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08-002089	Instrument Setpoint Methodology Topical Report	**001**

Instrument Setpoint Methodology Topical Report

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Revision 1

B&W mPower™ Reactor Program
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SIGNATURES

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RECORD OF REVISION

Revision No.	Date	Preparer	Description of Changes
0	10/18/2010	B. K. Arnholt	Original Issue
1	6/6/2011	B. K. Arnholt	1. Clarify Section 4.2.1 of the report to describe the mathematical relationship between the nominal trip set point (NTSP) and the limiting trip set point (LTSP). 2. Clarify the definition of margin. 3. Add to the report a typical calculation (not design-specific) showing the determination of uncertainties, and application of the setpoint methodology for a typical instrument channel with resulting sample results for the analytical limit (AL), the channel uncertainty (CU), LTSP, NTSP, and the allowable value (AV). 4. Remove references to the use of a "graded approach." 5. Revise Figure 5.1 to: a. Clarify the relationships between design and safety analysis methods and methods applied during surveillance and calibration. b. Clarify that as-found tolerance is derived from the NTSP to establish the allowable value. c. Clarify that the allowable value is the limiting safety system setting (LSSS). d. Clarify the relationship between the LTSP, the NTSP, and the AV in the main body.

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1. ABSTRACT

This report describes the instrument setpoint methodology applied to the B&W mPower™ reactor protection system and other important instrument setpoints associated with the B&W mPower reactor. The protection system is a digital, integrated reactor protection and engineered safety features actuation system implemented for the B&W mPower reactor.

The primary purpose of the protection system is to detect plant conditions that indicate the occurrence of a design basis event as defined by the plant safety analysis and initiate the plant safety features required to mitigate the event. These safety features consist of the automatic actuation of reactor trips and engineered safety features actuation systems.

The methodology described in this topical report is used to establish technical specification setpoints for the B&W mPower reactor protection system in accordance with 10 CFR 50.36. The scope of this report documents the methodology for establishing safety-related trip setpoints and their associated uncertainties to ensure the analytical limit applied to instrument trip setpoints is satisfied. An example calculation for a typical instrument loop is included in this report to demonstrate the application of the methodology.

2. INTRODUCTION

Instrumentation and control (I&C) safety systems monitor and control critical plant parameters to ensure safety limits are not exceeded under the most severe design basis accident or transient. Instrument setpoints and allowable values for these I&C safety system critical process parameter functions are chosen so that potentially unsafe or damaging process excursions (transients) can be avoided and terminated before plant conditions exceed safety limits. Accident analysis establishes the limits for critical process parameters. These analytical limits established by the accident analysis do not normally include considerations for the accuracy (uncertainty) of installed instrumentation. This report describes the method used for the B&W mPower reactor of identifying and combining instrument uncertainties, and applying these uncertainties to establish trip setpoints for critical process parameters to ensure vital plant protective features actuate at the appropriate setpoint during transient and accident conditions.

The methodology described in this report is applied to safety-related equipment that performs a specific safety function for uncertainty analysis, setpoint determination, and determination of allowable values to protect the analytical limit. Determination of instrument setpoints for non-safety related equipment that does not perform a specific safety function is controlled administratively by plant procedures. Typical instrument setpoints in this category are established for equipment that supports reliable power generation or equipment protection.

The results of the uncertainty evaluations can be applied to the following types of calculations:

- Determination of safety-related setpoints
- Extension of surveillance intervals
- Determination of instrument indication uncertainties
- Evaluation or justification of previously established setpoints

Important definitions and terminology used throughout this report are contained in Appendix B for reference.

3. BACKGROUND

3.1 Regulatory Basis

10 CFR Part 50, Appendix B, Criterion XI, “Test Control,” and Criterion XII, “Control of Measuring and Test Equipment,” provide requirements for tests and test equipment used in maintaining instrument setpoints.

10 CFR 50, Appendix A, GDC 13, "Instrumentation and Control," requires in part that instrumentation be provided to monitor variables and systems, and that controls be provided to maintain these variables and systems within prescribed operating ranges.

10 CFR 50, Appendix A, GDC 20, "Protection System Functions," requires in part that the protection system be designed to initiate automatically the operation of appropriate systems, including the reactivity control systems, to assure that specified acceptable fuel design limits are not exceeded as a result of anticipated operational occurrences.

10 CFR 50.36(c)(1)(ii)(A), “Technical Specifications,” requires that, where a limiting safety system setting (LSSS) is specified for a variable on which a safety limit (SL) has been placed, the setting must be so chosen that automatic protective action will correct the abnormal situation before a safety level is exceeded. LSSSs are settings for automatic protective devices related to variables with significant safety functions. Setpoints found to exceed technical specification limits are considered as malfunctions of an automatic safety system. Such an occurrence could challenge the integrity of the reactor core, reactor coolant pressure boundary, containment, and associated systems.

SRP Appendix 7.1-A refers to BTP 7-12 and Regulatory Guide (RG) 1.105 for guidance on establishing and maintaining instrument setpoints. This guidance is designed to meet 10 CFR 50.36(c)(1)(ii)(A), 10 CFR 50, Appendix A, GDC 13, GDC 20 and 10 CFR 50 Appendix B requirements.

The calculation of safety-related instrument setpoints for the B&W mPower reactor is based on RG 1.105, which describes a method acceptable to the NRC for complying with the applicable regulations. RG 1.105 endorses the use of ISA-67.04-1994, Part I. Recognizing that RG 1.105, Revision 3, was published in 1999, the B&W mPower instrument setpoint methodology follows the guidance provided by ANSI/ISA-S67.04.01-2000 (Ref. 6.3.1), which is equivalent to ANSI/ISA S67.04-1994, Part I (now ANSI/ISA-S67.04.01-2006), and ANSI/ISA-RP67.04.02-2000 (Ref. 6.3.2).

BTP 7-12 (Ref. 6.2.2) provides guidelines for reviewing the process that an applicant or licensee follows to establish and maintain instrument setpoints for the following objectives:

- To verify that setpoint calculation methods are adequate to ensure that protective actions are initiated before the associated plant process parameters exceed their analytical limits.
- To verify that setpoint calculation methods are adequate to ensure that control and monitoring setpoints are consistent with their requirements.
- To confirm that calibration intervals and methods established are consistent with safety analysis assumptions.

3.2 Uncertainties

The methodology described in this report relies on the determination of the types of uncertainty. It is not the intent of the report to provide a tutorial in statistical analysis but to provide a brief discussion on the types of uncertainty, their dependency, and their statistical combinations.

Instrument uncertainties are categorized as Random or Non-Random, and are discussed in Sections 3.3 and 3.4, respectively.

3.3 Random Uncertainties

Random uncertainties are referred to as a quantitative statement of the reliability of a single measurement or of a parameter, such as the arithmetic mean value, determined from a number of random trial measurements. This is often called the statistical uncertainty and is one of the precision indices. The most commonly used indices, usually in reference to the reliability of the mean, are the standard deviation, the standard error (also called the standard deviation of the mean), and the probable error. Typically, uncertainties specified by a manufacturer as having a ± magnitude, are random uncertainties.

For these types of uncertainties, B&W uses 95/95 tolerance limits as an acceptable criterion (i.e., a 95% probability that the constructed limits contain 95% of the population of interest for the surveillance interval selected). Typical manufacturers' published accuracy figures are at "2σ" level with a 95.6% probability on a normal error (Gaussian) distribution curve. Therefore, it is acceptable to combine these errors at "2σ" (2 times standard deviation) value by the Square Root of the Sum of the Squares (SRSS) method.

RG 1.105 states: "The 95/95 tolerance limit is an acceptable criterion for uncertainties." (Although the 95/95 tolerance limit has an actual confidence level of 1.96σ, the methodology described in this report uses 2σ to simplify calculations and adds an additional level of conservatism).

This methodology uses a double-sided acceptance criteria band for random uncertainties to ensure that the instrument setpoint is maintained within a prescribed range as defined in sections 4.2.2 and 4.2.3 of this report, and deviations of the trip setpoint beyond the acceptable tolerance range are identified and corrected.

