the identified calibration allowance is sufficient to encompass the Rack Reference Accuracy without an additional allowance.

- 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), and voltage and frequency from the reference calibration conditions. It has been determined that temperature is the most significant, with the other parameters being second order effects. For process instrumentation, a typical value of [ ]^{a,c} is used for analog channel temperature effects which allows for a ± 50 °F ambient temperature deviation.

- Range

The upper and lower limits of the operating region for a device, e.g., for a Steamline Pressure transmitter, 0 to 1400 psig. This is not necessarily the calibrated span of the device, although quite often the two are close. For further information see ANSI/ISA-51.1-1979 (R1993)[10].

- Safety Analysis Limit (**SAL**)

The parameter value in the UFSAR safety analysis or other plant operating limit at which a reactor trip or actuation function is assumed to be initiated.

- Sensor Calibration Accuracy (**SCA**)

The calibration accuracy for a sensor or transmitter as defined by the plant calibration procedures. For transmitters, this accuracy is typically [ ]^{a,c}. Utilizing Westinghouse recommendations for Resistance Thermal Detector (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. For example, assume a Water Level transmitter at 50 % level (presuming a 4 to 20 mA span) has an "as found" value of 12.05 mA from the current calibration and an "as left" value of 12.01 mA from the previous calibration. The magnitude of the drift would be {(12.05 - 12.01)(100/16) = + 0.25 % span} in the positive direction.

- 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 ANSI/ISA-51.1-1979 (R1993)[10] it is considered an integral part of SCA. Uncertainties due to M&TE that are 10 times more accurate than the device being calibrated are considered insignificant and are not included in the uncertainty 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 Δp transmitter.

- Sensor Reference Accuracy (**SRA**)

  The reference accuracy that is achievable by the device as specified in the manufacturer's specification sheets. This term is introduced into the uncertainty calculation to address repeatability effects 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), and voltage and frequency from the reference calibration conditions. It has been determined that temperature is the most significant, with the other parameters being second order effects. Note that the ambient temperature effects were evaluated using ± 60 °F.

- Span

  The region for which a device is calibrated and verified to be operable, e.g., for a Steamline Pressure transmitter, 1400 psi.

- Square-Root-of-the-Sum-of-the-Squares (**SRSS**)

  That is,

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

  as approved for use in setpoint calculations by ANSI/ISA-67.04.01-2006[11].

- Total Allowance (**TA**)

  The absolute value of the difference (in % instrument span) between the Safety Analysis Limit (SAL) and the Nominal Trip Setpoint (NTS).

  $$\text{TA} = |\text{SAL} - \text{NTS}|$$

Two examples of the calculation of TA are:

■ *Power Range Neutron Flux - High*

SAL	115% RTP	
NTS	<u>-109% RTP</u>	
TA	| 6% RTP |	= 6% RTP

If the instrument span = 120% RTP, then

$$TA = \frac{(6\%\ RTP)^*\ (100\%\ span)}{(120\%\ RTP)} = 5.0\ \%\ span$$

■ *Steamline Pressure - Low (SI)*

SAL	566.3 psig	
NTS	<u>-614.0 psig</u>	
TA	| -47.7 psig |	= 47.7 psig

If the instrument span = 1400 psig, then

$$TA = \frac{(47.7\ psig)^*\ (100\%\ span)}{(1400\ psig)} = 3.4\ \%\ span$$

3.3 References / Standards

1. Scientific Apparatus Makers Association Standard PMC 20.1-1973, "Process Measurement & Control Terminology," p. 4.

2. Ibid, p. 5.

3. Ibid, p. 19.

4. Ibid, p. 28.

5. ANSI/ISA-51.1-1979 (R1993), "Process Instrumentation Terminology," Reaffirmed May 26, 1995, p. 12.

6. Ibid, p. 16.

7. Ibid, p. 36.

8. Ibid, p. 49.

9. Scientific Apparatus Makers Association Standard PMC 20.1-1973, "Process Measurement & Control Terminology," p. 36.

10. ANSI/ISA-51.1-1979 (R1993), "Process Instrumentation Terminology," Reaffirmed May 26, 1995, p. 61.

11. ANSI/ISA-67.04.01-2006, "Setpoints for Nuclear Safety-Related Instrumentation," May 2006.

Table 3-1
Power Range Neutron Flux – High Setpoint

Parameter	Allowance*
Process Measurement Accuracy [ ]a,c [ ]a,c	[ ]a,c
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA) [ ]a,c	
Sensor Reference Accuracy (SRA) [ ]a,c	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
Sensor Drift (SD)	
Rack Calibration Accuracy (RCA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effect (RTE)	
Rack Drift (RD)	

* In percent span (120 % RTP)

Table 3-1 (continued)
Power Range Neutron Flux - High Setpoint

Channel Statistical Allowance =

$$\sqrt{PMA_1^2 + PMA_2^2 + PEA^2 + (SMTE + SCA)^2 + (SMTE + SD)^2 + SPE^2 + STE^2 + SRA^2 + (RMTE + RCA)^2 + (RMTE + RD)^2 + RTE^2}$$

