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January 9, 2013 MPWR-LTR-12-00101

U.S. Nuclear Regulatory Commission (NRC)
ATTN: Document Control Desk
11555 Rockville Pike
Rockville, MD 20852-2738

Babcock & Wilcox mPower, Inc.
Docket Number-PROJ0776
Project Number-776

Subject: Submittal of Babcock and Wilcox mPower, Inc. (B&W mPower) Instrument Setpoint Methodology Topical Report R0003-08-002089-A, Revision 003

References:

1. Letter from Jeffrey A. Halfinger, et al (B&W Nuclear Energy, Inc.) to NRC, Submittal of Babcock & Wilcox Nuclear Energy, Inc. (B&W NE) Instrument Setpoint Methodology Topical Report (Report Number 08-002089-000), October 28, 2010

2. Letter from Jeffrey A. Halfinger (B&W Nuclear Energy, Inc.) to NRC, Submittal of Babcock & Wilcox Nuclear Energy, Inc. (B&W NE) Instrument Setpoint Methodology Topical Report Revision 1 (Report Number 08-002089-001), June 30, 2011

3. Email from Jan Mazza (NRC) to Jeffrey A. Halfinger et al (B&W mPower), Request for Additional Information Letter No. 4 for the Review of Babcock & Wilcox (B&W) mPower Reactor Project Instrument Setpoint Methodology Topical Report 08-002-2089 [sic] Revision 1 (TAC No. RN6113), December 22, 2011

4. Letter from Jeffrey A. Halfinger (B&W Nuclear Energy, Inc.) to NRC, Babcock & Wilcox Nuclear Energy, Inc. (B&W NE) Response to NRC Request for Additional Information, February 2, 2012

5. Letter from Jeffrey A. Halfinger (B&W Nuclear Energy, Inc.) to NRC, Babcock & Wilcox Nuclear Energy, Inc. (B&W NE) Revised Response to Request for Additional Information No. 6236, RAI Letter No. 4 for Appendices 5, 6. 9, 11 and 13, May 21, 2012

6. Letter from Michael E. Mayfield (NRC) to Jeffrey A. Halfinger (B&W mPower), Final Safety Evaluation for Babcock & Wilcox mPower, Inc. Topical Report TR0003-08-002089, Revision 3, "Instrument Setpoint Methodology Topical Report" (TAC No. RN6113), October 12, 2012

Topical Report (TR) 08-002089-000, Revision 0, Instrument Setpoint Methodology Topical Report, (Reference 1) was submitted for NRC review and approval by then B&W NE on October 28, 2010. The TR was subsequently revised on the basis of preliminary feedback from the NRC staff, and Revision 1 of the report was submitted on June 30, 2011 (Reference 2).

By email dated December 22, 2011 (Reference 3), the NRC forwarded Request for Additional Information (RAI) No. 6236 (RAI Letter No. 4) that contained thirteen questions. B&W mPower provided its response to the RAI in a letter dated February 2, 2012 (Reference 4) that included proposed clarifications and changes to the TR. In a conference call on March 3, 2012, the NRC requested clarifications to portions of the B&W mPower response, and B&W provided a revised RAI response by letter dated May 21, 2012 (Reference 5). That letter also forwarded Revision 3 of the TR that incorporated changes consistent with the revised RAI response.

By letter dated October 12, 2012 (Reference 6), the NRC issued its final safety evaluation for Revision 3 of TR0003-08-002089 documenting the staff conclusion that this version of the report adequately described the B&W mPower Instrument Setpoint Methodology, and that the methodology complied with the applicable NRC regulations and industry standards.

The NRC's October 12, 2012 letter also requested that B&W mPower publish the accepted version (Revision 3) of TR0003-08-002089 within three months of the receipt thereof. Accordingly, the enclosure to this letter provides the B&W mPower R0003-08-002089-A, Revision 003, "Instrument Setpoint Methodology Topical Report." This approved version of the TR incorporates the October 12, 2012 NRC letter and its enclosed final safety evaluation following the TR cover page (with the document number reflecting the report's approved status). The TR with the revised document number is included at the very end of the enclosure. The approved TR also provides historical review information including the letters to and from the NRC, the NRC's RAIs, and B&W mPower response to the RAIs (References 1 through 5). A table of contents following the cover page is provided to assist in locating the referenced historical documents.

Questions concerning this letter may be directed to Jeff Halfinger at 434-316-7507 (email: jahalfinger@babcock.com) or Peter Hastings at 980-365-2071 (email: pshastings@generationmpower.com).

Jeffrey A. Halfinger
VP, NSSS Technology
B&W mPower

JAH/jlr

Enclosure: Babcock and Wilcox mPower Instrument Setpoint Methodology Topical Report R0003-08-002089-A, Revision 003

cc: Joelle L. Starefos, NRC, TWFN 9-F-27
Stewart L. Magruder, Jr., NRC, TWFN 9-F-27

Document No:	Title:	Rev:
R0003-08-002089-A	**Instrument Setpoint Methodology Topical Report**	**003**

Instrument Setpoint Methodology Topical Report
R0003-08-002089-A

January 2013
Revision 003

B&W mPower™ Reactor Program
Babcock & Wilcox mPower, Inc.
109 Ramsey Place
Lynchburg, VA 24501

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Section A

October 12, 2012

Mr. Jeffrey A. Halfinger, Vice President
NSSS Technology Development
Babcock & Wilcox mPower, Inc.
109 Ramsey Place
Lynchburg, VA 24501

SUBJECT: FINAL SAFETY EVALUATION FOR BABCOCK & WILCOX MPOWER, INC. TOPICAL REPORT TR0003-08-002089, REVISION 3, "INSTRUMENT SETPOINT METHODOLOGY TOPICAL REPORT" (TAC NO. RN6113)

Dear Mr. Halfinger:

On October 28, 2010, Babcock & Wilcox Company (B&W) Nuclear Energy Inc. (predecessor of Babcock & Wilcox mPower, Inc.), submitted to the U.S Nuclear Regulatory Commission (NRC) Topical Report (TR) 08-002089, Revision 0, "Instrument Setpoint Methodology," for the Design Certification of the B&W mPower™ Reactor to the NRC staff for review (Agencywide Documents Access and Management System (ADAMS) Accession Number ML103020473). By letter dated June 30, 2011, B&W submitted Topical Report 08-002089-01, Revision 1, "Instrument Setpoint Methodology," for the Design Certification of the B&W mPower™ Reactor to the NRC staff for review (ADAMS Accession Numbers ML11182C034 and ML11182C035). By letters dated February 2, 2012 and May 21, 2012, B&W responded to the NRC staff requests for additional information, and transmitted Revision 3 of Topical Report 08-002089-003 (ADAMS Accession Numbers ML12037A001, ML12153A304, and ML12143A424). By letter dated August 15, 2012, an NRC draft safety evaluation (SE) regarding our approval of TR0003-08-002089, Revision 3, was provided for your comments on any factual errors or clarity concerns (ADAMS ML12222A058). By letter dated August 23, 2012, B&W commented on the staff draft SE (ADAMS ML12237A281). The NRC staff's disposition of the B&W mPower, Inc. comments on the draft SE are addressed in the final SE enclosed with this letter.

On the basis of its review, the NRC staff concludes that Revision 3 of the B&W mPower, Inc. Instrument Setpoint Methodology Topical Report (TR), as documented in the referenced letters, adequately describes the B&W mPower Inc. Instrument Setpoint Methodology. Accordingly, the NRC staff finds that the B&W mPower, Inc. Instrument Setpoint Methodology complies with the applicable NRC regulations and industry standards.

The enclosed SE defines the basis for acceptance of the TR. Our acceptance applies only to material provided and we do not intend to repeat our review of the acceptable material described in the TR. When the TR appears as a reference in regulatory applications, our review will ensure that the material presented applies to the specific application involved. Licensing requests that deviate from this TR will be subject to a plant- or site-specific review in accordance with applicable review standards.

In accordance with the guidance provided on the NRC website, we request that B&W mPower, Inc. publish the accepted version of this TR within 3 months of receipt of this letter. The accepted version shall incorporate this letter and the enclosed SE after the title page.

Also, the accepted version must contain historical review information, including NRC requests for additional information and your responses after the title page. The accepted versions shall include a "-A" (designating accepted) following the TR identification symbol.

As an alternative to including the requests for additional information (RAIs) and RAI responses behind the title page, if changes to the TR were provided to the NRC staff to support the resolution of RAI responses, and the NRC staff reviewed and approved those changes as described in the RAI responses, there are two ways that the accepted version can capture the RAIs:

1. The RAIs and RAI responses can be included as an Appendix to the accepted version.
2. The RAIs and RAI responses can be captured in the form of a table (inserted after the final SE) which summarizes the changes as shown in the approved version of the TR. The table should reference the specific RAIs and RAI responses which resulted in any changes, as shown in the accepted version of the TR.

If future changes to the NRC's regulatory requirements affect the acceptability of this TR, B&W mPower, Inc. and/or licensee's referencing it will be expected to revise the TR appropriately, or justify its continued applicability for subsequent referencing.

If you have any questions, please contact Jan Mazza at (301) 415-0498, email Jan.Mazza@nrc.gov, or Joelle Starefos at (301) 415-6091, email Joelle.Starefos@nrc.gov.

Sincerely,

/RA/

Michael E. Mayfield, Director
Division of Advanced Reactors and Rulemaking
Office of New Reactors

Project No.: 0776

Enclosure:
Final Safety Evaluation

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OFFICE	PM:NRO/DARR/APRB	PM:NRO/DARR/APRB	GE:NRO/DE/ICB	BC:NRO/DE/ICB
NAME	JMazza	JStarefos	JAshcraft	IJung
DATE	10/4/12	10/9/12	10/10/12	10/10/12
OFFICE	BC:NRO/DARR/APRB	OGC* (NLO)	D:NRO/DARR	
NAME	SMagruder	MLewis	MMayfield(JColaccino for)	
DATE	10/11/12	10/3/12	10/12/12	

FINAL SAFETY EVALUATION REPORT FOR BABCOCK & WILCOX MPOWER, INC.TOPICAL REPORT R0003-08-002089, REVISION 3, "INSTRUMENT SETPOINT METHODOLOGY TOPICAL REPORT" (TAC NO. RN6113)

PROJECT NO. 0776

1.0 INTRODUCTION AND BACKGROUND

On October 28, 2010, Babcock & Wilcox Company (B&W) Nuclear Energy Inc. (predecessor of Babcock & Wilcox mPower, Inc.), submitted to the Nuclear Regulatory Commission (NRC) Topical Report (TR) 08-002089, Revision 0, "Instrument Setpoint Methodology," for technical staff review (Reference 1). The NRC staff identified areas for further discussion and transmitted them to B&W (Reference 2). B&W resubmitted TR 08-002089, Revision 1 (Reference 3) for acceptance review and was accepted by the NRC (Reference 4). Revision 2 of TR 08-002089 was not submitted to the NRC.