3.3.1 Independent Uncertainties

Independent uncertainties are those uncertainties for which no common root cause exists (i.e., uncertainty errors whose value at a particular future instant cannot be predicted with precision but can only be estimated by a probability distribution function). The algebraic sign of a random uncertainty is equally likely to be positive or negative with respect to a given median value. Therefore, random, independent uncertainties are eligible for the SRSS combination propagated from the process measurement module through the signal conditioning module of the instrument channel to the device that initiates the actuation. It is generally accepted that most instrument channel uncertainties are independent of each other.

3.3.2 Dependent Uncertainties

Complicated relationships may exist between instrument channels and various instrument uncertainties. As such, a dependency might exist between some random uncertainty terms and parameters of an overall uncertainty analysis. A common root cause may exist which influences other uncertainty terms in the analysis with a known relationship. When these uncertainties are included, they are added algebraically, which results in a statistically larger value for that parameter when evaluated in the overall channel uncertainty.

3.4 Non-Random Uncertainties

3.4.1 Bias

Bias uncertainties are those that consistently have the same algebraic sign. Bias terms are the fixed or systematic uncertainty components within a measurement and are not generally eligible for SRSS combinations. In some cases, they can be explicitly accounted for in the instrument channel calibration process (i.e., calibrated out), in which case they are not accounted for in the uncertainty calculation since they can be compensated for in the scaling of the instrumentation. Any bias effects that cannot be calibrated out are directly accounted for in the uncertainty calculation.

If they are predictable for a given set of conditions because of a known positive or negative direction, they are classified as bias with a known sign. If they do not have a known sign, they are treated conservatively by algebraically adding the bias in the worst direction based on the nature of the instrument channel. These are classified as bias with an unknown sign.

3.4.2 Abnormally Distributed Uncertainties

Some uncertainties not normally distributed may not be eligible for the SRSS combination and are categorized as abnormally distributed. This type of uncertainty is treated as a bias against both the positive and negative components of module uncertainty. Their unpredictable sign is conservatively treated by algebraically adding the bias in the worst direction based on the nature of the instrument channel.

3.5 Assumptions

The methodology for the determination and calculation of uncertainty terms, and ultimately the process described in this report for determining setpoints, is based on the assumptions listed below:

- Where bias terms have opposite effects on instrument accuracy (positive versus negative), and are both of known magnitude, the two uncertainties may be used to offset each other. If both magnitude and direction of a bias are known (e.g., transmitter static pressure span effects), this effect can be accounted for in the instrument channel calibration procedure and calibrated out of an instrument and thus eliminated from the uncertainty calculation.

- Any random independent term whose value is less than 1/10 of any of the other associated device random uncertainties can be statistically neglected.

- Uncertainty terms of devices are calculated in terms of percent calibrated span.

- For the purposes of the setpoint analyses, the instrumentation is assumed to be calibrated at 70°F nominal ambient temperature. Temperature Effect (TE) for the instrumentation is based on the temperature deviation between this assumed calibration temperature and the maximum and minimum ambient temperature of the specific location of the actual instrumentation. The normal temperature effects are accounted for as shown in the equations in Section 4.2.1. By using the actual vendor data (typically stated in terms of ± X % span per Y °F), actual calibration temperatures and plant operating temperatures, the overall temperature effect is determined and accounted for in the TE term for the specific instrument channel of interest, consistent with the guidance contained in ANSI/ISA RP67.04.02-2000.

4. METHODOLOGY

The B&W mPower methodology for uncertainty analysis, setpoint determination, calibration interval and determination of allowable values for safety-related instrumentation follows the standards and recommended practices of ANSI/ISA-S67.04.01-2000 (Ref. 6.3.1) and ANSI/ISA-RP67.04.02-2000 (Ref. 6.3.2) with guidance provided by Regulatory Guide 1.105 (Ref. 6.2.1). The term "uncertainty" is used to reflect the distribution of errors consistent with References 6.3.1 and 6.3.2.

This section provides the methodology used to establish the uncertainty of the instrument measurement channel that includes all of the elements of uncertainty described below and then describes how the calculated uncertainties are applied to the trip setpoints and allowable values. Uncertainties for calculated functions or composed points (points that are made up of multiple inputs or calculated inputs) are also discussed.

The general methodology described in this report used to combine instrument loop uncertainties 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 other independent terms. Random and independent instrument loop uncertainties are combined using the statistical SRSS approach with abnormally distributed and non-random or bias uncertainties combined algebraically in accordance with ANSI/ISA-RP67.04.02-2000 (Ref. 6.3.2). The calculation methodology for the B&W mPower reactor follows the intent of the procedure established in the ISA standard ANSI/ISA-S67.04.01-2000 (Ref. 6.3.1) and additional guidance on combining instrumentation uncertainties provided in ANSI/ISA-RP67.04.02-2000 (Ref. 6.3.2).

The methodology described in this report addresses only the highest grade discussed in the standard applied to those safety-related setpoints with established LSSSs for which a safety limit has been established as defined by the plant safety analysis. All elements of uncertainty, both normal and accident or abnormal conditions, are evaluated and addressed in instrument loop accuracy and setpoint calculations such that the results have a 95% probability with a 95% confidence (i.e., 95%/95% rigor).

There are many safety-related and non-safety related system instrument setpoints that are important to safety or important for reliable power generation and equipment protection. Because these setpoints may not have analytical limits established by the accident analysis for a safety limit, the basis for the setpoint calculation becomes system or equipment protection and maintaining generation capacity. The normal process limit (NPL) adjusted for the appropriate margin becomes the basis for establishing the setpoint when no analytical limit is established by the accident analysis and is governed and controlled by plant procedures.

4.1 Approach

The methodology follows the setpoint calculation flow depicted in Figure 2 of ANSI/ISA-RP67.04.02-2000 (Ref. 6.3.2), which has been reproduced as Figure 4.1, with minor modifications to add guidance for applying channel uncertainties and margin based on whether an instrument channel signal approach to a trip setpoint is decreasing or increasing. The instrument loop is diagrammed and analyzed as described in the following subsections. The general relationships between the various setpoints and limits are shown in Section 5, Summary.

A typical calculation data sheet/checklist shown as Table 4.1 is used as a guide and to provide consistency in the development of the calculation(s). This table also provides traceability and documentation of the loop data and uncertainties used. The results of the calculation are documented in accordance with controlled plant procedures and programs (such as the Setpoint Control Program) with adequate detail so that all bases, equations, and conclusions are fully understood and documented.