[ ] a,c

Table 3-2
Overtemperature ΔT

Parameter	**Allowance***
Process Measurement Accuracy (PMA)	[ ]a,c
[ ]a,c	
[ ]a,c	
[ ]a,c	
[ ]a,c	
[ ]a,c	
[ ]a,c	
[ ]a,c	
[ ]a,c	
[ ]a,c	
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA)	
[ ]a,c	
[ ]a,c	
Sensor Reference Accuracy (SRA)	
[ ]a,c	
[ ]a,c	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
[ ]a,c	
[ ]a,c	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
[ ]a,c	
Sensor Drift (SD)	
[ ]a,c	
[ ]a,c	
Bias	
[ ]a,c	

Table 3-2 (continued)
Overtemperature ΔT

Parameter	**Allowance***
Rack Calibration Accuracy (RCA)	[ ]a,c
[ ]a,c	
[ ]a,c	
[ ]a,c	
[ ]a,c	
[ ]a,c	
Rack Measuring & Test Equipment Accuracy (RMTE)	
[ ]a,c	
[ ]a,c	
[ ]a,c	
[ ]a,c	
Rack Temperature Effect (RTE)	
[ ]a,c	
[ ]a,c	
[ ]a,c	
[ ]a,c	
Rack Drift (RD)	
[ ]a,c	
[ ]a,c	
[ ]a,c	
[ ]a,c	

* In percent ΔT span (Tavg - 75 °F, Pressure - 1000 psi, ΔT - 100 °F = 159.4% RTP, ΔI - 120% ΔI)
N_H = # of hot leg RTDs = 2
N_C = # of cold leg RTDs = 1

Table 3-2 (continued)
Overtemperature ΔT

Channel Statistical Allowance =

$$\sqrt{\begin{array}{l} PMA_{\Delta I1}{}^2 + PMA_{\Delta I2}{}^2 + PMA_{PWR\,CAL}{}^2 + PEA^2 + \\ \left(\sqrt{\dfrac{(SCA_{\Delta T} + SMTE_{\Delta T})^2 + (SD_{\Delta T} + SMTE_{\Delta T})^2 + SRA_{\Delta T}{}^2}{N_H} + \dfrac{(SCA_{\Delta T} + SMTE_{\Delta T})^2 + (SD_{\Delta T} + SMTE_{\Delta T})^2 + SRA_{\Delta T}{}^2}{N_C}}\right)^2 + \\ (SMTE_P + SD_P)^2 + SRA_P{}^2 + SPE_P{}^2 + STE_P{}^2 + (SMTE_P + SCA_P)^2 + \\ \left(\sqrt{\dfrac{(RMTE_{\Delta T} + RD_{\Delta T})^2 + RTE_{\Delta T}{}^2 + (RMTE_{\Delta T} + RCA_{\Delta T})^2}{N_H} + \dfrac{(RMTE_{\Delta T} + RD_{\Delta T})^2 + RTE_{\Delta T}{}^2 + (RMTE_{\Delta T} + RCA_{\Delta T})^2}{N_C}}\right)^2 + \\ (RMTE_P + RD_P)^2 + (RMTE_P + RCA_P)^2 + RTE_P{}^2 + \\ 2 \times \left[(RMTE_{\Delta I} + RD_{\Delta I})^2 + (RMTE_{\Delta I} + RCA_{\Delta I})^2 + RTE_{\Delta I}{}^2\right] + \\ (RMTE_{NIS} + RD_{NIS})^2 + RTE_{NIS}{}^2 + (RMTE_{NIS} + RCA_{NIS})^2 \end{array}}$$

$$+ PMA_{bu\Delta T} + PMA_{buTavg} + BIAS_{pressure}$$

Table 3-2 (continued)
Overtemperature ΔT

[a,c]

Table 3-3
Overpower ΔT

Parameter	Allowance*
Process Measurement Accuracy (PMA)	[ ][a,c]
[ ][a,c]	
[ ][a,c]	
[ ][a,c]	
[ ][a,c]	
[ ][a,c]	
[ ][a,c]	
[ ][a,c]	
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA)	
[ ][a,c]	
Sensor Reference Accuracy (SRA)	
[ ][a,c]	
Sensor Measuring & Test Equipment Accuracy (SMTE)	
[ ][a,c]	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
Sensor Drift (SD)	
[ ][a,c]	
Environmental Allowance (EA)	
[ ][a,c]	
Rack Calibration Accuracy (RCA)	
[ ][a,c]	
[ ][a,c]	

Table 3-3 (continued)
Overpower ΔT

Parameter	**Allowance***
Rack Measuring & Test Equipment Accuracy (RMTE)	[ ]a,c
[ ]a,c	
Rack Temperature Effect (RTE)	
[ ]a,c	
Rack Drift (RD)	
[ ]a,c	