The staff submitted "Request for Additional Information No. 6236 RAI Letter No. 4" dated December 22, 2011 (Reference 5). The B&W response to RAIs 07.01-C Appendix-1 through 13 was submitted and incorporated into TR R0003-08-002089, Revision 3, by letters dated February 2 (Reference 6) and May 21, 2012 (Reference 7).

B&W states that the B&W TR details the instrument setpoint methodology applied to the reactor protection system (RPS) setpoints and other important instrument setpoints associated with the B&W mPower™ reactor. The RPS is a digital, integrated reactor protection and engineered safety features actuation system implemented for the B&W mPower™ reactor. The methodology described in this topical report is used to establish technical specification setpoints for the B&W mPower™ RPS in accordance with 10 CFR 50.36.

The methodology described in this report is for the uncertainty analysis, setpoint determination, and determination of allowable values that protect analytical limits as applied to safety-related equipment that perform specific safety functions. 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; and/or
- Evaluation or justification of previously established setpoints.

Determination of instrument setpoints using this methodology for non-safety related equipment that does not perform a specific safety function as discussed above, is controlled administratively by plant procedures.

Enclosure

2.0 REGULATORY BASIS

The following regulatory requirements and guidance documents are applicable to the staff's review of the TR R0003-08-002089:

Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Appendix A, General Design Criterion (GDC) 13, "Instrumentation and Control," requires, in part, that instrumentation be provided to monitor variables and systems over their anticipated ranges for normal operation, for anticipated operational occurrences, and for accident conditions as appropriate to assure adequate safety, and that appropriate controls be provided to maintain these variables and systems within prescribed operating ranges.

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

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 50.36(c)(1)(ii)(A) requires, in part, that if a limiting safety system setting (LSSS) is specified for a variable on which a safety limit has been placed, the setting be chosen so 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. Additionally, 10 CFR 50.36(c)(1)(ii)(A) requires that a licensee take appropriate action if it is determined that the automatic safety system does not function as required.

10 CFR 50.36(c)(3), "Technical Specifications," states that surveillance requirements are requirements relating to test, calibration, or inspection to assure that the necessary quality of systems and components is maintained, that facility operation will be within safety limits, and that the limiting conditions for operation will be met.

10 CFR 50.55a(h), "Protection and Safety Systems," requires compliance with IEEE Std. 603-1991, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations," and the correction sheet dated January 30, 1995. Clause 6.8.1 of IEEE Std. 603-1991, requires that allowances for uncertainties between the analytical limit of the safety system and device setpoint be determined using a documented methodology.

3.0 RELEVENT GUIDANCE

Regulatory Guide (RG) 1.105, Revision 3, "Setpoints for Safety-Related Instrumentation," provides guidance for ensuring that instrument setpoints for safety-related instrumentation are initially - and remain - within the technical specification limits. This RG endorses ISA-S67.04-1994, Part I, "Setpoints for Nuclear Safety-Related Instrumentation," with clarifications.

ISA-S67.04-1994, Part II, "Methodology for the Determination of Setpoints for Nuclear Safety-Related Instrumentation," provides additional guidance, but RG 1.105, Revision 3, does not endorse or address Part II of ISA-S67.04-1994.

In NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Report for Nuclear Power Plants: Light Water Edition," (SRP) section entitled, Branch Technical Position (BTP) 7-12, "Guidance on Establishing and Maintaining Instrument Setpoints," Revision 5, March 2007, there are guidelines for reviewing the process an applicant/licensee follows to establish and maintain instrument setpoints.

NRC Regulatory Issue Summary (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," discusses issues that could occur during testing of LSSSs and which therefore, may have an adverse effect on equipment operability.

Generic Letter (GL) 91-04, Enclosure 1, "Guidance on Preparation of a License Amendment Request for Changes in Surveillance Intervals to Accommodate a 24-Month Fuel Cycle," provides guidance on issues that should be addressed by the setpoint analysis when calibration intervals are extended from an 18-month or other refueling outage interval to 24 months.

The objectives of the review of TR R0003-08-002089 are to (1) verify that setpoint calculation methods are adequate to assure that protective actions are initiated before the associated plant process parameters exceed their analytical limits, (2) verify that setpoint calculation methods are adequate to assure that control and monitoring setpoints are consistent with their requirements, and (3) confirm that the established calibration intervals and methods are consistent with safety analysis assumptions. The staff evaluated the setpoint methodology using SRP BTP 7-12 to verify conformance with the previously cited regulatory bases and standards for instrument setpoints with emphasis on the following:

1. Relationships between the safety limit, the analytical limit, the limiting trip setpoint, the allowable value, the setpoint, the acceptable as-found band, the acceptable as-left band, and the setting tolerance.

2. Setpoint technical specifications meeting the requirements of 10 CFR 50.36. Additional information related to setpoint technical specifications is provided in RIS 2006-17.

3. Basis for selection of the trip setpoint.

4. Uncertainty terms that are addressed.

5. Method used to combine uncertainty terms.
6. Justification of statistical combination.
7. Relationship between instrument and process measurement units.
8. Data used to select the trip setpoint, including the source of the data.
9. Assumptions used to select the trip setpoint (e.g., ambient temperature limits for equipment calibration and operation, potential for harsh accident environment).
10. Instrument installation details and bias values that could affect the setpoint.
11. Correction factors used to determine the setpoint (e.g., pressure compensation to account for elevation difference between the trip measurement point and the sensor physical location).

Instrument test, calibration or vendor data, as-found and as-left; each instrument should be demonstrated to have random drift by empirical and field data. Evaluation results should be reflected appropriately in the uncertainty terms, including the setpoint methodology.

4.0 TECHNICAL EVALUATION

The establishment of setpoints and the relationships between nominal trip setpoints (NTSPs), limiting trip setpoints (LTSPs), allowable value (AV), as-left values, as-found values, as-left tolerance (ALT), as-found tolerance (AFT), analytical limit (AL), and safety limit (SL) are discussed in this report. A thorough understanding of these terms is important in order to properly utilize the total instrument channel uncertainty in the establishment of setpoints.

The SLs are chosen to protect the integrity of physical barriers that guard against the uncontrolled release of radioactivity. The SLs are typically provided in the plant safety analyses. The AL is established to ensure that the SL is not exceeded. The ALs are developed from event analyses models that consider parameters such as process delays, rod insertion times, reactivity changes, analysis margin, transient response, modeling error, instrument response times, etc. and are provided in Chapter 15, "Transient and Accident Analysis," of the design control document (DCD) of the application. A properly established setpoint initiates a plant protective action before the process parameter exceeds its AL. This, in turn, assures that the transient will be avoided and/or terminated before the process parameters exceed the established SLs.

This TR is based on following the requirements of RG 1.105, Revision 3, which describes a method acceptable to the NRC for complying with the applicable regulations. The TR follows ANSI/ISA-67.04.01-2000 (Reference 8) rather than ISA-S67.04-1994, Part I as endorsed by RG 1.105, Revision 3. The use of ANSI/ISA-67.04.01-2000 proposed by the TR is acceptable in lieu of ISA-S67.04-1994, Part I because ANSI/ISA-67.04.01-2000, Section 2, states, "ANSI/ISA RP67.04.02-2000 is equivalent to ISA-S67.04-1994." This TR also follows the guidance listed in recommended practice ANSI/ISA-67.04.02-2000.

In the B&W methodology, the AL is established to ensure that a trip occurs before the SL is reached. The purpose of an LSSS is to assure that a protective action is initiated before the process conditions reach the AL. Trip setpoints are chosen based on the LSSS and to minimize spurious trips close to the normal operating point of the process. Figure 5.1 of the TR shown below provides a pictorial representation of the B&W setpoint methodology relationships.

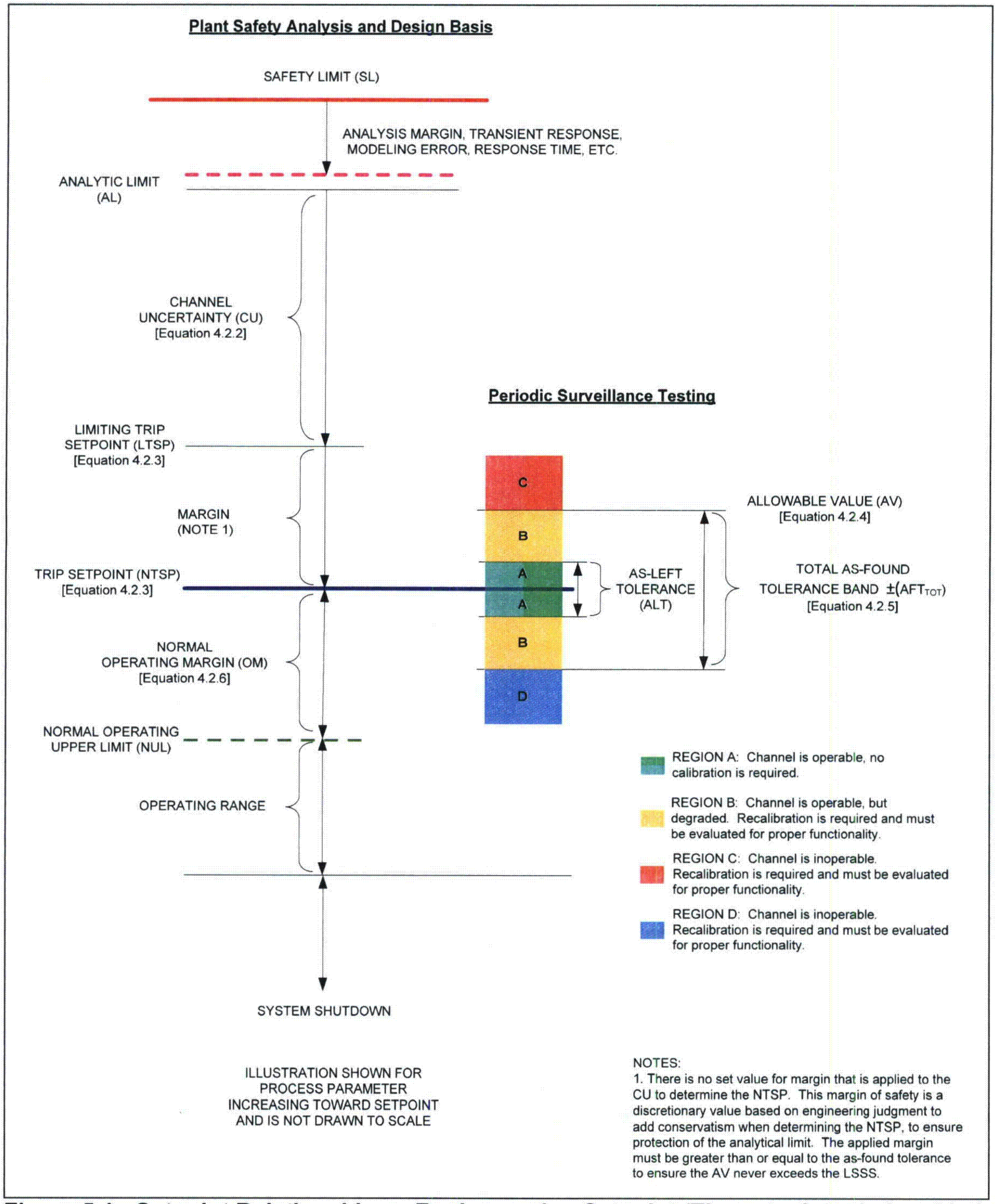

Figure 5.1: Setpoint Relationships – For Increasing Setpoint (The setpoint relationship is similar for decreasing setpoints, except that the process is decreasing towards the setpoint and AL).