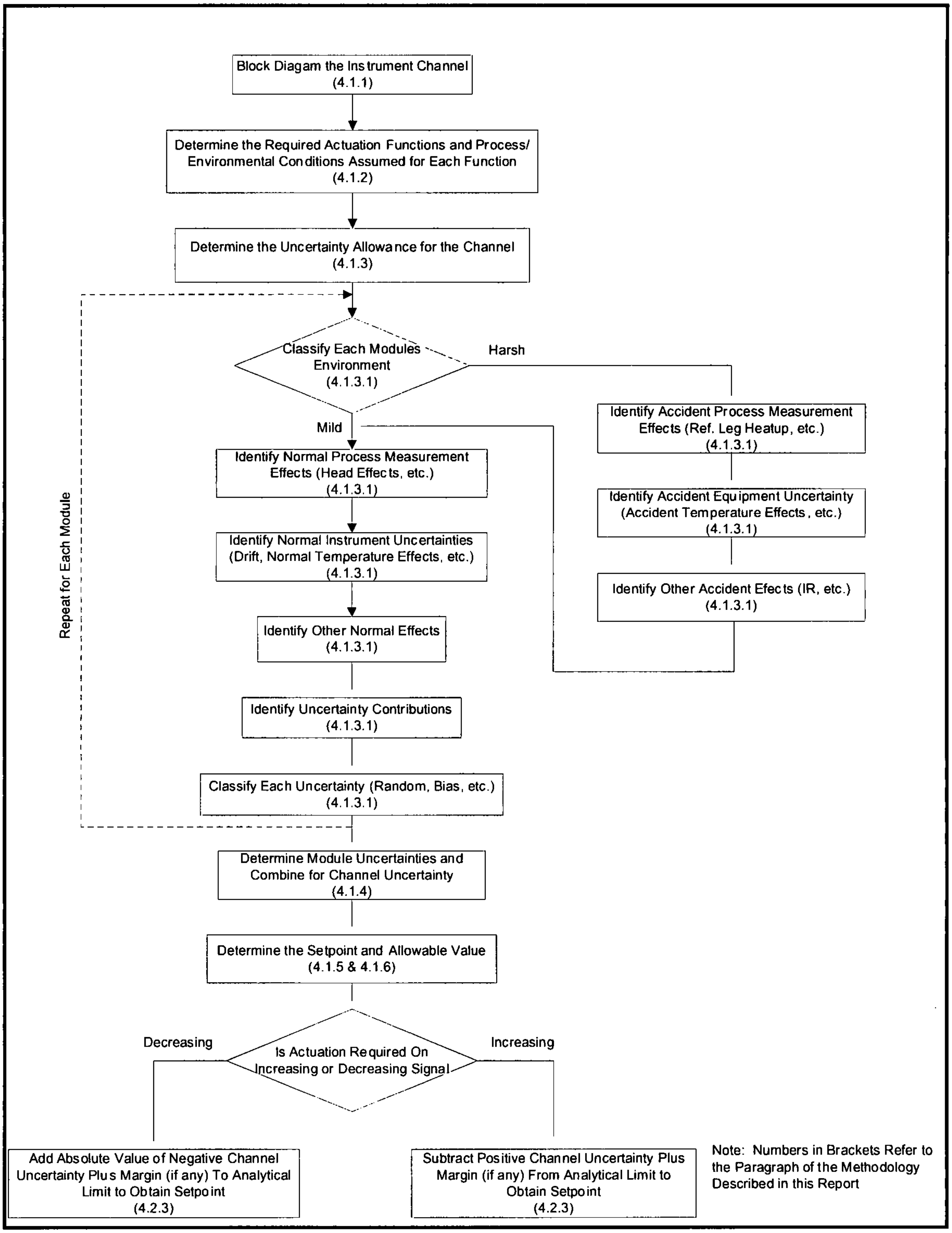

Figure 4.1: Setpoint Calculation Flow

Table 4.1: Calculation Data Sheet

ITEM	DESCRIPTION (PARAMETER)	REFERENCE	REMARKS
Component ID			
Service Description			
Location			
Manufacturer			
Model Number			
Quality Category			
Adjustable Range			
Process Calibrated Range			
Input Signal Calibrated Range			
Output Signal Calibrated Range			
Reference Accuracy (RA)			
Drift (DR)			
Bias (B)			
Static Pressure Effect (SP)			
External Pressurization Effect (EP)			
Overpressure Effect (OP)			
Temperature Effect – Normal (TE); Accident (TEA)			
Humidity Effect (HE)			
Radiation Effect - Normal (RE); Accident (REA)			
Seismic Effect (SE)			
Insulation Resistance Effect (IRE)			
Power Supply Effect (PS)			
Indicator Reading Uncertainty (R)			
Process Measurement Effect (PM)			
Primary Element Effect (PE)			
Measurement & Test Uncertainty (MTE)			
Technical Specification (If Applicable)			
Analytical Limit (AL)			
Normal Process Limit (NPL)			
Allowable Value (AV)			
Trip Setpoint (NTSP)			
Calibration Frequency			
Calibration Procedure			
As-Found Tolerance (AFT)			
As-Left Tolerance (ALT)			
Module Algorithm			
EQ and Functional Operating Environment			
Safety Function/Other Functional Requirements			
Function Duration			
Normal Operation Upper Limit (NUL)			
Normal Operation Lower Limit (NLL)			
Operating Margin (OM)			

Module Uncertainty ($e^{\pm}_n$):	Equation 4.2.1
Channel Uncertainty (CU):	Equation 4.2.2
Trip Setpoint (NTSP):	Equation 4.2.3 (for calculated functions: Equation 4.2.7)
Allowable Value (AV):	Equation 4.2.4
As-Found Tolerance (AFT):	Equation 4.2.5
Operating Margin (OM):	Equation 4.2.6

4.1.1 Loop Diagram

The loop is diagrammed to identify the various modules and interconnection devices that make up the instrument loop. If necessary, multiple channel diagrams are developed. A typical process measurement channel diagram is shown in Figure 4.2. The diagram shown is used to include the interfaces, functions, sources of uncertainty, and the instrument module environments. Although the figure shows a flow measurement loop, the layout is generally applicable to temperature, level, pressure, and other parameter measurements.

A specified number of transmitters or sensors may be used to satisfy the requirements for redundancy and reliability. If each independent instrument loop is functionally equivalent in terms of the types of modules and environment, only one instrument channel diagram is needed. Each loop is analyzed and arrangements and characteristics are compared to verify that all loops are identical. In this case, a single calculation is valid for all of the loops.

Environmental boundaries are drawn for the channel as shown in the loop diagram. For simplicity, two sets of environmental conditions are shown. The process measurement elements are usually located in plant areas where a harsh environment may exist during the time the instrument loop must function. For most channels, signal conditioning and actuation are located in mild environments.

4.1.2 Loop Function

The loop function is analyzed for its role in the system operation considering the following:

- functional requirements
- actuation functions
- display functions
- operating times
- postulated environments

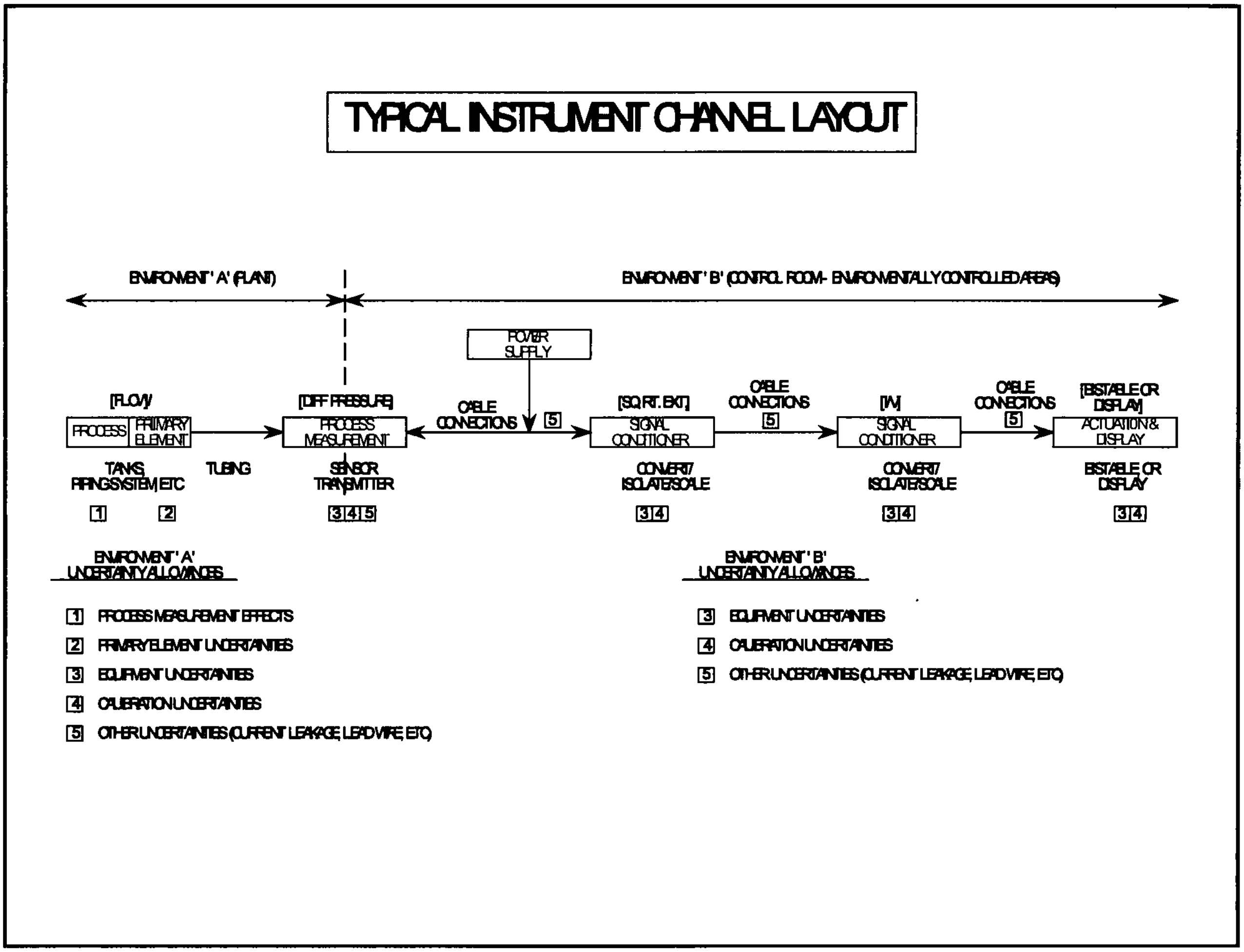

Figure 4.2: Typical Instrument Channel Layout

4.1.3 Uncertainty Analysis

Once the loop is diagrammed as described in Section 4.1.1, and the actuation functions, process and environmental conditions are established for each function, then the loop is evaluated, uncertainties calculated, limits are established, and the trip setpoint is determined.