* In percent ΔT span (T_{avg} - 75 °F, ΔT - 100 °F = 159.4 % RTP)
N_H = # of hot leg RTDs = 2
N_C = # of cold leg RTDs = 1

Table 3-3 (continued)
Overpower ΔT

Channel Statistical Allowance =

$$\sqrt{\begin{array}{l} PMA_{PWR\,CAL}{}^{2} + PEA^{2} + \\ \left(\sqrt{\dfrac{(SCA_{\Delta T} + SMTE_{\Delta T})^{2} + (SD_{\Delta T} + SMTE_{\Delta T})^{2} + SRA_{\Delta T}{}^{2}}{N_{H}} + \dfrac{(SCA_{\Delta T} + SMTE_{\Delta T})^{2} + (SD_{\Delta T} + SMTE_{\Delta T})^{2} + SRA_{\Delta T}{}^{2}}{N_{C}}} \right)^{2} + \\ \left(\dfrac{(RMTE_{\Delta T} + RD_{\Delta T})^{2} + RTE_{\Delta T}{}^{2} + (RMTE_{\Delta T} + RCA_{\Delta T})^{2}}{N_{H}} + \dfrac{(RMTE_{\Delta T} + RD_{\Delta T})^{2} + RTE_{\Delta T}{}^{2} + (RMTE_{\Delta T} + RCA_{\Delta T})^{2}}{N_{C}} \right)^{2} \end{array}}$$

$$+ PMA_{bu\Delta T} + PMA_{buTavg} + EA$$

a,c

Table 3-4
High Steam Line Flow – SI, Steam Line Isolation

Parameter		Allowance*
Process Measurement Accuracy (PMA)		[ ][a,c]
[ ][a,c]		
[ ][a,c]		
[ ][a,c]		
Primary Element Accuracy (PEA)		
Steam Flow	[ ][a,c]	
Sensor Calibration Accuracy (SCA)		
Steam Flow	[ ][a,c]	
Turbine Pressure	[ ][a,c]	
Sensor Reference Accuracy (SRA)		
Steam Flow	[ ][a,c]	
Turbine Pressure	[ ][a,c]	
Sensor Measurement & Test Equipment Accuracy (SMTE)		
Steam Flow	[ ][a,c]	
Turbine Pressure	[ ][a,c]	
Sensor Pressure Effects (SPE)		
Steam Flow	[ ][a,c]	
Sensor Temperature Effects (STE)		
Steam Flow	[ ][a,c]	
Turbine Pressure	[ ][a,c]	
Sensor Drift (SD)		
Steam Flow	[ ][a,c]	
Turbine Pressure	[ ][a,c]	
Environmental Allowances (EA)		
Steam Flow		
Turbine Pressure		
Bias		
Steam Flow – static pressure correction [ ][a,c]		

Table 3-4 (continued)
High Steam Line Flow – SI, Steam Line Isolation

Parameter		Allowance*
Rack Calibration Accuracy (RCA)		[ ]a,c
Steam Flow	[ ]a,c	
Turbine Pressure	[ ]a,c	
Rack Measurement & Test Equipment Accuracy (RMTE)		
Steam Flow	[ ]a,c	
Turbine Pressure	[ ]a,c	
Rack Temperature Effect (RTE)		
Steam Flow	[ ]a,c	
Rack Drift (RD)		
Steam Flow	[ ]a,c	
Turbine Pressure	[ ]a,c	

* In percent flow span (135.9 % Span). Values are converted to flow via Equation 3-14.8 where F_{max} = 135.9 % and F_N = 114 %; therefore, gain = (1/2)(135.9/114) = 0.60.

Table 3-4 (continued)
High Steam Line Flow – SI, Steam Line Isolation

Channel Statistical Allowance =

$$\sqrt{\begin{aligned}&PEA_{SF}^{2} + \\ &(SMTE_{SF} + SCA_{SF})^{2} + SRA_{SF}^{2} + (SMTE_{SF} + SD_{SF})^{2} + SPE_{SF}^{2} + STE_{SF}^{2} + \\ &(RMTE_{SF} + RCA_{SF})^{2} + (RMTE_{SF} + RD_{SF})^{2} + RTE_{SF}^{2} + \\ &(SMTE_{TP} + SCA_{TP})^{2} + SRA_{TP}^{2} + (SMTE_{TP} + SD_{TP})^{2} + SPE_{TP}^{2} + STE_{TP}^{2} + \\ &(RMTE_{TP} + RCA_{TP})^{2} + (RMTE_{TP} + RD_{TP})^{2} + RTE_{TP}^{2}\end{aligned}}$$
$$+ PMA_{1SF} + PMA_{2SF} + PMA_{TP} + Bias_{1} + EA$$