-6-

Note: This figure is intended to provide relative position and not to imply direction. Sections 4.1.5 and 4.2.3, of the TR defines LTSP as an LSSS and also defines NTSP as the desired value of the measured variable at which an actuation occurs. The calculation of the LTSP value is set forth in Section 4.2.3 of the TR as LTSP = AL+/- CU, where CU is the total channel uncertainty. Note 1 on Figure 5.1 of the TR defines AV such that it will never exceed the LTSP (LSSS) and in most cases should be more conservative than the LTSP. The calculation of the AV is set forth in Section 4.2.4 of TR as AV = NTSP +/- AFTTOT where AFTTOT is the total AFT for the entire instrument channel. The NTSP includes additional margin such that it is more conservative than the LTSP. In Section 4.2.5 of TR defines the AFT and ALT as double sided bands around the NTSP. The applicant states that at a minimum the AFT includes reference accuracy, drift, and ALT uncertainties. The ALT is based on accuracy of the channel calibration. The staff finds that this approach is consistent with RG 1.105, Revision 3 and ANSI/ISA-67.04.01-2000.

Based on the discussion, sample calculations, and figures presented in the TR, the staff finds that the B&W setpoint methodology demonstrates that the correct relationships between the SL, AL, AV, NTSP, LTSP, AFT, and ALT will be ensured, that the basis for the trip setpoint is correct, and that the requirements of GDC 13 and 20 are met.

NRC RIS 2006-17 detailed a concern with verification of operability using only AV or a one-sided approach during periodic testing (channel operational test, calibration test). To address this concern the B&W mPower™ setpoint methodology uses double-sided acceptance criteria bands. Figure 5.1 (above) and Table 4.2 (below) of the TR describe how the operability of the instrument loop is evaluated. Exceeding the AFT in either the high or low direction may indicate degraded performance and inability of the instrument channel to meet its intended function.

Another concern detailed in RIS 2006-17 is that 10 CFR 50.36(c)(1)(ii)(A) includes requirements for a general class of LSSSs related to variables having significant safety functions but which do not protect SLs. All operating plant licenses have TSs for LSSSs that are not related to SLs. For these LSSSs, 10 CFR 50.36(c)(1)(ii)(A) requires that a licensee take appropriate action if it is determined that the automatic safety system does not function as required. To address this concern the B&W mPower™ setpoint methodology uses double-sided acceptance criteria bands. For this reason, the staff finds that the B&W setpoint methodology addresses the concerns noted in RIS 2006-17 and is consistent with the requirements of 10 CFR 50.36.

Table 4.2: Instrument Operability During Periodic Surveillance Testing

As-found NTSP During Surveillance Testing	Status of Channel Operability and Required Actions
As-found NTSP within ALT (Region A of Figure 5.1)	Channel is operable, no action required. The results are tracked by plant procedures for historical trending.
As-found NTSP outside of ALT band, but within AFT band (Region B of Figure 5.1)	Channel is operable, recalibration is necessary to restore the NTSP within the ALT.
<u>Increasing process:</u> As-found NTSP is conservative with respect to the AV (NTSP < AV) but outside AFT band (Region D of Figure 5.1); or <u>Decreasing process:</u> As-found NTSP is conservative with respect to the AV (NTSP > AV) but outside AFT band.	Channel is inoperable. Recalibration is necessary to restore the NTSP within the ALT, and evaluation of channel functionality is required.
As-found NTSP non-conservative to the AV (Region C of Figure 5.1)	Channel is inoperable. Recalibration is necessary to restore NTSP within the ALT, and evaluation of channel functionality is required to return channel to an operable status.

The B&W setpoint methodology allows for a minimum set of assumptions to be used (refer to Section 3.5 of the TR). This minimum set of assumptions will yield conservative uncertainties used in the calculations and less chance of error during calibration of instrument channels, which the staff finds reasonable and acceptable. Following the setpoint calculation flow depicted in Figure 4.1of the TR, the pertinent information required to be documented for each calculation is collected in a typical data sheet as shown in Table 4.1 of the TR. 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. Table 4.1 of the TR includes a list of uncertainties that must be considered for inclusion in the total channel uncertainty (CU) calculation.

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 that there is reasonable assurance that the plant protection system instrumentation is functioning as expected between the surveillance intervals. Plant-specific procedures will include required methods to evaluate the historical performance of the drift for each instrument channel and confirm that the surveillance and calibration intervals do not exceed the assumptions in the plant safety analysis. The guidance contained in GL 91-04 is used to evaluate and determine the acceptable surveillance and calibration intervals for each instrument channel as needed. For these reasons the staff finds that the B&W setpoint methodology conforms to ANSI/ISA-67.04.01-2000 and RG 1.105, Revision 3 with respect to assumptions and data used to determine the uncertainties and select the trip setpoint.

The B&W setpoint methodology combines the uncertainty of the instrument loop components to determine the CU for the functions of the reactor protection system and other important instrument setpoints. All appropriate and applicable uncertainties are considered for each reactor protection system and other important instrument setpoint functions. Section 4.1.3.1 of the TR lists elements of uncertainty that are considered typical, but not inclusive, and the list is consistent with ANSI/ISA-67.04.01-2000. Other considerations that contribute to the uncertainty, such as environmental conditions and installation details of the components are also factored into the CU. For these reasons, the staff finds that the B&W setpoint methodology conforms to ANSI/ISA-67.04.01-2000 and RG 1.105, Revision 3 with respect to uncertainty terms, bias values, and correction factors used to select the trip setpoint.

The CU values are established at a 95 percent probability and a 95 percent confidence level, using a 2 sigma Gaussian distribution which is consistent with RG 1.105, Revision 3. The CU calculation is based on the following:

I. Random, independent uncertainties are eligible for the square-root-sum-of-squares method (SRSS) combination propagated from the process measurement module through the signal conditioning module of the instrument channel to the device that initiates the actuation. Refer to Sections 3.3 and 3.3.1 of the TR.

II. Dependent uncertainties are combined algebraically to create a larger independent uncertainty that is eligible for SRSS combination. Refer to Section 3.3.2 of the TR.

III. Non-random, bias and abnormally distributed uncertainties are those that consistently have the same algebraic sign. 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 to the CU of interest (negative bias for increasing setpoints and positive bias for decreasing setpoint) as shown in the equations in Sections 4.2.2 and 4.2.3 of the TR. These are classified as bias with an unknown sign. Refer to Sections 3.4.1 and 3.4.2 of the TR.

The staff finds that the described method of statistical combination of uncertainties conforms to ANSI/ISA-67.04.01-2000 and to RG 1.105, Revision 3.

The equations for determining module and channel uncertainty, and trip setpoint shown in Sections 4.2.1, 4.2.2, and 4.2.3 conform to ANSI/ISA-67.04.01-2000 and to RG 1.105, Revision 3.

All NRC RAIs and acceptance review comments have been resolved (References 2 through 7) and incorporated into TR R0003-08-002089, Revision 3. There are no RAI open items.

Based on the discussion above, the staff finds that TR R0003-08-002089, Revision 3 follows the guidance of RG 1.105, Revision 3, RIS 2006-17, GL 94-01, and ANSI/ISA-67.04.01-2000 with respect to setpoint methodology and therefore complies with the NRC regulations for ensuring that setpoints for safety-related instruments are initially within and remain within the technical specification limits.

5.0 CONCLUSION

The staff has reviewed the B&W mPower™ Instrument Setpoint Methodology Topical Report (Reference 7) and found that (1) the setpoint calculation methods are adequate to assure that protective actions are initiated before the associated plant process parameters exceed their analytical limits, (2) the setpoint calculation methods are adequate to assure that control and monitoring setpoints are consistent with their requirements, and (3) the established calibration intervals and methods are consistent with safety analysis assumptions. Therefore, the staff concludes that the proposed TR R0003-08-002089, Revision 3, is an acceptable setpoint methodology that satisfies the requirements of 10 CFR Part 50, Appendix A, GDC 13 and 20, of 10 CFR Part 50, Appendix B, Criterion XI, of 10 CFR 50.36(c)(1)(ii)(A) and 10 CFR 50.36 (c)(3), and of 10 CFR 50.55a(h), which requires compliance with IEEE Std. 603-1991.

If this TR is referenced in a design certification application under 10 CFR Part 52, the application must include ITAAC for the plant-specific setpoint analysis, which details the procedures for establishing the setpoints including the margins and their location. Prior to initial fuel load, a reconciliation of the setpoint analysis and setpoint program against the final design for each plant must be performed, as required by the ITAAC. The staff will review the proposed ITAAC during the design certification review.

6.0 REFERENCES

1. B&W letter BW-JAH-2010-230, dated October 28, 2010, (ML103020473) B&W submitted, for U.S. Nuclear Regulatory Commission (NRC) staff review, TR 08-002089, Revision 0, "Instrument Setpoint Methodology."

2. NRC Request for the Review of Babcock & Wilcox Company TR 08-002089-000, Revision 0, "Instrument Setpoint Methodology, October 2010," dated April 7, 2011 (ML110900508).

3. B&W letter BW-JAH-2011-253, dated June 30, 2011, (ML11182C034) B&W submitted, for U.S. Nuclear Regulatory Commission (NRC) staff review, TR 08-002089, Revision 1, "Instrument Setpoint Methodology" (ML11182C035).

4. NRC Acceptance for Review of Babcock & Wilcox Company TR 08-002089-001, Revision 1, "Instrument Setpoint Methodology Topical Report," dated August 24, 2011 (ML112351116).

5. Request for Additional Information 6236 RAI Letter No. 4, dated December, 22, 2011, for the review of B&W mPower Reactor Project Instrument Setpoint Methodology Topical Report 08-002089 Revision 1 (ML11357A141).

6. B&W letter BW-JAH-2012-277, dated February 2, 2012, "Babcock & Wilcox Nuclear Energy, Inc. (B&W NE) Response to NRC Request for Additional Information" (ML12037A001)

7. B&W letter MPWR-LTR-12-00051, dated May 21, 2012, (ML12143A424) B&W submitted, for NRC staff review, TR R0003-08-002089, Revision 3, "Instrument Setpoint Methodology" (ML12153A304).

8. ANSI/ISA--67.04.01-2000, "Setpoints for Nuclear Safety-Related Instrumentation," February 2000 (Equivalent to ANSI/ISA-S67.04-1994, Part 1).

Section B

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October 28, 2010 BW-JAH-2010-230

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

Babcock & Wilcox Nuclear Energy, Inc.
Docket Number-PROJ0776
Project Number-776

Subject: Submittal of Babcock & Wilcox Nuclear Energy, Inc. (B&W NE) Instrument Setpoint Methodology Topical Report (Report Number 08-002089-000)

In accordance with the B&W NE schedule for submittal of technical and topical reports as updated on July 22, 2010, we are providing the above referenced topical report for NRC review. This report is non-proprietary.