This methodology includes a rigorous review of the instrument loop layout and design. Each element of uncertainty, for each module or device is evaluated in detail and the estimated loop uncertainty is justified. Additional uncertainties that may apply to a particular instrument channel are accounted for in determining the trip setpoint allowance. Not all of the uncertainties listed apply to every measurement channel. The setpoint is carefully established with respect to the process analytical limit and the channel uncertainty.

4.1.3.1 Contributing Uncertainties

The environment is analyzed and classified as mild or harsh. The environment in any plant area is considered harsh if, because of postulated accidents, the temperature, pressure, relativity humidity, vibration (seismic displacement) or radiation significantly increases above the normal conditions. A mild environment is an environment that at no time is more severe than the expected environment during normal plant operation, including anticipated operational occurrences.

For portions of the instrument channel that are located in a harsh environment, the accident process measurement effects are determined (e.g., reference leg heat-up, density changes, radiation exposure, seismic experience, etc.) and the uncertainties are determined. For portions of the instrument channel that are located in a mild environment, the normal process measurement effects are identified and uncertainties are determined. All uncertainties are included as applicable.

After the environmental conditions are determined, the potential uncertainties affecting each portion of the channel are identified.

Uncertainties are classified as random or non-random (Section 3.2). This determination is an interactive process requiring the development of assumptions and, where possible, verification of assumptions based on actual data. The determination of type of uncertainty establishes whether the SRSS method can be used or if the uncertainty is to be added algebraically, or a combination of both.

Elements of uncertainty for any module that are considered are listed below (not all of the uncertainties listed apply to every measurement channel). Definitions, as appropriate, are provided in Appendix B.

- process measurements effect
- primary element accuracy
- drift
- temperature effects
- radiation effects
- static and ambient pressure effects
- overpressure effect
- measuring and test equipment uncertainty
- power supply effects

- indicator reading uncertainty
- conversion accuracy
- seismic effects
- environmental effects – accident
- as-left tolerance specification
- as-found specification
- propagation of uncertainty through modules

4.1.4 Channel Uncertainty

Individual module uncertainties and other uncertainty terms are combined to determine the overall channel uncertainty (CU) using the equations shown in Sections 4.2.1 and 4.2.2, respectively.

As described earlier, the methodology used in this report to combine instrument loop uncertainties 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 other independent terms.

As can be seen from the equations, process measurement effect (PM) and primary element accuracy (PE) are now accounted for. These parameters are considered independent of sensor and digital process equipment parameters. The PM term provides allowances for the non-instrument related effects such as velocity effects, fluid density changes, and temperature changes. If additional, independent and random PM terms apply, they can be combined using the SRSS methodology. The PE term typically is a calculated or measured accuracy for the device and accounts for the accuracy of the device being installed in the process (e.g., nozzles, venturis, orifice plates, etc.). The primary element uncertainties are typically considered to be random, unless explicitly stated by the manufacturer and are accounted for in the equations shown in Section 4.2.2 using the SRSS method.

The process measurement uncertainty consists of both random and bias uncertainties. Random PM uncertainties are appropriately treated using the SRSS method. PM bias uncertainties than cannot be accounted for in the channel calibration (such as with a flow or level instrument channel) and eliminated, are included in the bias term of the equations shown in Section 4.2.2.

Note that the CU also includes the module uncertainty (e) for each module. A "module" is defined in this methodology as any assembly of interconnecting components that constitutes an identifiable device, instrument or piece of equipment. This includes any elements in the channel attributed to the digital system where there are random errors.

As stated earlier, error propagation for signal conditioning modules (when they are selected and defined) is combined using the guidance in ANSI/ISA-RP67.04.02-2000, Annex K.

4.1.5 Trip Setpoint

The trip setpoint (NTSP) cannot be established until the analytical limit (AL) is defined by the safety analysis. Any inherent margins in the analytical limit are quantified in the determination of the trip setpoint.

The analytical limit is the limit of a measured or calculated variable established by the safety analysis for the actuation of protective functions. Actuating protective functions at or before the analytical limit ensures that the safety limit (SL) is not exceeded and design conditions of equipment/systems assumed in other analyses are not exceeded. Analytical limits are developed from event analysis models that consider parameters such as process delays, control rod insertion times, reactivity changes, instrument response times, etc.

The limiting trip setpoint (LTSP) is the limiting safety system setting that accounts for all known channel uncertainties associated with the instrument channel. The LTSP is determined from the AL and provides reasonable assurance that the trip or actuation will occur before the AL is reached regardless of the process or environmental conditions effect on the instrumentation.

The NTSP is established for normal plant operation by adding margin to the total channel uncertainty. The margin associated with the establishment of the NTSP is discretionary based on engineering judgment to add a level of conservatism. Typically, margin would be applied to account for such factors as conservatively rounding to the nearest engineering unit or accounting for any assumptions used in determination of initial channel setpoints. The margin applied also takes into consideration the operating range for the instrument channel to ensure the trip setpoint is not established too close to the operating range limits that may cause spurious channel trips. By definition, the NTSP is equal to or more conservative than the LTSP.

4.1.6 Allowable Value

The allowable value (AV) is calculated using equation 4.2.4.

Periodic surveillance testing is required to verify the safety-related instrument channel performs as required to protect the AL. The allowable value defines the maximum and/or minimum limits of operability. It is the limiting value of the measured variable at which the trip setpoint or calibration setting may be found during instrument surveillance to provide adequate assurance that the AL remains protected. The allowable value is an LSSS specified in plant Technical Specifications. It is used by the plant to verify instrument channel operability at periodic surveillance intervals.

The AV is a value that the trip setpoint might have when tested periodically and accounts for instrument drift and other uncertainties applicable to normal plant operation associated with the test during normal plant operation including: instrument drift, reference accuracy, as-left tolerance from the previous calibration and measurement and test equipment uncertainty. A setpoint found within the allowable value region, but outside the as-found tolerance, is considered operable, but degraded. It is acceptable with respect to the analytical limit; however, the instrument must be reset to return it within the allowed as-left tolerance region (see definitions). A channel setpoint found outside the allowable value region requires an evaluation for operability, and calibration to return the setpoint within the acceptable tolerance range.

4.1.7 Calculated Functions (Composed Points)

Channel uncertainties for calculated functions or composed points (input points where two or more signals are combined) are calculated using the methods described in ANSI/ISA–RP67.04.02-2000, Annex K. For these points, the most limiting safety margin assigned to each input parameter is normalized (converted to the appropriate engineering units) and then summed together. The resulting total safety margin (TSM) is then used to determine NTSP.

4.2 Equations

Equations that are used in preparation of calculations in this methodology are shown in the following sections.