a,c

Table 3-5
Steam Flow / Feedwater Flow Mismatch

Parameter		Allowance*
Process Measurement Accuracy (PMA)		[ ]a,c
[ ]a,c		
[ ]a,c		
[ ]a,c		
Primary Element Accuracy (PEA)		
Steam Flow	[ ]a,c	
Feed Flow		
Sensor Calibration Accuracy (SCA)		
Steam Flow	[ ]a,c	
Feed Flow	[ ]a,c	
Steam Pressure	[ ]a,c	
Sensor Reference Accuracy (SRA)		
Steam Flow	[ ]a,c	
Feed Flow	[ ]a,c	
Steam Pressure	[ ]a,c	
Sensor Measurement & Test Equipment Accuracy (SMTE)		
Steam Flow	[ ]a,c	
Feed Flow	[ ]a,c	
Steam Pressure	[ ]a,c	
Sensor Pressure Effects (SPE)		
Steam Flow	[ ]a,c	
Feed Flow	[ ]a,c	
Sensor Temperature Effects (STE)		
Steam Flow	[ ]a,c	
Feed Flow	[ ]a,c	
Steam Pressure	[ ]a,c	
Sensor Drift (SD)		
Steam Flow	[ ]a,c	
Feed Flow	[ ]a,c	
Steam Pressure	[ ]a,c	

Table 3-5 (continued)
Steam Flow / Feedwater Flow Mismatch

Parameter		Allowance*
Environmental Allowances (EA)		[ ]a,c
Bias		
Steam Flow - static pressure correction ($Bias_1$)	[ ]a,c	
Feedwater Flow - static pressure correction ($Bias_2$)	[ ]a,c	
Rack Calibration Accuracy (RCA)		
Steam Flow		
Feed Flow		
Rack Measurement & Test Equipment Accuracy (RMTE)		
Steam Flow		
Feed Flow		
Rack Temperature Effect (RTE)		
Feed Flow		
Rack Drift (RD)		
Steam Flow		
Feed Flow		

* In percent flow span (135.9 % Span). Values are converted to flow span via Equation 3-14.8 where F_{max} = 135.9 %, F_N (steam flow) = 100 %, and F_N (feedwater flow) = 80 %; therefore, gain (steam flow) = (1/2)(135.9/100) = 0.68 and gain (feedwater flow) = (1/2)(135.9/80) = 0.85. The gain for steam pressure = 1.2

Table 3-5 (continued)
Steam Flow / Feedwater Flow Mismatch

Channel Statistical Allowance =

$$\sqrt{\begin{array}{l}(SMTE_{SP} + SCA_{SP})^2 + SRA_{SP}{}^2 + (SMTE_{SP} + SD_{SP})^2 + STE_{SP}{}^2 + \\ PEA_{SF}{}^2 + (SMTE_{SF} + SCA_{SF})^2 + SRA_{SF}{}^2 + (SMTE_{SF} + SD_{SF})^2 + SPE_{SF}{}^2 + STE_{SF}{}^2 + \\ (RMTE_{SF} + RCA_{SF})^2 + (RMTE_{SF} + RD_{SF})^2 + \\ PEA_{FF}{}^2 + (SMTE_{FF} + SCA_{FF})^2 + SRA_{FF}{}^2 + (SMTE_{FF} + SD_{FF})^2 + SPE_{FF}{}^2 + STE_{FF}{}^2 + \\ (RMTE_{FF} + RCA_{FF})^2 + (RMTE_{FF} + RD_{FF})^2 + RTE_{FF}{}^2\end{array}}$$
$$+ PMA_{1SF} + PMA_{2SF} + PMA_{FF} + Bias_1 + Bias_2 + EA$$

[ ] a,c

Table 3-6
Steam Generator Water Level – Low, Low-Low

Parameter	Allowance*
Process Measurement Accuracy**	[ ]a,c
[ ]a,c	
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA)	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
Sensor Drift (SD)	
Environmental Allowance** (EA)	
Bias**	
[ ]a,c	
Rack Calibration Accuracy (RCA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effect (RTE)	
Rack Drift (RD)	

* In percent span (100 %)
** [ ]a,c

Table 3-6 (continued)
Steam Generator Water Level – Low, Low-Low

Channel Statistical Allowance =

$$\sqrt{PEA^2 + (SMTE + SCA)^2 + SRA^2 + SPE^2 + STE^2 + (SMTE + SD)^2 + (RMTE + RCA)^2 + RTE^2 + (RMTE + RD)^2}$$

$$+ Bias_1 + Bias_2 + EA + PMA_{PP} + PMA_{RL} + PMA_{FV} + PMA_{SC} + PMA_{MD}$$

[ ] a,c

Table 3-7
Steam Generator Water Level – High-High

Parameter	Allowance*
Process Measurement Accuracy**	[
[ ]a,c	
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA)	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
Sensor Drift (SD)	
Environmental Allowance** (EA)	
Bias**	
[ ]a,c	
Rack Calibration Accuracy (RCA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effect (RTE)	
Rack Drift (RD)	]a,c

* In percent span (100 %)
** [ ]a,c

Table 3-7 (continued)
Steam Generator Water Level – High-High

Channel Statistical Allowance =

$$-\sqrt{\begin{array}{l}PEA^2 + (SMTE + SCA)^2 + SRA^2 + SPE^2 + STE^2 + (SMTE + SD)^2 + \\ (RMTE + RCA)^2 + RTE^2 + (RMTE + RD)^2\end{array}}$$

$$+ Bias_1 + Bias_5 + EA + PMA_{PP} + PMA_{RL} + PMA_{FV} + PMA_{SC} + PMA_{MD} + PMA_{DL}$$

a,c

[ ]

Note: Negative sign (–) denotes direction (i.e. indicated lower than actual).