Questions concerning this submittal may be directed to Jeff Halfinger at 434-316-7507 (email: jahalfinger@babcock.com) or T. J. Kim at 434-382-9791 (email: tjkim@babcock.com).

Jeffrey A. Halfinger
VP, Technology Development
B&W NE

Robert E. McLaughlin
Director, Quality Assurance
B&W NE

T.J Kim
Licensing Director
B&W NE

JHA/jlr

cc: Joelle L. Starefos, NRC, TWFN 9-F-27
Stewart L. Magruder, Jr., NRC, TWFN 9-F-27

D104
NRD

Section C

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June 30, 2011 BW-JAH-2011-253

U.S. Nuclear Regulatory Commission (NRC)
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Babcock & Wilcox Nuclear Energy, Inc.
Docket Number-PROJ0776
Project Number-776

Subject: Submittal of Babcock & Wilcox Nuclear Energy Inc. (B&W NE) Instrument Setpoint Methodology Topical Report Revision 1 (Report Number 08-002089-001)

On October 28, 2010, B&W NE submitted to NRC Revision 0 of the above referenced topical report for technical staff review as part of our pre-application effort. Enclosed is Revision 1 of the referenced report for review. We have revised the report based on preliminary feedback from the NRC staff. Accordingly, limited portions of this report have been modified to:

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 use of a "graded approach",
5. clarify the relationships between design and safety analysis methods and methods applied during surveillance and calibration (Figure 5.1),
6. clarify that as-found tolerance is derived from the NTSP to establish the allowable value,(Figure 5.1), and
7. clarify that the allowable value is the limiting safety system setting (LSSS) in Figure 5.1.

Questions concerning this submittal may be directed to Jeff Halfinger at 434-316-7507 (email: jahalfinger@babcock.com) or T. J. Kim at 434-382-9791 (email: tjkim@babcock.com).

Jeffrey A. Halfinger

VP, Technology Development
B&W NE

JAH/jlr

T007
NRR

babcock & wilcox nuclear energy, inc., *a Babcock & Wilcox company*

Enclosure: Babcock & Wilcox Nuclear Energy Inc. (B&W NE) Instrument Setpoint Methodology Topical Report Revision 1 (Report Number 08-002089-001)

cc: Joelle L. Starefos, NRC, TWFN 9-F-27
Stewart L. Magruder, Jr., NRC, TWFN 9-F-27

Section D

Mazza, Jan

From: Mazza, Jan
Sent: Thursday, December 22, 2011 4:51 PM
To: 'jahalfinger@babcock.com'; 'pshastings@generationmpower.com'; 'Poslusny, Chester'
Cc: Starefos, Joelle; Ashcraft, Joseph; Jung, Ian; Magruder, Stewart
Attachments: Request for Additional Information 6236 RAI Letter No. 4.pdf

December 22, 2011

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 4 FOR THE REVIEW OF BABCOCK & WILCOX (B&W) mPOWER REACTOR PROJECT INSTRUMENT SETPOINT METHODOLOGY TOPICAL REPORT 08-002-2089 REVISION 1 (TAC NO. RN6113)

Dear Mr. Halfinger:

By letter dated June 30, 2011, (ML11182C034) B&W submitted, for U.S. Nuclear Regulatory Commission (NRC) staff review, Topical Report (TR) 08-0022089, Revision 1, "Instrument Setpoint Methodology" (ML11182C035). The NRC staff is performing a detailed review of this topical report to enable the staff to reach a conclusion on the safety of the proposed application. The NRC staff has identified that additional information is needed to continue portions of the review. The staff's request for additional information (RAI) is contained in the enclosure to this email.

Consistent with the NRC letter dated, August 24, 2011(ML112351116), to support the review schedule, you are requested to respond by February 2, 2012. If changes are needed to the topical report, the staff requests that a revision to TR 08-002-2089, "Instrument Setpoint Methodology," be submitted with the RAI responses.

If you have any questions or comments concerning this matter, you may contact me at 301-415-6091.

Sincerely,

/RA/

Jan Mazza, Project Manager
Projects Branch
Division of Advanced Reactors and Rulemaking
Office of New Reactors

Docket No. PROJ0776
eRAI Tracking No. 6236

Email Attachment: Request for Additional Information 6236 RAI Letter No. 4

OFFICE	NRO/DE/ICE	NRO/DE/ICE	NRO/DARR/APRB	NRO/DARR/APRB
NAME	*JAshcraft	*IJunge	*JMazza	JStarefos
DATE	12/21/2011	12/21/2011	12/22/2011	12/ 22 /2011

*Approval captured electronically in the electronic RAI system.

Jan Mazza

Project Manager, Projects Branch
Division of Advanced Reactors and Rulemaking
NRC Office of New Reactors
301-415-0498
Jan.Mazza@nrc.gov

Request for Additional Information No. 6236
RAI Letter No. 4
12/22/2011

mPower Pre-Application Activities
Babcock and Wilcox
Docket No. PROJ 0776

SRP Section: 07.01-C Appendix - Guidance for Evaluation of Conformance to IEEE Std. 603
Application: Topical Report 08-002089 Instrument Setpoint Methodology
Acceptance Criteria: IEEE Std. 603 1991, Clause 6.8, RG 1.105-Rev.3, ISA-67.04-1994, Part I
Technical Branch: Instrumentation and Controls Branch (ICB)

07.01-C Appendix-1

Section 3.1 - On page 3, paragraph 6 states, "Recognizing that RG 1.105, Revision 3, was published in 1999, the B&W mPower instrument setpoint methodology follows the guidance provided by ANSI/ISAS67.04.01-2000 (Ref. 6.3.1), which is equivalent to ANSI/ISA S67.04-1994, Part I (now ANSI/ISAS67.04.01-2006)."
What is meant by "(now ANSI/ISAS67.04.01-2006)?" It is listed as reference 6.3.3, however, other than this statement, it is not mentioned anywhere else. Clarify whether the mPower setpoint methodology conforms to RG 1.105 Rev. 3 which endorses ANSI/ISA S67.04-1994. If the setpoint methodology does not meet RG 1.105 Rev. 3 then demonstrate how the methodology meets the Regulations.

07.01-C Appendix-2

Section 3.3.2 - Regarding the last sentence of 3.3.2, the staff requests the applicant to clarify whether after the uncertainties are algebraically summed, the SRSS would then be applied as discussed in the second paragraph of 4.1.4.

07.01-C Appendix-3

Section 3.5 - The first bullet in this section appears to conflict with Section 3.4.1 (both stated below). The staff requests the applicant explain this inconsistency.

3.4.1 Any bias effects that cannot be calibrated out are directly accounted for in the uncertainty calculation.
3.5 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.

07.01-C Appendix-4

Section 3.5 - In the paragraph titled, *Assumptions*, clarify the assumption for instrument calibration (last bullet) is valid for sensor locations that may be exposed to the environment during calibration.

07.01-C Appendix-5

Figure 4.1 - The setpoint steps at the bottom of the figure (below the step "Determine the Setpoint and Allowable Value"), deviate from ANSI/ISA 67.04.02 Figure 2. Explain how this meets the guidance in RG 1.105 Rev 3.

07.01-C Appendix-6

Section 4.1.3.1 - The last paragraph in this section lists the "elements of uncertainty for any module" and further specifies the definitions are provided in Appendix B. Two of the elements the "as-left tolerance specification" and "as-found specification" are not defined in Appendix B. The staff requests the applicant clarify the definitions of these elements.

07.01-C Appendix-7

Section 4.1.5 - The staff requests the applicant specify which equation applies to "Trip SetPoint".

07.01-C Appendix-8

Section 4.1.6 - The last half of the second paragraph states "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)..." This appears to conflict with Section 4.2.5 which states "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 staff requests that the applicant explain this apparent contradiction and/or to revise Section 4.1.6 or Section 4.2.5 to eliminate the conflict.
In addition, providing an explanation for the following four scenarios listed in the mPower Setpoint Methodology Topical Report in terms of calibration requirements, instrument operability, and channel operability is optional but would aid in additional clarification for the section.

- As-found is within as-left tolerance
- As-found is outside as-left tolerance but within as-found tolerance
- As-found is outside as-found tolerance but within AV
- As-found is above/below AV

07.01-C Appendix-9

Figure 5.1 - This figure shows Margin (Note 2) added to the setpoint calculation.
The staff requests that the applicant clarify the use of margin in the figure and revise the figure to reflect both the +/- of AFT, ALT, and the location of Margin (Note 2) in relationship to NTSP, AFT and AV (see below).

2

Sections 4.2.4, 4.2.5 and Figure 5.1:

- Section 4.2.4 - How is AFT^{TOT} calculated as a +/- value and shown on both sides of NTSP on Figure 5.1?
- Section 4.2.5 - How is AFTn calculated as a +/- value?
- Section 4.2.4 - Explain why the definition of Margin is different from Note 2 on Figure 5.1.
- Is Margin (Note 2) correctly shown on Figure 5.1? see bullet 1 above.
- What value of ALT would be used in Figure 5.1? (Refer to RG 1.105 Rev. 3 Figure 1, "E. Region of Calibration Tolerance")

07.01-C Appendix-10

Section 4.2.5 - The staff requests the applicant to explain how the mPower Setpoint Methodology conforms to BTP 7-12 or the corresponding regulations with regards to:

- Use of as found and as left data (sensors, SPs)
- How are AV, as-found and as-left values verified for a SP that is within a digital platform?

07.01-C Appendix-11

Appendix A Figure A.2 - The staff requests the applicant to respond to the following:

- Is margin correctly shown as 5.5 psig?
- Using example problem and Notes 1& 2 from Figure 5.1, what would AV, Margin 2 and AFT^{TOT} be if Margin 1 is 5.5 psig (allowed by note 1) versus 55 psig?

07.01-C Appendix-12

Appendix A Figure A.2 - The staff requests the applicant to respond to the following:

- Using AFT^{TOT} +/- 15.1 psig (-15.1 psig), what would be the operating margin (OM) as described in Section 4.2.6 in order to avoid potential spurious channel trips?
- Is the methodology described in 4.2.6 sufficient for all cases?

07.01-C Appendix-13

Figure 4.1 - The portion of the figure that shows the setpoint calculation for a harsh environment does not specify seismic effects as described in section 4.3.1.1 paragraph 2 and equation 4.2.1. Is seismic considered in figure 4.1 and if so how would this be

3

applied to the setpoint calculation for normal, seismic, and other postulated accident conditions, as applicable?

4

Section E

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February 2, 2012 BW-JAH-2012-277

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Babcock & Wilcox Nuclear Energy, Inc.
Docket Number-PROJ0776
Project Number-776

Subject: Babcock & Wilcox Nuclear Energy, Inc. (B&W NE) Response to NRC Request for Additional Information

Reference: 1. B&W NE Instrument Setpoint Methodology Topical Report 08-002089-001
2. Request for Additional Information Letter No.4 for the Review of Babcock & Wilcox (B&W) mPower Reactor Project Instrument Setpoint Methodology Topical Report 08-002-2089 [sic] Revision 1

On October 28, 2010, B&W NE submitted to the NRC Revision 0 of the above referenced topical report for technical staff review as part of our pre-application effort. Subsequently, on June 30, 2011, as a result of preliminary feedback from the NRC staff, B&W submitted Revision 1 to the Report (Ref 1).