4.2.1 Module Uncertainty

$$e_n^+ = +(RA^2+DR^2+TE^2+HE^2+RE^2+PS^2+SP^2+OP^2+SE^2+TEA^2+REA^2+EP^2+ALT^2+MTE^2+R^2)^{1/2} + B^+$$

$$e_n^- = -(RA^2+DR^2+TE^2+HE^2+RE^2+PS^2+SP^2+OP^2+SE^2+TEA^2+REA^2+EP^2+ALT^2+MTE^2+R^2)^{1/2} - B^-$$

Where:

e_n	=	Total module uncertainty. When all module uncertainties are combined to calculate the channel uncertainty, CU, the random portion of the "e_x" terms is placed under the square root radical and the bias portions are combined algebraically.
RA	=	Sensor reference accuracy specified by the manufacturer.
DR	=	Drift of the sensor over a specific period. This has historically been the drift specified by the manufacturer.
TE	=	Temperature effect for the sensor; the effect of ambient temperature variations on the sensor accuracy.
HE	=	Humidity effect for the sensor; the effect of changes in ambient humidity on sensor accuracy, if any.
RE	=	Radiation effect for the sensor; the effect of radiation exposure on sensor accuracy.
PS	=	Power supply variation effects; the uncertainty due to instrument power supply variations.
SP	=	Static pressure effects for the sensor; the effect of changes in process static pressure on sensor accuracy.
OP	=	Overpressure effect; the effect of over ranging the pressure sensor of a transmitter.
SE	=	Seismic effect for the sensor; the effect of seismic or operational vibration on the sensor accuracy.
TEA	=	Temperature effects during accidents; the uncertainty effects of adverse conditions due to temperature on the instrument channel during a design basis accident.
REA	=	Radiation effects during accidents; the effect of adverse radiation environments on the instrument channel during a design basis accident.
EP	=	The error of a specific instrument that is associated with ambient pressure variations.
ALT	=	Calibration setting tolerances for the sensor; the uncertainty associated with calibration tolerances.
MTE	=	Measurement and test equipment effect for the sensor; the uncertainties in the equipment utilized for calibration of the sensor.
R	=	Readability error associated with display functions.
B	=	Bias associated with the sensor, if any.

Note that the possible sources of uncertainty above only include those associated with the sensor. Similar terms for signal isolators, indicators, bistables or other signal conditioning instruments can be combined in similar fashion to obtain an overall uncertainty expression for an entire instrument loop. The random uncertainty terms would be included with the sensor random terms within the square root term. The bias terms are combined according to their direction outside the square root radical.

Error propagation for signal conditioning modules (when they are selected and defined) is combined using the guidance in ISA-RP67.04.02-2000, Annex K.

4.2.2 Channel Uncertainty

$$CU+ = +(PM^2 + PE^2 + e_1^2 + \ldots\ldots + e_n^2)^{1/2} + B+$$

$$CU- = -(PM^2 + PE^2 + e_1^2 + \ldots\ldots + e_n^2)^{1/2} - B-$$

Where:

CU	=	Total channel uncertainty (For the purpose of this methodology, the uncertainty is calculated for a setpoint(s). It could also be the uncertainty for an indication function or a control function. Because each function typically uses different end-use devices, the channel uncertainty is calculated separately for each function.)
PM	=	Random uncertainties that exist in the channel's basic process measurement.
PE	=	Random uncertainties that exist in a channel's primary element, if present, such as the accuracy of a flow orifice plate.
$e_1 \ldots e_n$	=	Total random uncertainty for each module in the loop from Module 1 through Module n.

B+ is positive bias, and B- is negative bias.

4.2.3 Trip Setpoint

$$LTSP = AL \pm CU$$

$$NTSP = AL \pm (CU + Margin)$$

Where:

LTSP	=	Limiting trip setpoint.
NTSP	=	Nominal trip setpoint.
AL	=	Analytical limit.
CU	=	Trip setpoint uncertainty (the channel uncertainty for the bistable).
Margin	=	Amount chosen for conservatism. Note that when the trip setpoint is very close to the system's normal operating point, the margin may be very small or zero.

4.2.4 Allowable Value

$AV = NTSP \pm (AFT_{TOT} + Margin)$

Where:

AV	=	Allowable value.
NTSP	=	Trip setpoint.
AFT_{TOT}	=	Total as-found tolerance for the entire instrument channel.
Margin	=	Value added to protect the AL and yet maintain an acceptable AFT to assure identification of a module that may be functionally degrading during normal surveillance intervals.

AFT_{TOT} determination includes consideration of all channel AFT uncertainties pertaining to the calibration being performed. Therefore, when considering AV, AFT_{TOT} is based on;

$AFT_{TOT} = (AFT_1^2 + AFT_2^2 + ... + ... + ... + AFT_n^2)^{1/2}$

Where:

AFT_n	=	as-found tolerance for module "n" (see 4.2.5).

4.2.5 As-Found Tolerance

This is the module uncertainty as discovered during module calibration. Therefore, it does not include uncertainties due to harsh environment or process measurement, and does not include primary element uncertainty. As-found tolerance (AFT) includes consideration of reference accuracy (RA), drift (DR), and as-left tolerance (ALT) uncertainties. It may include measurement and test equipment uncertainty if the equipment contributes errors greater than one tenth of the measurement uncertainty (refer to Section 3.5). For some modules, it may be necessary to include additional uncertainties (e.g., TE may be included in the determination of AFT if a change in the calibration environment occurred).

Therefore:

$AFT_n = (RA_n^2 + DR_n^2 + ALT_n^2 + MTE_n^2)^{1/2}$

Where:

AFT	=	As-found tolerance (any typical module).
n	=	Module "n".
RA	=	Device reference accuracy.
DR	=	Device allowance for drift.
ALT	=	As-left tolerance.
MTE	=	Measurement and test equipment effect.

The AFT is included to determine if the instrument needs to be reset after calibration or, if outside of the tolerance, requires further investigation as to its operability. The as-found readings also provide data for establishing actual instrument drift.

The uncertainty for drift is typically obtained for the sensor from manufacturers in terms of X% URL over Y period of time. Since drift is assumed to be random, the guidance provided in ANSI/ISA RP67.04.02-2000 applies in calculating the SRSS of the individual drift periods between calibrations as shown in the example provided below:

$$DR_{TOT} = \pm (DR_{int1}^{2} + DR_{int2}^{2} + \ldots + DR_{intn}^{2})^{1/2}$$

Where DR_{TOT} is the drift for the total surveillance interval and DR_{intn} is the drift for the time interval specified by the manufacturer.

For the B&W mPower reactor, the surveillance and calibration intervals are determined as part of the development of the reference technical specifications. Determination of surveillance and calibration intervals takes into account the uncertainty due to instrument drift as described in this report such there is reasonable assurance that the plant protection system instrumentation is performing as expected between the surveillance intervals.

4.2.6 Operating Margin

Operating margin (OM) is required between the setpoint and the normal upper or lower limit, as applicable, to avoid spurious channel trips during normal operation

OM = NTSP – NUL (increasing setpoint)
OM = NLL – NTSP (decreasing setpoint)

Where:

OM	=	Operating margin.
NTSP	=	Trip setpoint.
NUL	=	Normal operating upper limit.
NLL	=	Normal operating lower limit.

4.2.7 Calculated Functions

Total safety margin (TSM) = (safety margin A x KA) + (safety margin B x KB) ….+ (safety margin n x Kn).

Where:

A, B, ..n are process measurement inputs to the calculated function.

Safety margin is a discretionary value determined by engineering judgment.

KA, KB,..Kn are constants used to normalize each parameter to the engineering units of the function setpoints.

Then:

NTSP = AL ± (CU +TSM)

5. SUMMARY/CONCLUSIONS

The results of the calculations are documented in accordance with controlled plant procedures with adequate detail so that all conclusions are fully understood. The relationships of the various uncertainty terms, trips, margins, and operating values are diagrammed in Figure 5.1.