Table 3-8
Steamline Pressure – Low (SI)
Outside Containment Steam Break

Parameter	Allowance*
	[ ]a,c
Process Measurement Accuracy (PMA)	
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA)	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
Sensor Drift (SD)	
Environmental Allowances (EA) [ ]a,c	
Bias [ ]a,c [ ]a,c	
Rack Calibration Accuracy (RCA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effect (RTE)	
Rack Drift (RD)	

* In percent span (1400 psig)

Table 3-8 (continued)
Steamline Pressure – Low (SI)
Outside Containment Steam Break

Channel Statistical Allowance =

$$\sqrt{\begin{array}{l}PMA^2 + PEA^2 + (SMTE + SCA)^2 + SRA^2 + (SMTE + SD)^2 + SPE^2 + STE^2 + \\ (RMTE + RCA)^2 + (RMTE + RD)^2 + RTE^2\end{array}}$$

$$+ EA + Bias_1 + Bias_2$$

a,c

[ ]

Table 3-9
Steamline Pressure – Low (SI)
Inside Containment Steam Break

Parameter	Allowance*
	[ ] a,c
Process Measurement Accuracy (PMA)	
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA)	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
Sensor Drift (SD)	
Environmental Allowances (EA) [ ] a,c	
Bias [ ] a,c [ ] a,c	
Rack Calibration Accuracy (RCA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effect (RTE)	
Rack Drift (RD)	

* In percent span (1400 psig)

Table 3-9 (continued)
Steamline Pressure – Low (SI)
Inside Containment Steam Break

Channel Statistical Allowance =

$$\sqrt{\begin{aligned}&PMA^2 + PEA^2 + (SMTE + SCA)^2 + SRA^2 + (SMTE + SD)^2 + SPE^2 + STE^2 + \\ &(RMTE + RCA)^2 + (RMTE + RD)^2 + RTE^2\end{aligned}}$$

$$+ EA + Bias_1 + Bias_2$$

a,c

[ ]

Table 3-10
Reactor Coolant Flow - Low

Parameter	**Allowance***
Process Measurement Accuracy (PMA)	[ ][a,c]
[ ][a,c]	
[ ][a,c]	
Primary Element Accuracy (PEA)	
[ ][a,c]	
Sensor Calibration Accuracy (SCA)	
[ ][a,c]	
Sensor Reference Accuracy (SRA)	
[ ][a,c]	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
[ ][a,c]	
Sensor Pressure Effects (SPE)	
[ ][a,c]	
Sensor Temperature Effects (STE)	
[ ][a,c]	
Sensor Drift (SD)	
[ ][a,c]	
Rack Calibration Accuracy (RCA)	
[ ][a,c]	
Rack Measurement & Test Equipment Accuracy (RMTE)	
[ ][a,c]	
Rack Temperature Effect (RTE)	
[ ][a,c]	
Rack Drift (RD)	
[ ][a,c]	

* In % flow span (120 % Thermal Design Flow). Percent ΔP span converted to flow span via Equation 3-14.8, with Fmax = 120 % and FN = 90 %, therefore, gain = (1/2) (120% / 90%) = 0.67.

Table 3-10 (continued)
Reactor Coolant Flow - Low

Note the CSA equation for this function has been defined by FPL as:

Channel Statistical Allowance =

$$\sqrt{\begin{array}{l} PMA_1^{\,2} + PMA_2^{\,2} + PEA^2 + \\ \left\{\sqrt{PEA^2 + (SMTE + SCA)^2 + (SMTE + SD)^2 + STE^2 + SPE^2 + SRA^2}\right\}^2 + \\ (SMTE + SCA)^2 + (SMTE + SD)^2 + STE^2 + SPE^2 + SRA^2 + \\ (RMTE + RCA)^2 + (RMTE + RD)^2 + RTE^2 \end{array}}$$

a,c

Table 3-11
Reactor Trip System / Engineered Safety Features Actuation System Channel Error Allowances
Turkey Point Units 3 & 4 (FPL/FLA)