On December 22, 2011, the NRC issued a Request for Additional Information (RAI) (Ref 2) containing thirteen (13) questions and a request that the responses to the questions and a revision to the Instrument Setpoint Methodology Topical Report, if needed, be submitted by February 2, 2012.

Enclosed is the set of B&W's responses to the RAI's questions which include proposed clarification to information provided in the topical report, and where appropriate, revised text, tables or figures to be incorporated into Revision 2 to B&W's Instrument Setpoint Methodology Topical Report 08-002089, pending satisfactory resolution of this RAI.

Questions concerning this submittal may be directed to Jeff Halfinger at 434-326-7507 (email: jahalfiner@babcock.com) or T.J. Kim at 434-382-9791 (email: tjkim@babcock.com).

Jeffrey A. Halfinger
VP, Technology Development
B&W NE

babcock & wilcox nuclear energy, inc., a *Babcock & Wilcox company*

JAH/jlr

Attachment: Setpoint Methodology Topical Report RAI Responses

cc: Joelle L. Starefos, NRC, TWFN 9-F-27
Stewart L. Magruder, Jr., NRC, TWFN 9-F-27

Babcock & Wilcox Nuclear Energy, Inc. Response to
Requests for Additional Information No. 6236
RAI Letter No. 4

B&W mPower Pre-Application Activities
Docket No. PROJ 0776
Topical Report 08-002089-001

Question 07.01-C Appendix-1
Section 3.1 *- On page 3, paragraph 6 states, "Recognizing that RG 1.105, Revision 3, was published in 1999, the B&W mPower instrument setpoint methodology follows the guidance provided by ANSI/ISAS67.04.01-2000 (Ref. 6.3.1), which is equivalent to ANSI/ISA S67.04-1994, Part I (now ANSI/ISAS67.04.01-2006)."*

What is meant by "(now ANSI/ISAS67.04.01-2006)?" It is listed as reference 6.3.3, however, other than this statement, it is not mentioned anywhere else. Clarify whether the mPower setpoint methodology conforms to RG 1.105 Rev. 3 which endorses ANSI/ISA S67.04-1994. If the setpoint methodology does not meet RG 1.105 Rev. 3 then demonstrate how the methodology meets the Regulations.

B&W NE Response

The intent of the cited reference was to demonstrate that the B&W Instrument Setpoint Methodology follows the guidance provided by ANSI/ISA S67.04.01-2000, which is equivalent to ISA-67.04-1994, Part I. The current version of this standard was issued as ANSI/ISA 67.04.01-2006.

The statement was intended to make note of the fact that since the issuance of ISA S67.04-1994 Part I, which is endorsed by RG 1.105, Revision 3, updated versions of the applicable standards have been issued. By incorporating the latest industry guidance contained in ANSI/ISA 67.04.01-2000 and ANSI/ISA 67.04.01-2006, the B&W Instrument Setpoint methodology also ensures that RG 1.105, Revision 3, and the issues identified in RIS 2006-17 are also addressed.

The reference to ANSI/ISAS67.04.01-2006 will be deleted (Ref. 6.3.3), and Section 3.1, paragraph 6 (page 3) will be revised as follows:

> 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, and to ensure the issues identified in RIS 2006-17 (Ref. 6.2.4) are addressed, 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 ISA 67.04-1994, Part I and ANSI/ISA-RP67.04.02-2000.

Question 07.01-C Appendix-2

***Section 3.3.2** - Regarding the last sentence of 3.3.2, the staff requests the applicant to clarify whether after the uncertainties are algebraically summed, the SRSS would then be applied as discussed in the second paragraph of 4.1.4.*

B&W NE Response

Section 3.3.2 contains information for the treatment of random uncertainties that are not independent (i.e., dependent uncertainties). In treating dependent uncertainties, the methodology conservatively combines these random, dependent uncertainties algebraically into a larger, more conservative independent uncertainty term which can then be combined using the SRSS method. This is consistent with the guidance presented in ISA-RP67.04.02-2000.Section 3.3.2 and 4.1.4 will be revised to clarify the treatment of dependent uncertainties.

A sentence will be added to the end of section 3.3.2 (pages 4-5) as shown with changes as highlighted in shaded text:

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. These combined dependent uncertainties are then treated as an additional independent random uncertainty, which can then be combined with other independent terms using the SRSS method in the overall uncertainty calculation.

A sentence will be added to section 4.1.4, paragraph 2 (page 14) as shown below in shaded text:

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 summed algebraically creating a new, larger independent uncertainty that are eligible for combination with other independent terms using the SRSS method described in this report.

<u>Question 07.01-C Appendix-3</u>
Section 3.5 *- The first bullet in this section appears to conflict with Section 3.4.1 (both stated below). The staff requests the applicant explain this inconsistency.*

> *3.4.1 Any bias effects that cannot be calibrated out are directly accounted for in the uncertainty calculation.*
>
> *3.5 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.*

<u>B&W NE Response</u>

B&W agrees with NRC's comment above.

For cases where the bias terms are known with respect to sign and magnitude, the bias effect can be accounted for directly in the instrument calibration procedure. The intent of the methodology was that in these cases, the bias term does not need to be included in the uncertainty calculation.

Therefore, the topical report will be revised to delete the first sentence of the first bullet of section 3.5 (page 5) and reads as follows:

- 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.

Question 07.01-C Appendix-4

Section 3.5 *- In the paragraph titled, Assumptions, clarify the assumption for instrument calibration (last bullet) is valid for sensor locations that may be exposed to the environment during calibration.*

B&W NE Response

To clarify how the temperatures of the instrumentation equipment are accounted for during calibration, the last bullet of section 3.5 (page 6) will be revised as shown below in shaded text:

- For the purposes of the setpoint analyses, the instrumentation is assumed to be calibrated based on the ambient conditions in which the instrumentation components are expected to operate and specified in the plant calibration procedures. The temperature effect (TE) for the instrumentation accounts for possible differences between the temperatures associated with the instrument calibration and the ambient conditions of the installed equipment and 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 (Ref. 6.3.2).

Question 07.01-C Appendix-5

Figure 4.1 *- The setpoint steps at the bottom of the figure (below the step "Determine the Setpoint and Allowable Value"), deviate from ANSI/ISA 67.04.02 Figure 2. Explain how this meets the guidance in RG 1.105 Rev 3.*

B&W NE Response

Figure 4.1 of the B&W Instrument Setpoint Methodology is similar to Figure 2 in ANSI/ISA 67.04.02-2000, slightly amplified to provide more prescriptive guidance for obtaining the trip setpoint (NTSP) from the analytical limit (AL) based upon either an increasing or decreasing direction of the process variable. The amplified portion of Figure 4.1 refers to section 4.2.3 for the mathematical equation to use for calculating of the trip setpoint and provides guidance on the use of the equations based upon the direction of the process variable.

The equation in section 4.2.3 for calculating the trip setpoint (NTSP) and limiting trip setpoint (LTSP) is shown below in its current form:

LTSP = AL ± CU

NTSP = AL ± (CU + Margin)

Therefore, when following the guidance illustrated in Figure 4.1, and applying the mathematical expressions from equation 4.2.3, for cases where the process signal increases towards the analytical limit, NTSP and LTSP calculated as follows:

LTSP = AL - CU	(increasing process)
NTSP = AL - (CU + Margin)	(increasing process)

For cases where the process signal increases towards the analytical limit, NTSP and LTSP calculated as follows:

LTSP = AL + CU	(decreasing process)
NTSP = AL + (CU + Margin)	(decreasing process)

To summarize these steps, <u>for an increasing process</u> the channel uncertainty (CU) is subtracted from the AL to obtain the LTSP, and the CU plus margin (if any) is subtracted from the AL to obtain the NTSP. <u>For a decreasing process</u>, the CU is added to the AL to obtain the LTSP, and the CU plus margin (if any) is added to the AL to obtain the NTSP. This is consistent with and identical to the methods described in section 7.2 of ISA/ANSI-67.04.02-2000.

These methods are consistent with the guidance in RG 1.105 for establishment of the LTSP as the LSSS. The LTSP is determined by subtracting the CU from the AL for an increasing process, and adding the CU to the AL for a decreasing process. To determine the NTSP, a value for safety margin may be added to the CU to add conservatism when establishing the trip setpoint. The CU is determined using accepted statistical methods. The AV is determined as the limiting value that the NTSP may have when tested periodically and ensure that both the AL and the SL are protected.

No changes to Figure 4.1 will be made; however, equation 4.2.3 (page 18) of the topical report will be slightly modified to more clearly show this mathematical relationship with changes as highlighted in shaded text:

4.2.3 Trip Setpoint

$LTSP = AL - CU$ (increasing process)
$LTSP = AL + CU$ (decreasing process)

$NTSP = AL - (CU + Margin)$ (increasing process)
$NTSP = AL + (CU + Margin)$ (decreasing process)

Question 07.01-C Appendix-6
Section 4.1.3.1 *- The last paragraph in this section lists the "elements of uncertainty for any module" and further specifies the definitions are provided in Appendix B. Two of the elements the "as-left tolerance specification" and "as-found specification" are not defined in Appendix B. The staff requests the applicant clarify the definitions of these elements.*

B&W NE Response

The list in section 4.1.3.1 lists the various elements of uncertainty for a module. The terms "as-left tolerance specification" and "as-found specification" should have matched the terms defined in Appendix B. B&W recognizes that the identified names for the terms in our report did not exactly match information included in Appendix B. Therefore, the list in paragraph 5 of section 4.1.3.1 (pages 13-14) will be revised to exactly match the defined terms provided in Appendix B as shown with changes highlighted in shaded text below.

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
- as-found tolerance
- propagation of uncertainty through modules

Question 07.01-C Appendix-7
***Section 4.1.5** - The staff requests the applicant specify which equation applies to "Trip SetPoint."*

B&W NE Response

B&W will revise the Instrument Setpoint Methodology topical report to explicitly identify the equations for the terms described in section 4.1.5. The following sentence will be added to the beginning of section 4.1.5 (page 14) as listed below:

4.1.5 Trip Setpoint

The nominal trip setpoint (NTSP) and limiting trip setpoint (LTSP) are calculated using equation 4.2.3.

Question 07.01-C Appendix-8

Section 4.1.6 *- The last half of the second paragraph states "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)..."*

This appears to conflict with Section 4.2.5 which states "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 staff requests that the applicant explain this apparent contradiction and/or to revise Section 4.1.6 or Section 4.2.5 to eliminate the conflict.

In addition, providing an explanation for the following four scenarios listed in the mPower Setpoint Methodology Topical Report in terms of calibration requirements, instrument operability, and channel operability is optional but would aid in additional clarification for the section.