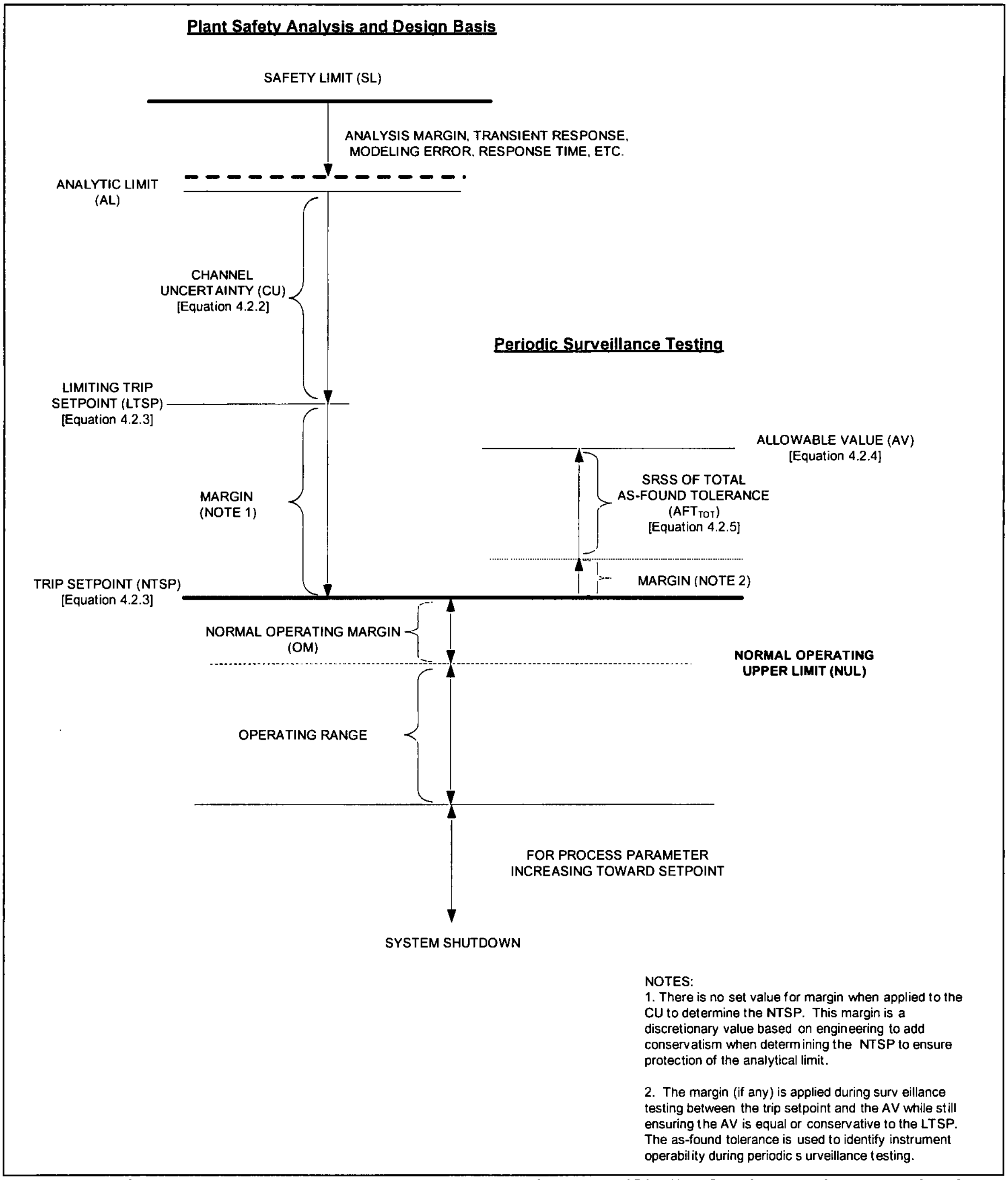

Figure 5.1: Setpoint Relationships – For Increasing Setpoint (Similar for decreasing setpoint, but process is decreasing towards the setpoint).

6. REFERENCES

6.1 Code of Federal Regulations

6.1.1 10 CFR 50.36, "Technical Specifications."

6.1.2 10 CFR 50, Appendix A, General Design Criteria (GDC) 13, "Instrumentation and Control."

6.1.3 10 CFR 50, Appendix A, GDC 20 "Protection System Functions."

6.1.4 10 CFR 50, Appendix B, Criterion XI, "Test Control."

6.1.5 10 CFR 50, Appendix B, Criterion XII, "Control of Measuring and Test Equipment."

6.2 U.S. Nuclear Regulatory Guidance

6.2.1 Regulatory Guide 1.105, "Setpoints for Safety Related Instrumentation," Rev. 3, December 1999.

6.2.2 NUREG-0800, Standard Review Plan (SRP), BTP 7-12, "Guidance on Establishing and Maintaining Instrument Setpoints," Rev. 5, March 2007.

6.2.3 NUREG-0800, SRP, Appendix 7.1-A, "Acceptance Criteria and Guidelines for Instrumentation and Control Systems Important to Safety," Rev. 5, March 2007.

6.2.4 RIS 2006-17, "NRC Staff Position on the Requirements of 10 CFR 50.36, 'Technical Specifications', regarding Limiting Safety System Settings during Periodic Testing and Calibration of Instrument Channels," Regulatory Issue Summary August 2006.

6.3 U.S. Industry Guidance

6.3.1 ANSI/ISA-S67.04.01-2000, "Setpoints for Nuclear Safety-Related Instrumentation," February 2000 (Equivalent to ANSI/ISA-S67.04, Part I-1994).

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

6.3.3 ANSI/ISA-S67.04.01-2006, "Setpoints for Nuclear Safety-Related Instrumentation," May 2006.

6.3.4 Not used.

Appendix A – Example Setpoint Calculation for a Safety-Related Pressure Channel

Purpose

This section presents an example to demonstrate the application of this setpoint methodology for the determination of the nominal trip setpoint (NTSP), limiting trip setpoint (LTSP) and allowable value (AV) based on the analytical limit (AL) for a typical safety-related instrument channel. For this example, a safety-related system pressure channel is used for an increasing process. The safety analysis established a safety limit for high system pressure for an increasing process. The establishment of trip setpoints using this methodology will establish the LTSP to verify the limiting safety system setting (LSSS) is satisfied and ensure the safety limit is protected.

Loop Characteristics and Assumptions

The analytical limit for this example pressure channel is 1047.0 psig which is based on the plant safety analysis. The example pressure channel protects a high safety-related pressure limit and has a span of 100–1200 psig, with an upper-range limit of 1500 psig. The simplified loop consists of two modules: the pressure transmitter and the plant protection layer digital reactor protection system. The pressure transmitter is located in a mild environment in the reactor service building and the digital reactor protection system is located in an environmentally controlled electrical equipment room. The assumptions for this example instrument loop are:

- The sensor is located in a mild environment not subject to excessive temperature, humidity, pressure or radiation.
- M&TE errors are bounded by administrative plant procedures to be less than one-quarter of the total reference accuracy.
- There are no known interdependencies between individual component errors for the loop. All random uncertainties will be treated as independent.
- There are no known biases associated with this instrument channel.
- The uncertainty associated with process measurement effects (PM) and primary element (PE) effects are negligible for this channel and will not be considered.
- The inter-connection wiring uncertainty contribution is assumed negligible.
- The uncertainty related to drift is obtained from the manufacturer and is confirmed to be consistent with the required surveillance interval.

The example loop diagram for this instrument channel is shown in Figure A.1.

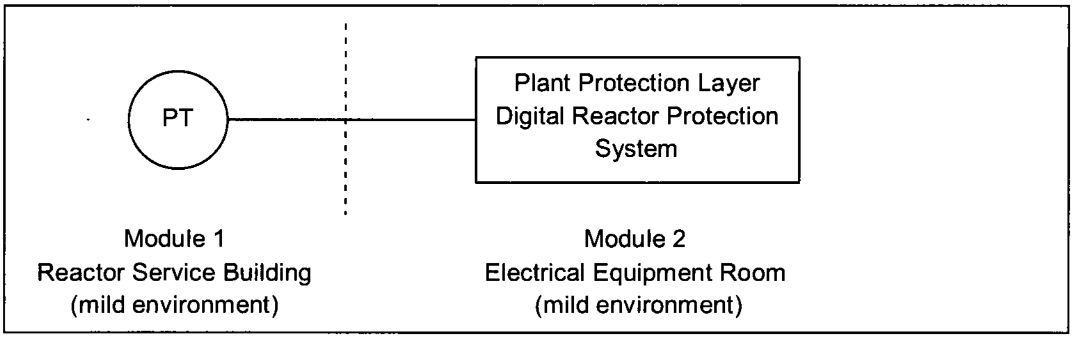

Figure A.1: Example Loop Diagram for Safety-Related Instrument Channel

The applicable uncertainties to the pressure transmitter include reference accuracy, drift, power supply effects, as-left tolerances resulting from the channel calibration, measurement and test equipment uncertainties, and environmental effects. All other uncertainty effects are not applicable for this example.

The pressure sensor is located in a mild environment. The terms for RE, TE, SE, and HE are combined into an overall environmental uncertainty effect (EE) and conservatively set at 2.5% of span. This is confirmed to be conservative with respect to data reported by the manufacturer.