				SENSOR							INSTRUMENT RACK										
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
	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)	DRIFT (1)	ENVIRONMENTAL ALLOWANCE (1)	CALIBRATION ACCURACY (1)	MEASUREMENT & TEST EQUIPMENT ACCURACY (1)	TEMPERATURE EFFECTS (1)	DRIFT (1)	SAFETY ANALYSIS LIMIT (2 or 3)	ALLOWABLE VALUE (4)	TRIP SETPOINT (4)	TOTAL ALLOWANCE (1)	CHANNEL STATISTICAL ALLOWANCE (1)	MARGIN (1)	
1	POWER RANGE NEUTRON FLUX – HIGH SETPOINT													a,c	115% RTP	109.6% RTP	109% RTP	5.0		a,c	1
2	OVERTEMPERATURE ΔT ΔT CHANNEL TAVG CHANNEL PRESSURIZER PRESSURE CHANNEL f(ΔI) CHANNEL NIS CHANNEL														FUNCTION (11)	FUNCTION (12)	FUNCTION (12)	8.8ΔT Span			2
3	OVERPOWER ΔT ΔT CHANNEL Tavg CHANNEL														FUNCTION (11)	FUNCTION (13)	FUNCTION (13)	3.8ΔT Span			3
4	HIGH STEAMLINE FLOW – SI, STEAM LINE ISOLATION STEAM FLOW TURBINE PRESSURE														60% / 129% full steam flow	41.2% / 114.4% full steam flow	40% / 114% full steam flow	14.7 / 11.0 flow span			4
5	STEAM FLOW / FEEDWATER FLOW MISMATCH STEAM FLOW FEEDWATER FLOW STEAM PRESSURE														—	20.7% below rated steam flow	20% below rated steam flow	---			5
6	STEAM GENERATOR WATER LEVEL – LOW, LOW-LOW														4% span	15.5% span	16% span	12.0			6
7	STEAM GENERATOR WATER LEVEL – HIGH-HIGH														96.8% span (30)	80.5% span	80% span	16.8			7
8	STEAMLINE PRESSURE – LOW (SI) OUTSIDE CONTAINMENT STEAM BREAK														432.3 psig	607 psig	614 psig	13.0			8
9	STEAMLINE PRESSURE – LOW (SI) INSIDE CONTAINMENT STEAM BREAK														566.3 psig	607 psig	614 psig	3.4			9
10	REACTOR COOLANT FLOW – LOW														84.5% thermal design flow	89.6% thermal design flow	90% thermal design flow	4.6 flow span			10

NOTES:

1. All values percent of span unless otherwise noted.
2. As noted in Chapter 14 of the UFSAR.
3. Not included in Chapter 14 of UFSAR but used in Safety Analysis.
4. As noted in Tables 2.2-1 and 3.3-3 of the Plant Technical Specifications.
5. [ ]a,c
6. [ ]a,c
7. [ ]a,c
8. [ ]a,c
9. [ ]a,c
10. [ ]a,c
11. As noted in Figure 7.2-1 of the UFSAR.
12. As noted in Table 2.2-1, Notes 1 and 2 of the Plant Technical Specifications.
13. As noted in Table 2.2-1, Notes 3 and 4 of the Plant Technical Specifications.
14. [ ]a,c
15. [ ]a,c
16. [ ]a,c
17. Incore/Excore f(ΔI) comparison as noted in Table 4.3-1 of Plant Technical Specifications.
18. [ ]a,c
19. [ ]a,c
20. [ ]a,c
21. [ ]a,c
22. [ ]a,c
23. [ ]a,c
24. [ ]a,c
25. [ ]a,c
26. [ ]a,c
27. [ ]a,c
28. [ ]a,c
29. [ ]a,c
30. [ ]a,c
31. [ ]a,c
32. [ ]a,c
33. [ ]a,c
34. [ ]a,c

Table 3-12
Overtemperature ΔT Calculations

The equation for Overtemperature ΔT is:

$$\Delta T \frac{(1+\tau_1 S)}{(1+\tau_2 S)}\left(\frac{1}{1+\tau_3 S}\right) \le \Delta T_0 \left\{K_1 - K_2 \frac{(1+\tau_4 S)}{(1+\tau_5 S)}\left[T\frac{1}{(1+\tau_6 S)} - T'\right] + K_3(P-P') - f_1(\Delta I)\right\}$$

K_1 (nominal)	$\le$	1.31
K_1 (max)	=	[ ] ^{a,c}
K_2	$\ge$	0.023/°F
K_3	$\ge$	0.00116/psi
ΔT	=	62.74 °F smallest ΔT allowance for uprate conditions
ΔI gain	=	2.37 %

PMA conversions:

ΔI ($PMA_{\Delta I1}$)	=	[
ΔI ($PMA_{\Delta I2}$)	=	
ΔT ($PMA_{bu\Delta T}$)	=	
T_{avg} (PMA_{buTavg}) *	=	
Power Cal. ($PMA_{PWR\ CAL}$)	=	] ^{a,c}

Pressure gain	=	[
Pressure (SCA_P)	=	
Pressure (SRA_P)	=	
Pressure ($SMTE_P$)	=	
Pressure (STE_P)	=	
Pressure (SD_P)	=	
Pressure (RCA_P)	=	
Pressure ($RMTE_P$)	=	
Pressure (RTE_P)	=	
Pressure (RD_P)	=	
Pressure ($Bias_1$)	=	] ^{a,c}