- *As-found is within as-left tolerance*
- *As-found is outside as-left tolerance but within as-found tolerance*
- *As-found is outside as-found tolerance but within AV*
- *As-found is above/below AV*

B&W NE Response

To more clearly demonstrate the conditions during periodic surveillance testing that could occur, and the status of channel operability during periodic surveillance testing, the following revisions to the topical report will be made.

- Section 4.1.6 and 4.2.5 will be revised to clearly delineate the disposition of the as-found conditions during periodic surveillance testing.

- Revisions to Figure 5.1 (see response to Question 07.01-C Appendix-9) will be made to more clearly demonstrate the process of verifying channel function and operability during testing.

The following text will be revised in paragraph 2 in section 4.1.6 (pages 15-16) with changes highlighted in shaded text below:

> 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 is declared inoperable and an evaluation of acceptable channel functionality is performed. The channel is required to be calibrated to return the setpoint within the acceptable tolerance range. Plant-specific procedures will maintain and track the results of the periodic surveillance test procedures and the historical as-found and as-left data obtained during surveillance testing. These data will be evaluated to confirm the assumptions for instrument channel drift and uncertainty data remains valid.

The changes to section 4.2.5 include revisions to the first paragraph and additional information provided are shown below (pages 19-21) with changes highlighted in shaded text below:

The as-found tolerance (AFT) 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. AFT includes consideration at a minimum of reference accuracy (RA), drift (DR), and as-left tolerance (ALT) uncertainties. The as-left tolerance (ALT) is also referred to as "calibration tolerance" in ANSI/ISA-S67.04.01-2000 (Ref. 6.3.1) or "setting tolerance" in RIS 2006-17.

The ALT is specified as a double-sided band around the NTSP. Depending on the condition of the as-found values for the NTSP, plant specific procedures will direct the operability determination and requirements for channel calibration or maintenance. The ALT typically is based on the reference accuracy of the module being calibrated; however, depending on the particular instrument loop in question, the limitations of the calibration procedure or need to minimize maintenance time, the magnitude of the ALT may be specified as a smaller or larger value in the specific calibration procedure. In this case, if the ALT used in the procedure differs from the reference accuracy specified by the vendor, the ALT would be included as a separate, explicit term in the setpoint calculation. Thus, in the equation to determine AFT_n, the as-left term is included as a bounding method to account for cases where not all attributes of the reference accuracy may verified in the particular calibration procedure.

Determination of the AFT may also 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:

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

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 evaluated 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. In accordance with RG 1.105 (Ref. 6.2.1) and BTP 7-12, plant specific procedures are required to track, trend and maintain the results of periodic surveillance testing (i.e., the as-found and as-left values for sensors (as applicable) and modules associated with the instrument loop) for proper management of instrument uncertainties including drift.

Table 4.2 below, that will be added to the report, shows the various conditions to consider during surveillance testing of the instrumentation channel and are consistent with RIS 2006-17 (Ref. 6.2.4).

Table 4.2: Instrument Operability During Periodic Surveillance Testing

As-found NTSP During Surveillance Testing	Status of Channel Operability and Required Actions
As-found NTSP within ALT (Region A of Figure 5.1)	Channel is operable, no action required. The results are tracked by plant procedures for historical trending.
As-found NTSP outside of ALT band, but within AFT band (Region B of Figure 5.1)	Channel is operable, recalibration is necessary to restore the NTSP within the ALT.
Increasing process: As-found NTSP is conservative with respect to the AV (NTSP < AV) but outside AFT band (Region D of Figure 5.1); or Decreasing process: As-found NTSP is conservative with respect to the AV (NTSP > AV) but outside AFT band.	Recalibration is necessary to restore the NTSP within the ALT, and evaluation of channel functionality is required.
As-found NTSP non-conservative to the AV (Region C of Figure 5.1)	Recalibration is necessary to restore NTSP within the ALT, and evaluation of channel functionality is required to return channel to an operable status.

Question 07.01-C Appendix-9

Figure 5.1 *- This figure shows Margin (Note 2) added to the setpoint calculation. The staff requests that the applicant clarify the use of margin in the figure and revise the figure to reflect both the +/- of AFT, ALT, and the location of Margin (Note 2) in relationship to NTSP, AFT and AV (see below).*

Sections 4.2.4, 4.2.5 and Figure 5.1:

- *Section 4.2.4 - How is AFT^{TOT} calculated as a +/- value and shown on both sides of NTSP on Figure 5.1?*
- *Section 4.2.5 - How is AFTn calculated as a +/- value?*
- *Section 4.2.4 - Explain why the definition of Margin is different from Note 2 on Figure 5.1.*
- *Is Margin (Note 2) correctly shown on Figure 5.1? see bullet 1 above.*
- *What value of ALT would be used in Figure 5.1? (Refer to RG 1.105 Rev. 3 Figure 1, "E. Region of Calibration Tolerance")*

B&W NE Response

To clarify the relationship between Margin and NTSP, AFT and AV a number of changes will be made to Figure 5.1 and the text contained in Sections 4.2.4 and 4.2.5 of the topical report.

The as-found tolerance is used, when applied to the NTSP, to determine the allowable value for the instrument channel. The AV is the limiting value of an instrument's as-found trip setting during surveillance testing while still ensuring the AL and SL are protected. If the as-found value for the NTSP is non-conservative with respect to the AV, actions are required to restore the NTSP. Additionally, RIS 2006-17 raised concerns about conditions where the as-found NTSP may be more conservative than the AV, indicating that abnormally large changes in the trip setpoint have occurred which could be signs of the channel malfunctioning. Thus a concept of a double-sided acceptance criteria band for the measured trip setpoint during surveillance testing was introduced.

The determination of the AFT_{TOT} in section 4.2.4 (page 19) has been revised by removing the margin term in the determination of the AV, and includes the proper mathematical operator (±) to ensure the double-sided band is correctly applied as shown below with changes highlighted in shaded text:

4.2.4 Allowable Value

$AV = NTSP \pm AFT_{TOT}$

Where:

AV	=	Allowable value.
NTSP	=	Trip setpoint.
AFT_{TOT}	=	Total as-found tolerance for the entire instrument channel.

To protect against identification of potential masking of equipment degradation during periodic surveillance testing, no margin is included as part of the AV determination and the AFT_{TOT} is applied as a double-sided band around the NTSP.

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;

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

Where:

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

Figure 5.1 will be updated to properly illustrate the application of a double-sided band for the AFT_{TOT} as applied to the NTSP to ensure consistency with revisions to equation 4.2.4 described above. Additional revisions and enhancements to Figure 5.1 (page 24) include the following and the revised figure is shown below:

- Addition of a double-sided band for the ALT to aid in determination of channel operability and be consistent with Figure 1 in RG. 1.105.
- Illustration of regions of different conditions that may exist during periodic surveillance testing to clarify status of channel operability and required actions (if any).
- Removal of the margin applied to the AFT_{TOT} and its associated note (Note 2). (To protect against the potential for masking of equipment degradation during periodic surveillance testing.)

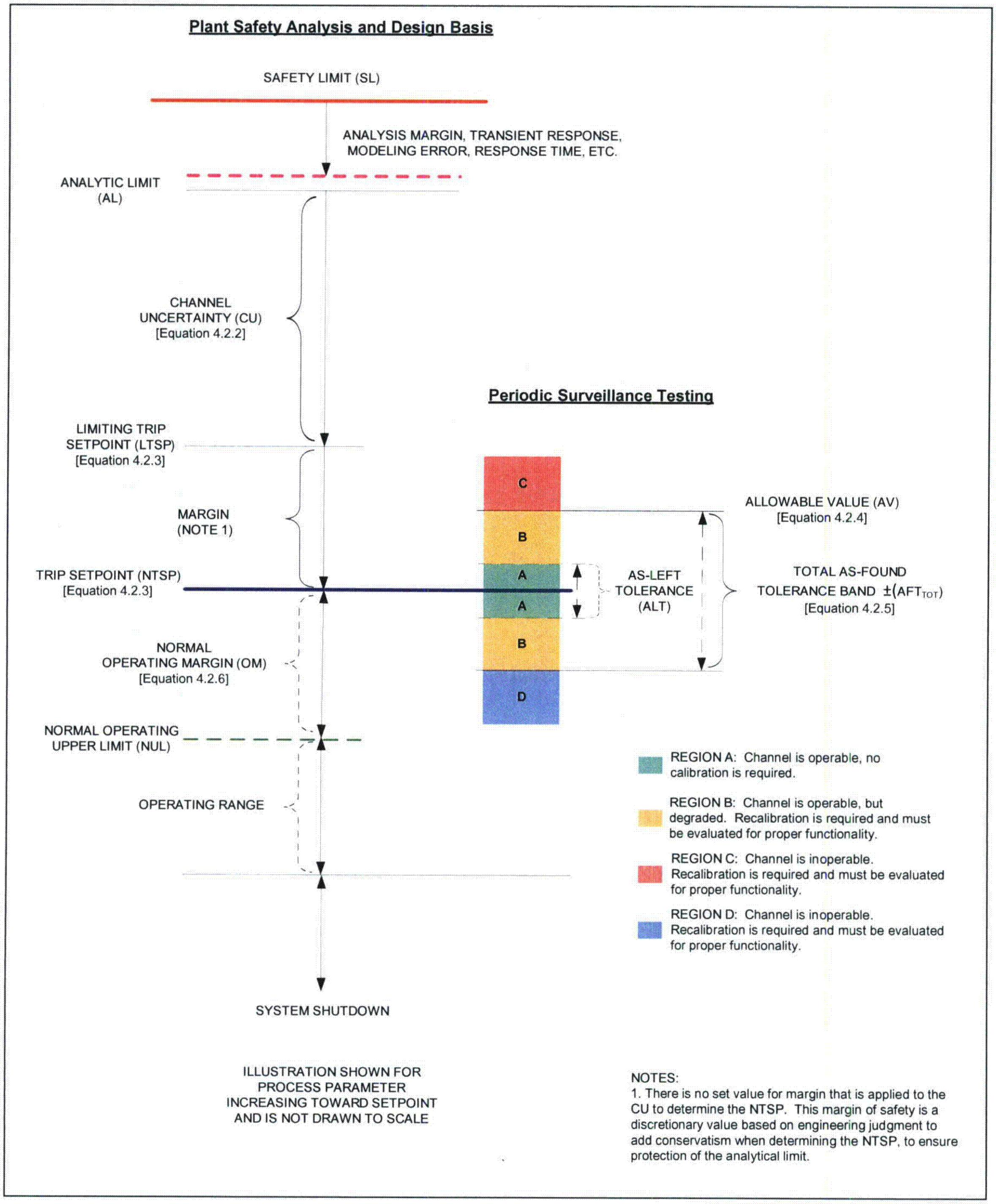

Figure 5.1: Setpoint Relationships – For Increasing Setpoint (Similar for decreasing setpoint, but process is decreasing towards the setpoint).