Sensor Module Uncertainty, e_1

Equation 4.2.1 is simplified into the following for the transmitter module uncertainty, e_1:

$$e_1 = (RA_1^2+DR_1^2+PS_1^2+ALT_1^2+MTE_1^2+EE_1^2)^{1/2}$$

Digital Reactor Protection System Module Uncertainty, e_2

The digital reactor protection system (RPS) consists generically of an input processing module, logic processing module, and output processing module. For simplicity, these three sub-systems are considered as one, single integrated system with respect to system uncertainties of the RPS. The system cannot be calibrated; therefore, the only applicable uncertainty is the overall system reference accuracy for the digital RPS specified by the vendor. Equation 4.2.1 is simplified into the following for the digital RPS module uncertainty, e_2:

$$e_2 = (RA_2^2)^{1/2}$$

Calculation of Total Channel Uncertainty, CU

The overall channel uncertainty is determined using equation 4.2.2. Since PM and PE are not applicable, the total channel uncertainty is determined as follows:

$$CU = (e_1^2+e_2^2)^{1/2}$$

$CU = (RA_1^2+DR_1^2+PS_1^2+ALT_1^2+MTE_1^2 + EE_1^2+RA_2^2)^{1/2}$

The parameters for the instrument channel span and range are shown in Table A.1. The parameters for RA_1, DR_1, PS_1, and RA_2 are typical values specified by the manufacturer. The uncertainty for MTE_1 is assumed to be one-quarter of the total reference accuracy of the sensor and is controlled by administrative procedures. The as-left tolerance is governed by administrative procedures to be no greater than 0.5% of the span for the instrument channel.

Table A.1: Example Instrument Channel Uncertainties

	% span	psig
Sensor (e_1)		
RA_1	0.25%	2.75
DR_1	1.25%	13.75
PS_1	0.05%	0.55
ALT_1	0.50%	5.50
MTE_1	0.06%	0.69
EE_1	2.50%	27.50
Digital RPS (e_2)		
RA_2	0.10%	1.10

The uncertainties from Table A.1 are used to calculate the total channel uncertainty. Using the equation for CU, the resulting calculation is:

CU = 31.4 psig, (2.85% span)

LTSP and NTSP are determined as follows for an increasing process using equation 4.2.3. A margin of 5.0% of span (55 psig) is applied to the NTSP to account for rounding errors and avoid spurious channel trips. The LTSP is the LSSS used in the plant technical specifications.

LTSP = AL - CU = 1047.0 psig – 31.4 psig = 1015.6 psig

NTSP = AL - (CU + Margin) = 1047.0 - (31.4 psig + 55.0 psig) = 960.6 psig

In determining the allowable value, the as-found tolerance for both modules is considered and equation 4.2.4 is used to calculate the total as-found value for the instrument channel. Since the digital RPS cannot be calibrated, the only applicable component for AFT_2 is the reference accuracy.

$AFT_1 = (RA_1^2 + DR_1^2 + ALT_1^2 + MTE_1^2)^{1/2}$; $AFT_2 = (RA_2^2)^{1/2}$

$AFT_{TOT} = (AFT_1^2 + AFT_2^2)^{1/2}$

$AFT_{TOT} = (RA_1^2 + DR_1^2 + ALT_1^2 + MTE_1^2 + RA_2^2)^{1/2}$

Substituting the numerical values from Table A.1, the as-found tolerance value is:

AFT_{TOT} = 15.1 psig, (1.37% span)

With the value for the total channel as-found tolerance, the allowable value is now calculated using equation 4.2.4. The channel setpoint is confirmed during periodic surveillance testing to ensure it remains within the AV to ensure the LTSP remains satisfied.

$AV = NTSP + AFT_{TOT}$ = 960.6 psig + 15.1 psig = 975.7 psig

The relationships between the analytical limit and calculated setpoints for this channel are illustrated in Figure A.2.

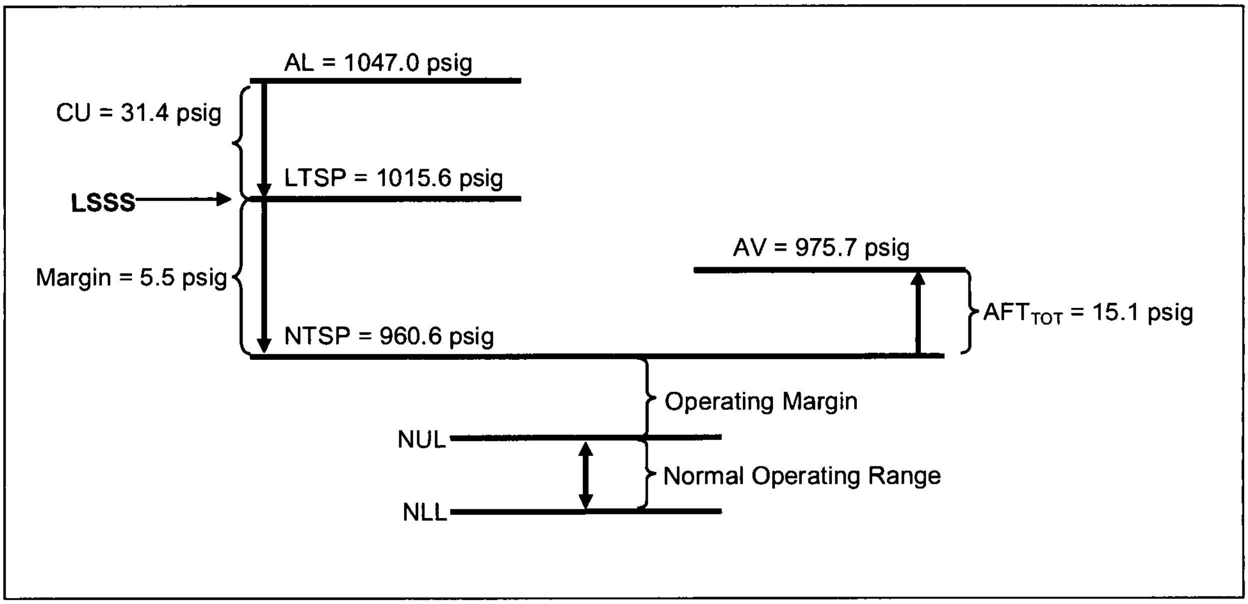

Figure A.2: Relationships between analytical limit and calculated setpoints

Appendix B - Definitions

The definitions herein are mostly derived from ANSI/ISA-S67.04.01-2000 (Ref. 6.3.1) and its references. Additional definitions for terms specifically used in this methodology are also included.

95/95: A standard statistics term meaning that the results have a 95 percent probability with a 95 percent confidence level.

Allowable Value: The limiting safety system setting for nuclear reactors is the automatic protective device value for variables having significant safety functions. It is the value that the trip setpoint or calibration setting may have when tested periodically, beyond which appropriate action shall be taken (ANSI/ISA–S67.04.01–2000). The allowable value defines the maximum and minimum limits of operability. It is the limiting value of the measured variable at which the trip setpoint or calibration setting may be found during instrument surveillance to provide adequate assurance that the analytical limit remains protected.

Analytical Limit: Limit of a measured or calculated variable established by the safety analysis for the actuation of protective actions. Actuating protective actions at or before the analytical limits ensures that the safety limit is not exceeded and design conditions of equipment/systems assumed in other analyses are not exceeded. Analytical limits are developed from event analysis models that consider parameters such as process delays, rod insertion times, reactivity changes, instrument response times, etc.

As-Found: The condition in which a channel or a portion of channel is found after a period of operation and before recalibration (if necessary) (ANSI/ISA–S67.04.01–2000). The as-found value is compared to the allowable value to determine channel operability.

As-Found Tolerance: The tolerance allowed in accuracy between calibrations of a device or group of devices. The as-found tolerance establishes the limit of error the defined device can have and still be considered functional, beyond which additional evaluation may be required.

As-Left: The condition in which a channel, or portion of a channel, is left after calibration or a surveillance check.

As-Left Tolerance: The tolerance that establishes the required accuracy band that a device or group of devices must be calibrated to and remain within to avoid recalibration when periodically tested. If an instrument is found to be within the as-left tolerance, no further calibration is required for the instrument and calculations should assume that an instrument might be left anywhere within this tolerance.