Table 3-12 (continued)
Overtemperature ΔT Calculations

ΔI conversion	=	[	] [a,c]
ΔI ($RCA_{\Delta I}$)	=		
ΔI ($RMTE_{\Delta I}$)	=		
ΔI ($RTE_{\Delta I}$)	=		
ΔI ($RD_{\Delta I}$)	=		

NIS conversion	=	[	] [a,c]
NIS (RCA_{NIS})	=		
NIS ($RMTE_{NIS}$)	=		
NIS (RTE_{NIS})	=		
NIS (RD_{NIS})	=		

Total Allowance = [ ] [a,c] = 8.8 % ΔT span

*T_{avg} burndown allowance, T' – T_{ref} mismatch, accounted for in safety analyses

Table 3-13
Overpower ΔT Calculations

The equation for Overpower ΔT is:

$$\Delta T \frac{(1+\tau_1 S)}{(1+\tau_2 S)}\left(\frac{1}{1+\tau_3 S}\right) \le \Delta T_0 \left\{ K_4 - K_5 \frac{\tau_7 S}{1+\tau_7 S}\left(\frac{1}{1+\tau_6 S}\right) T - K_6 \left[T \frac{1}{1+\tau_6 S} - T'' \right] - f_2(\Delta I) \right\}$$

K_4 (nominal)	≤	1.10
K_4 (max)	=	[ ] a,c
K_5	=	0.0/°F
K_6	≥	0.0016/°F for T > T" and K_6 = 0 for T≤ T"
ΔT	≥	62.74 °F smallest ΔT allowance for uprate conditions

PMA conversions:

a,c

ΔT ($PMA_{bu\Delta T}$) = [ ]
T_{avg} (PMA_{buTavg}) * = [ ]
Power Cal. ($PMA_{PWR\ CAL}$) = [ ]

Total Allowance = [ ] a,c = 3.8 % ΔT span

* T_{avg} burndown allowance, T' – T_{ref} mismatch, accounted for in safety analyses

Table 3-14
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

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

thus

$$\partial F_N = \frac{\partial \Delta P_N}{2 F_N} \qquad \text{Eq. 3-14.1}$$

Error at a point (not in percent) is:

$$\frac{\partial F_N}{F_N} = \frac{\partial \Delta P_N}{2(F_N)^2} = \frac{\partial \Delta P_N}{2 \Delta P_N} \qquad \text{Eq. 3-14.2}$$

and

$$\frac{\Delta P_N}{\Delta P_{max}} = \frac{(F_N)^2}{(F_{max})^2} \qquad \text{Eq. 3-14.3}$$

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

$$\frac{\partial \Delta P_N}{\Delta P_{max}}(100) = \text{ percent error in Full Scale } \Delta P \text{ (\% } \varepsilon \text{ FS } \Delta P) \qquad \text{Eq. 3-14.4}$$

Table 3-14 (continued)
ΔP Measurements Expressed in Flow Units

Therefore,

$$\frac{\partial F_N}{F_N} = \frac{\Delta P_{max}\left[\frac{\%\,\varepsilon\,FS\,\Delta P}{100}\right]}{2\Delta P_{max}\left[\frac{F_N}{F_{max}}\right]^2} = \left[\frac{\%\,\varepsilon\,FS\,\Delta P}{(2)(100)}\right]\left[\frac{F_{max}}{F_N}\right]^2 \qquad \text{Eq. 3-14.5}$$

Error in flow units is:

$$\partial F_N = F_N\left[\frac{\%\,\varepsilon\,FS\,\Delta P}{(2)(100)}\right]\left[\frac{F_{max}}{F_N}\right]^2 \qquad \text{Eq. 3-14.6}$$

Error in percent nominal flow is:

$$\frac{\partial F_N}{F_N}(100) = \left[\frac{\%\,\varepsilon\,FS\,\Delta P}{2}\right]\left[\frac{F_{max}}{F_N}\right]^2 \qquad \text{Eq. 3-14.7}$$

Error in percent full span is:

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

$$= \left[\frac{\%\,\varepsilon\,FS\,\Delta P}{2}\right]\left[\frac{F_{max}}{F_N}\right] \qquad \text{Eq. 3-14.8}$$

Equation 3-14.8 is used to express errors in percent full span in this document.

4.0 APPLICATION OF THE SETPOINT METHODOLOGY

4.1 Uncertainty Calculation Basic Assumptions / Premises

The equations noted in Sections 2 and 3 are based on several premises. These are:

1) The instrument technicians make reasonable attempts to achieve the NTS as an "as left" condition at the start of each process rack's surveillance interval.

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

3) The process rack calibration accuracy will be evaluated (probability distribution function characteristics and calibration magnitude) over multiple surveillance intervals.

4) The process racks, including the bistables, are verified/functionally tested in a string or loop process.