Question 07.01-C Appendix-10
Section 4.2.5 *- The staff requests the applicant to explain how the mPower Setpoint Methodology conforms to BTP 7-12 or the corresponding regulations with regards to:*

- *Use of as found and as left data (sensors, SPs)*
- *How are AV, as-found and as-left values verified for a SP that is within a digital platform?*

B&W NE Response

The review guidelines contained in BTP 7-12 contain numerous acceptance criteria and review procedures. Specifically, the review procedures contain guidance that the instrument setpoint methodology should include the basis for determination of the as-found and acceptable as-left bands and evaluation of the instrument operability based on acceptable as-found and acceptable as-left bands. Additionally, the methodology should contain measures for tracking and trending of historical as-found and as-left data to ensure each instrument channel exhibits random drift characteristics, and confirmation that the uncertainty data remains valid.

The basis for the acceptable as-found and as-left bands and operability determination method is presented in the B&W Instrument Setpoint Methodology. Please see the response to Questions 07.01-C Appendix-8 and 07.01-C Appendix-9 that addresses this question.

Plant-specific procedures will track the results of the periodic surveillance test procedures to trend and evaluate the as-found and as-left data to evaluate the instrument channel drift and uncertainty data. Section 4.2.5, paragraph 3 (page 20) and paragraph 5 (page 20) of the topical report will be revised to include requirements for these steps as shown below.

The following sentences will be added to section 4.2.5, paragraph 3 (page 20) with changes highlighted in shaded text below:

> In accordance with RG 1.105 (Ref. 6.2.1) and BTP 7-12, plant specific procedures are required to track, trend and maintain the results of periodic surveillance testing (i.e., the as-found and as-left values for sensors (as applicable) and modules associated with the instrument loop) for proper management of instrument uncertainties including drift.

The following sentences will be added to section 4.2.5, paragraph 5 (page 20) as shown in shaded text below:

> Plant-specific procedures will contain required methods to evaluate the historical performance of the drift for each instrument channel and confirm the surveillance and calibration intervals do not exceed the assumptions in the plant safety analysis. The guidance contained in Generic Letter 91-04 may be used to evaluate and determine the acceptable surveillance and calibration intervals for each instrument channel.

In channels using digital processing equipment, uncertainties are introduced by analog-to-digital (A/D) and digital-to-analog (D/A) conversions within the specific platform hardware. These uncertainties are typically provided by the platform manufacturer or determined through testing. Uncertainty data sources within the software are typically determined by the software designer and quantified. They can then be combined using the methods described in the topical report.

With most digital platforms, they are self-calibrating and errors due to drift or temperature are accounted in the reference accuracy determined by the platform manufacturer. Thus, the only applicable uncertainty is associated with the A/D conversion input into the microprocessor which also is typically combined into the reference accuracy. Generally, there is only one module associated with this conversion, thus combining uncertainties from multiple modules is not applicable. The NTSP is determined from the AL as described in section 4.2.3 of the topical report. Once the appropriate channel uncertainty has been determined based on the reference accuracy for the digital instrument channel, the AV, ALT, and AFT can be determined for use during surveillance testing following the methods described in the topical report.

Configuration control measures will be applied as part of the setpoint control program to maintain instrument setpoint databases for digital systems ensuring installed trip setpoints are installed and programmed as required. The online diagnostics of most digital platforms continually perform system checks and self-report errors or faults associated with digital channels.

During periodic surveillance testing, the test is a simple verification that the digital channel processes channel trips as determined by the digital signal processing within the AFT band. The results are evaluated and the operability determination steps are identical. However, typically, if the channel trip setpoint is found to be outside of the AFT band, this would indicate a failure with the digital channel and the faulty components will require replacement. There is typically no ability to re-calibrate the setpoint.

Question 07.01-C Appendix-11

Appendix A Figure A.2 *- The staff requests the applicant to respond to the following:*

- *Is margin correctly shown as 5.5 psig?*
- *Using example problem and Notes 1& 2 from Figure 5.1, what would AV, Margin 2 and AFT^{TOT} be if Margin 1 is 5.5 psig (allowed by note 1) versus 55 psig?*

B&W NE Response

Appendix A Figure A.2 contains a typographical error where the margin was incorrectly shown as 5.5 psig. The proper value for the margin as determined in this example is 5.0% of the span which is 55.0 psig.

Based on the revision to Figure 5.1 and section 4.2.4 discussed in response to Question 07.01-C Appendix-9, the relationship between the allowable value, as-found and as-left tolerances is more clearly understood. Figure A.2 has been revised to more clearly illustrate the relationships in the example between the AFT and ALT as shown below:

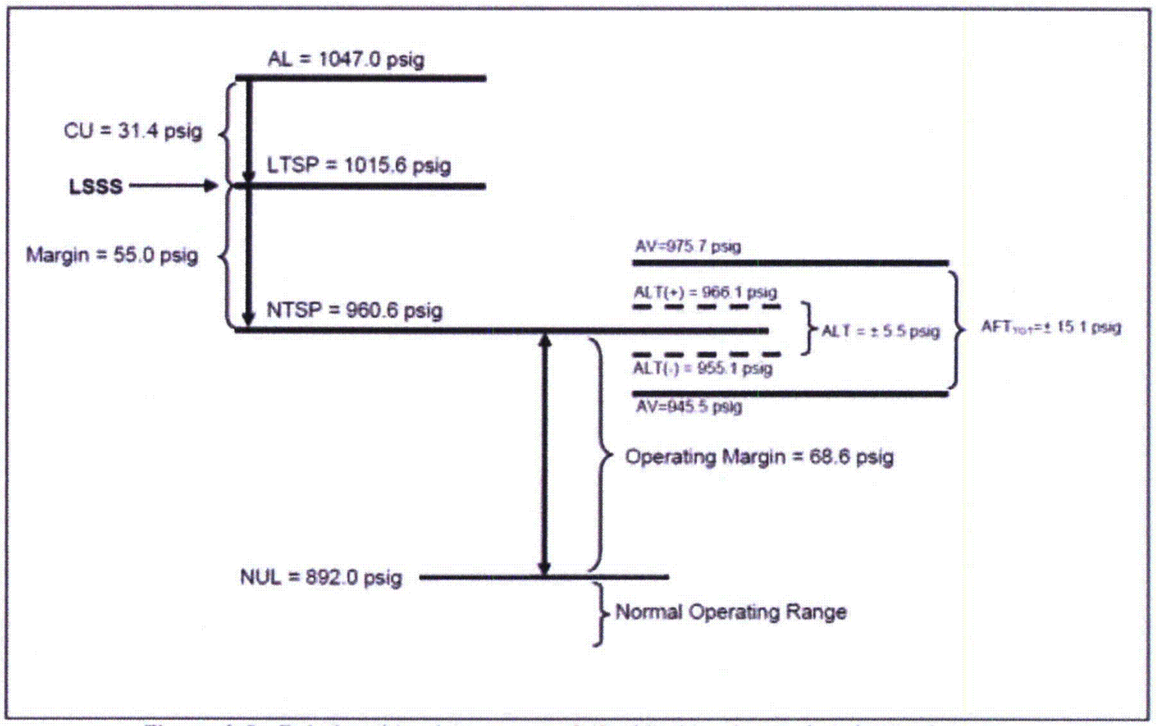

Figure A.2: Relationships between analytical limit and calculated setpoints

Question 07.01-C Appendix-12
Appendix A Figure A.2 *- The staff requests the applicant to respond to the following:*

- *Using AFT^{TOT} +/- 15.1 psig (-15.1 psig), what would be the operating margin (OM) as described in Section 4.2.6 in order to avoid potential spurious channel trips?*
- *Is the methodology described in 4.2.6 sufficient for all cases?*

B&W NE Response

Additional information was included in the example presented in Appendix A to specify the normal upper limit (NUL) is 892 psig. Therefore, when applying equation 4.2.6 for an increasing process the operating margin (OM) is calculated as follows:

OM = NTSP – NUL (increasing setpoint).

While this particular case is a simple example to demonstrate the application of the setpoint methodology, the methodology to determine the operating margin described in section 4.2.6 is sufficient and conforms with RG 1.105, revision 3 (Figure 1) that shows the operating margin is simply the difference between the normal operating range of the process variable and the NTSP. If, during worse cases the setpoint were to drift to the lower range of operability, the operating margin would be sufficient to minimize spurious channel trips.

This additional calculation will be added to the example in Appendix A, page A-4, with changes highlighted in shaded text below:

> The operating margin is calculated using equation 4.2.6 and ensures that sufficient operating margin exists to minimize and prevent spurious channel trips should the NTSP drift.
>
> OM = NTSP – NUL (increasing setpoint) = 960.6 psig – 892.0 psig = 68.6 psig.

Question 07.01-C Appendix-13

Figure 4.1 *- The portion of the figure that shows the setpoint calculation for a harsh environment does not specify seismic effects as described in section 4.3.1.1 paragraph 2 and equation 4.2.1. Is seismic considered in figure 4.1 and if so how would this be applied to the setpoint calculation for normal, seismic, and other postulated accident conditions, as applicable?*

B&W NE Response

The flow path presented in Figure 4.1(page 9) was provided for illustrative purposes to demonstrate how, for instrument channels in harsh environments, the additional evaluation of uncertainties is required. It was not intended to list all uncertainty contributions for instrument channels subject to harsh conditions during normal or postulated design basis accident conditions in this figure.

The method for treating channel uncertainties for portions of the instrument channel that are subject to harsh environments during normal, seismic and other postulated design basis accidents is included in the current text in section 4.1.3.1 (pages 13-14) in the topical report. The existing applicable portions of this section that explicitly include the uncertainties due to seismic effects are shown in the boxed sections below.

There are no changes to the topical report in response to this question.

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
- as-found tolerance
- propagation of uncertainty through modules

Section F

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May 21, 2012 MPWR-LTR-12-00051

U.S. Nuclear Regulatory Commission
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Babcock & Wilcox Nuclear Energy, Inc. (B&W NE)
Docket Number-PROJ0776
Project Number-776

Subject: Babcock & Wilcox Nuclear Energy (B&W NE) Revised Response to Request for Additional Information No.6236, RAI Letter No.4 for Appendices 5, 6, 9, 11 and 13.

References:
1. B&W NE Instrument Setpoint Methodology Topical Report 08-00289-001
2. Request for Additional Information Letter No.4 for the Review of Babcock & Wilcox (B&W) mPower Reactor Project Instrument Setpoint Methodology Topical Report 08-002-2089 [sic] Revision 1
3. B&W NE Response to NRC Request for Additional Information dated February 2, 2012 (BW-JAH-2012-277)

By letter dated June 30, 2011, B&W NE submitted, for U.S. Nuclear Regulatory Commission (NRC) staff review, Topical Report (TR) 08-0022089, Revision 1, (Reference 1 above). Subsequently, NRC issued a Request for Additional Information (RAI) on December 22, 2011 (Reference 2 above). On February 2, 2012, B&W NE submitted a response to the RAI, (Reference 3 above). Recently, in a conference call on March 3, 2012, the NRC staff requested that B&W NE provide additional clarification regarding our RAI response related to Appendices 5, 6, 9, 11 and 13. The requested clarification is provided in the enclosures as discussed below.