Bias: An uncertainty component that consistently has the same algebraic sign and is expressed as an estimated limit of error. Bias is defined in ISA–RP67.04.02–2000. Bias terms are the fixed or systematic uncertainty components within a measurement and are not generally eligible for square root of the sum of the squares combinations. Sometimes they can be removed, in which case they are not accounted for in the uncertainty calculation since they can be compensated for in the scaling of the instrumentation. Any bias effects that cannot be calibrated out are accounted for in the uncertainty calculation.

Bistable: A device that changes state when it reaches a preselected signal value.

Channel Uncertainty: The total uncertainty at a designated point in the channel. The channel uncertainty can be calculated for any point in a channel from module '1' to module 'n', as needed. Depending on the loop configuration, this uncertainty could apply to actuation or indication.

Control Loop: A group of interconnected instruments that measures the process variable, compares that value to a predetermined desired value, and applies to the process variable any change necessary to make the process value match the desired value.

Drift: An undesired change in output over a period of time where change is unrelated to the input, environment, or load (ANSI/ISA–S67.04.01–2000).

External Pressurization Effects: The error of a specific instrument that is associated with ambient pressure variation.

Harsh Environment: The environment in any plant area that is considered to be harsh as a result of postulated accidents if the temperature, pressure, relativity humidity, or radiation significantly increase above the normal conditions.

Humidity Effect: The change in instrument output for a constant input when exposed to varying levels of ambient humidity.

Hysteresis: The difference between upscale and downscale results in instrument response when subjected to the same input approached from the opposite direction.

Independent: Independent events, in statistics, are those in which the probability of all occurring at once is the same as the product of the probabilities of each occurring separately. The uncertainty components are independent of each other if their magnitudes or algebraic signs are not significantly correlated. In setpoint determination, independent uncertainties are those for which the sign or magnitude of one uncertainty does not affect the sign or magnitude of any other uncertainty.

Indicator Reading Uncertainty: The uncertainty associated with reading an indicator (or recorder) due to resolution and parallax distortion error. Typically, this is applied to analog indicators. For equipment that has a digital display or readout, this error is usually considered to be negligible.

Instrument Channel: An arrangement of components and modules required to generate a single protective action or indication signal when required by a generating plant condition. A channel loses its identity where single protective action signals are combined.

Insulation Resistance Effect: The change in signal caused by a low insulation resistance of an interconnecting device or cable. The insulation resistance effect accounts for biases imposed in a loop due an increase in leakage current between the conductors of instrument signal transmission components such as signal cables, connectors, splices, terminal block, containment penetration, etc. The increased leakage is caused by the decrease of component insulation resistance due to extreme changes in environmental (e.g., elevated temperature and humidity) conditions and is treated as bias. Leakage currents are negligibly small under normal, non-accident conditions. Therefore, the insulation resistance effect is only considered credible during an accident environment. This term is used only in determining instrument channel uncertainty under high-energy line break or loss-of-coolant accident conditions. Additional guidance is provided in ISA-RP67.04.02-2000 for determination of insulation resistance.

Limiting Safety System Setting: The same as allowable value. Limiting safety system settings for nuclear reactors are settings for automatic protective devices related to those variables having significant safety functions (ANSI/ISA–S67.04.01–2000). Where a limiting safety system setting is specified for a variable on which a safety limit has been placed, the setting must be so chosen that automatic protective action will correct the abnormal situation before a safety limit is exceeded. The limiting safety system settings are values defined in the plant Technical Specifications, which determine equipment operability.

Limiting Trip Setpoint: The limiting trip setpoint is the limiting setting for the channel trip setpoint considering all credible instrument errors associated with the instrument channel such that a trip or actuation will occur before the analytical limit is reached, regardless of the process or environmental conditions affecting the instrumentation.

Margin: An additional allowance added to the instrument channel uncertainty to allow for unknown uncertainty components. The addition of margin moves the setpoint further away (more conservative) from the analytical limit or nominal process limits. This is a discretionary value added to protect the analytical limit, prevent spurious trips, or both, or other reason to add conservatism to the calculation.

Measurement and Test Equipment Uncertainty: Uncertainties of the measurement and test equipment used during the calibration of a device or multiple devices in an instrument loop.

Mild Environment: An environment that is never more severe than the expected environment during normal plant operation, including anticipated operational occurrences.

Module: Any assembly of interconnecting components that constitutes an identifiable device, instrument or piece of equipment. A module can be removed as a unit and replaced with a spare. It has definable performance characteristics that permit it to be tested as a unit. A module can be a card, a draw-out circuit breaker or other subassembly or a larger device, provided it meets the requirements of this definition.

Module Uncertainty: The total uncertainty attributable to each module that makes up the loop from module ‘1’ through module ‘n’. This uncertainty consists of both random and non-random (bias) terms.

Normal Process Limit: The high or low limit, beyond which the normal process parameter should not vary. Trip setpoints associated with safety-related functions not having analytical limits established in the accident analysis and non-safety related functions might be based on the normal process limit.

Normal Operation Lower Limit: The minimum value the process parameters may attain during normal operation that will not result in occurrence of an alarm, protective trip or abnormal plant condition.

Normal Operation Upper Limit: The maximum value the process parameters may attain during normal operation that will not result in occurrence of an alarm, protective trip or abnormal plant condition.

Operating Margin: The allowance between the trip setpoint and the normal operation upper or lower limit that is determined necessary to avoid inadvertent trips from process noise, normal transients and normal measurement uncertainties. The operating margin encompasses the range of operating conditions to which a device may be subjected without impairment of designed operational characteristics.

Overpressure Effect: The effect of over ranging the pressure sensor of a transmitter.

Power Supply Effect: The uncertainty attributed to variations in normally expected power supply output voltage.

Primary Element Accuracy: The accuracy of the device installed in the process being measured. It is the measurement error of a primary element (excluding associated transmitter) that is in contact with a process resulting in some form of interaction (e.g., this parameter is generally limited to use in flow elements).

Process Measurement Effect: The uncertainty that accounts for variations in actual process conditions (not attributable to the measurement device) that influence the measurement, such as temperature stratification, density variations, pressure variations, etc.

Radiation Effect: The uncertainty attributed to radiation exposure. Most instruments (excluding post accident monitoring) are designed to perform their trip functions before harsh radiation conditions are established; however, the environmental data must be evaluated and it must be shown in the calculation that the radiation level for trip conditions is below the threshold for radiation induced error. It is a random error obtained from vendor's functional specifications or qualification data.

Random Variable: A variable whose value at a particular future instant cannot be predicted exactly, but can only be estimated by a probability distribution function.

Reference Accuracy: A number or quantity that defines the limit that errors will not exceed when the device is used under reference operating conditions. In this context, error represents the change or deviation from the ideal value. Reference accuracy includes, as a minimum, repeatability, hysteresis, and linearity.

Repeatability: The ability of an instrument to produce exactly the same result every time it is subjected to the same conditions.

Safety Limit: A limit on an important process variable that is necessary to reasonably protect the integrity of physical barriers that guard against the uncontrolled release of radioactivity.

Seismic Effect: The uncertainties caused by the vibration associated with an earthquake. This effect is only considered if the device must function after a seismic event and its value is based on instrument qualification data by the vendor. This is generally a random independent error.

Sensor: The portion of a channel that responds to changes in a process variable and converts the measured variable into an instrument signal (ANSI/ISA–S67.04.01–2006); for example, an electric or pneumatic output.

SRSS: Square root of the sum of the squares used to combine random uncertainties.

Static Pressure: The steady-state pressure applied to a device.

Static Pressure Effect: The change in instrument output for a constant input when measuring a differential pressure and simultaneously exposed to a static pressure.

Span: The algebraic difference between minimum and maximum range value of the instrument in service.

Temperature Effect: The change in instrument output for a constant input when exposed to different ambient temperatures.

Total Safety Margin: The algebraic sum of the uncertainties, normalized to the appropriate engineering units, resulting from the combination of two or more signals.

Trip Setpoint: The desired value of the measured variable at which an actuation occurs.

Uncertainty: The amount to which an instrument channel's output is in doubt (or allowance made therefore) due to possible errors, either random or systematic. The term is generally identified within a probability and confidence level (ANSI/ISA–S67.04.01–2006) and is generally identified in terms of a percentage of the span of the instrument.