It should be noted for (1) above 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. This evaluation assumes that the RCA and RD parameters values noted in Tables 3-1 through 3-10 are satisfied on at least a 95 % probability / 95 % confidence level basis. It is therefore necessary for the plant to periodically reverify the continued validity of these assumptions. 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 process rack channel is considered to be "calibrated" when the two-sided "as left" calibration procedural tolerance is satisfied. An instrument technician may determine 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.

4.2 Process Rack Operability Determination Program and Criteria

The parameter of most interest as a first pass operability criterion is relative drift ("as found" – "as left") found to be within RD, where RD is the 95/95 drift value assumed for that channel. However, 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 requires having the "as left" value for that device at the time of drift determination and Turkey Point Units 3 and 4 have elected to have a plant specific requirement to determine if the drift allowance assumptions were exceeded since the last calibration activity.

An alternative for the process racks is the Westinghouse method for use of a fixed magnitude, two-sided "as found" tolerance about the NTS. It would be reasonable for this "as found" tolerance to be RMTE + RD, where RD is the actual statistically determined 95/95 drift value and RMTE is defined in the Turkey Point Units 3 and 4 procedures. However, comparison of this value with the RCA tolerance utilized in the Westinghouse uncertainty calculations would yield a value where the "as found" tolerance is less than the RCA tolerance. This is due to RD being defined as a relative drift magnitude as opposed to an absolute drift magnitude and the process racks being very stable, i.e., no significant drift. Thus, it is not reasonable to use this criterion as an "as found" tolerance in an absolute sense, as it conflicts with the second criterion for operability determination, which is the ability of the equipment to be returned to within its calibration tolerance. That is, a channel could be found outside the absolute drift criterion, yet be inside the calibration criterion. Therefore, a more reasonable approach for the plant staff was determined. The "as found" criterion based on an absolute magnitude is the same as the RCA criterion, i.e., the allowed deviation from the NTS on an absolute indication basis is plus or minus the RCA tolerance. A process loop found inside the RCA tolerance on an indicated basis is considered to be operable. A channel found outside the RCA tolerance is evaluated and recalibrated. The channel must be returned to within the procedural "as left" tolerance, for the channel to be considered operable. This criterion is incorporated into plant, function specific calibration and drift procedures as the defined "as found" tolerance about the NTS. At a later date, once the "as found" data is compiled, the relative drift ("as found"– "as left") can be calculated and compared against the RD value. This comparison can then be utilized to ensure consistency with the assumptions of the uncertainty calculations documented in Tables 3-1 through 3-10. A channel found to exceed this criterion multiple times should trigger a more comprehensive evaluation of the operability of the channel.

It is believed that a Turkey Point Units 3 and 4 systematic program of drift and calibration review used for the process racks is acceptable as a set of first pass criteria. More elaborate evaluation and monitoring may be included, as necessary, if the drift is found to be excessive or the channel is found difficult to calibrate. Based on the above, it is believed that the total process rack program used at Turkey Point Units 3 and 4 will provide a more comprehensive evaluation of operability than a simple determination of an acceptable "as found."

4.3 Application to the Plant Technical Specifications

The drift operability criteria described for the process racks in Section 4.2 would be based on a statistical evaluation of the performance of the installed hardware. Thus this criterion would change if the M&TE is changed, or the procedures used in the surveillance process are changed significantly and particularly if the process rack modules themselves are changed. Therefore, the operability criteria are not expected to be static. In fact they are expected to change as the characteristics of the equipment change. This does not imply that the criteria can increase due to increasingly poor performance of the equipment over time. But rather just the opposite. As new and better equipment and processes are instituted, the operability criteria magnitudes would be expected to decrease to reflect the increased capabilities of the replacement equipment. For example, if the plant purchased some form of equipment that allowed the determination of relative drift in the field, it would be expected that the rack operability would then be based on the RD value.

Sections 4.1 and 4.2 are basically consistent with the recommendations of the Westinghouse paper presented at the June 1994, ISA/EPRI conference in Orlando, FL[1]. In addition, the plant operability determination processes described in Sections 4.2 and 4.3 are consistent with the basic intent of the ISA paper [1].

Therefore the AVs for the Turkey Point Units 3 and 4 Technical Specifications are "performance based" and are determined by adding (or subtracting) the calibration accuracy (RCA) of the device tested during the Channel Operational Test to the NTS in the non-conservative direction (i.e., toward or closer to the SAL) for the application.

Two examples of the AV calculations are as follows:

- *Power Range Neutron Flux - High*

  NTS = 109% RTP
  SAL = 115% RTP
  RCA = 0.6% RTP (0.5 % span)
  SPAN = 120% RTP

  AV = NTS + RCA

  AV = 109% RTP + 0.6% RTP

  AV = 109.6% RTP

- *Steamline Pressure - Low (SI)*

  NTS = 614 psig
  SAL = 432.2 psig
  RCA = 7 psig (0.5 % span)
  SPAN = 1400 psig

  AV = NTS - RCA

  AV = 614 psig – 7 psig

  AV = 607 psig

4.4 References / Standards

1. 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.