Enclosure 1 is the revised response to the referenced RAI that includes the proposed clarification and appropriate revision of TR information. Enclosure 2 is a markup of the original RAI response (Reference 3) provided to facilitate the NRC's review. In addition Enclosure 3 is the revised Instrument Setpoint Methodology Topical Report that incorporates changes consistent with the revised RAI response.

Questions concerning this submittal may be directed to Jeff Halfinger at 434-316-7507 (email: jahalfinger@babcock.com) or Peter Hastings at 704-625-4978 (email: pshastings@generationmpower.com).

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Enclosures:
1. B&W NE's revised response to RAI No. 6236 Appendices 5, 6, 9, 11 and 13
2. B&W NE's revised response to RAI No. 6236 Appendices 5, 6, 9, 11 and 13 (Markup)
3. Instrument Setpoint Methodology Topical Report, dated May 2012 (R0003-08-002089, Revision 003)

cc:
Joelle L. Starefos, NRC, TWFN 9-F-27
Joseph F. Williams, NRC, TWFN 6-E-4
Stewart L. Magruder, Jr., NRC, TWFN 9-F-27

Enclosure 1
B&W NE's revised response to the RAI No. 6236
Appendices 5, 6, 9, 11 and 13

Enclosure 1
Babcock & Wilcox Nuclear Energy, Inc. Revised Response to
Requests for Additional Information No. 6236
RAI Letter No. 4 for Appendices 5, 6, 9, 11, 13

B&W mPower Pre-Application Activities
Docket No. PROJ 0776
Topical Report 08-002089-001

Question 07.01-C Appendix-5

***Figure 4.1** - The setpoint steps at the bottom of the figure (below the step "Determine the Setpoint and Allowable Value"), deviate from ANSI/ISA 67.04.02 Figure 2. Explain how this meets the guidance in RG 1.105 Rev 3.*

B&W NE Response

Figure 4.1 of the B&W Instrument Setpoint Methodology is similar to Figure 2 in ANSI/ISA 67.04.02-2000, slightly amplified to provide more prescriptive guidance for obtaining the trip setpoint (NTSP) from the analytical limit (AL) based upon either an increasing or decreasing direction of the process variable. Figure 4.1 contains additional information not contained in Figure 2 of ANSI/ISA 67.04.02-2000, this additional information has been removed.

The equation in section 4.2.3 for calculating the trip setpoint (NTSP) and limiting trip setpoint (LTSP) is shown below in its current form:

LTSP = AL ± CU

NTSP = AL ± (CU + Margin)

Therefore, when following the guidance illustrated in Figure 4.1, and applying the mathematical expressions from equation 4.2.3, for cases where the process signal increases towards the analytical limit, NTSP and LTSP calculated as follows:

LTSP = AL - CU (increasing process)
NTSP = AL - (CU + Margin) (increasing process)

For cases where the process signal decreases towards the analytical limit, NTSP and LTSP calculated as follows:

LTSP = AL + CU (decreasing process)
NTSP = AL + (CU + Margin) (decreasing process)

To summarize these steps, for an increasing process the channel uncertainty (CU) is subtracted from the AL to obtain the LTSP, and the CU plus margin (if any) is subtracted from the AL to obtain the NTSP. For a decreasing process, the CU is added to the AL to obtain the LTSP, and the CU plus margin (if any) is added to the AL to obtain the NTSP. This is consistent with and identical to the methods described in section 7.2 of ISA/ANSI-67.04.02-2000.

These methods are consistent with the guidance in RG 1.105 for establishment of the LTSP as the LSSS. The LTSP is determined by subtracting the CU from the AL for an increasing process, and adding the CU to the AL for a decreasing process. To determine the NTSP, a value for safety margin may be added to the CU to add conservatism when establishing the trip setpoint. The CU is determined using accepted statistical methods. The AV is determined as the limiting value that the NTSP may have when tested periodically and ensure that both the AL and the SL are protected.

Equation 4.2.3 (page 18) of the topical report has been slightly modified to more clearly show the mathematical relationship for calculation of the LTSP and NTSP explicitly for increasing and decreasing processes as shown below:

4.2.3 Trip Setpoint

LTSP = AL - CU (increasing process)
LTSP = AL + CU (decreasing process)

NTSP = AL - (CU + Margin) (increasing process)
NTSP = AL + (CU + Margin) (decreasing process)

Figure 4.1 has been revised as shown on the following page.

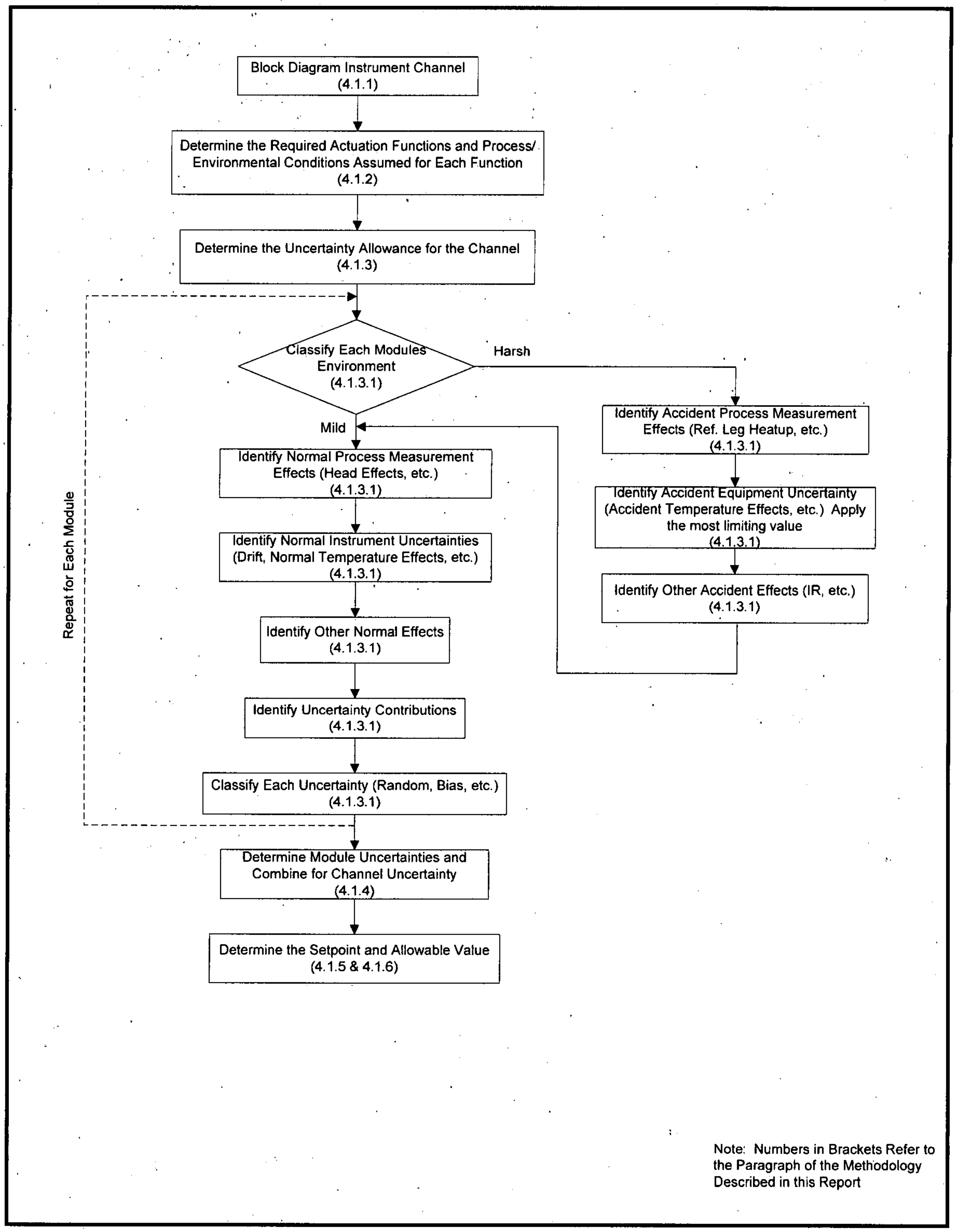

Figure 4.1: Setpoint Calculation Flow

Question 07.01-C Appendix-6

Section 4.1.3.1 *- The last paragraph in this section lists the "elements of uncertainty for any module" and further specifies the definitions are provided in Appendix B. Two of the elements the "as-left tolerance specification" and "as-found specification" are not defined in Appendix B. The staff requests the applicant clarify the definitions of these elements.*

B&W NE Response

The list in section 4.1.3.1 lists the various elements of uncertainty for a module and is not intended to be all inclusive, but typical for an instrument channel. The terms "as-left tolerance specification" and "as-found specification" should have matched the terms defined in Appendix B. B&W recognizes that confusion was introduced since the names for the terms do not exactly match those definitions provided in Appendix B. Therefore, the list in paragraph 5 of section 4.1.3.1 (pages 13-14), as shown below, has been revised to exactly match the defined terms provided in Appendix B as shown below and provide clarification that the list is not all inclusive but is typical for an instrument channel.

Elements of uncertainty for any module that are considered are listed below (not all of the uncertainties listed apply to every measurement channel). This list is not intended to be all inclusive but is typical for the instrument 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
- as-found tolerance
- propagation of uncertainty through modules

Question 07.01-C Appendix-9

***Figure 5.1** - This figure shows Margin (Note 2) added to the setpoint calculation.*
The staff requests that the applicant clarify the use of margin in the figure and revise the figure to reflect both the +/- of AFT, ALT, and the location of Margin (Note 2) in relationship to NTSP, AFT and AV (see below).

Sections 4.2.4, 4.2.5 and Figure 5.1:

- *Section 4.2.4 - How is AFT^{TOT} calculated as a +/- value and shown on both sides of NTSP on Figure 5.1?*
- *Section 4.2.5 - How is AFTn calculated as a +/- value?*
- *Section 4.2.4 - Explain why the definition of Margin is different from Note 2 on Figure 5.1.*
- *Is Margin (Note 2) correctly shown on Figure 5.1? see bullet 1 above.*
- *What value of ALT would be used in Figure 5.1? (Refer to RG 1.105 Rev. 3 Figure 1, "E. Region of Calibration Tolerance")*

B&W NE Response

To clarify the relationship between Margin and NTSP, AFT and AV a number of changes were made to Figure 5.1 and the text contained in Sections 4.1.5, 4.2.4, 4.2.5, and 4.2.7 of the topical report.

The as-found tolerance is used, when applied to the NTSP, to determine the allowable value for the instrument channel. The AV is the limiting value of an instrument's as-found trip setting during surveillance testing while still ensuring the AL and SL are protected. If the as-found value for the NTSP is non-conservative with respect to the AV, actions are required to restore the NTSP. Additionally, RIS 2006-17 raised concerns about conditions where the as-found NTSP may be more conservative than the AV, indicating that abnormally large changes in the trip setpoint have occurred which could be signs of the channel malfunctioning. Thus a concept of a double-sided acceptance criteria band for the measured trip setpoint during surveillance testing was introduced.

Section 4.1.5 (page 15) has been revised, as shown below, to clarify that the margin must be greater than or equal to the as-found tolerance to ensure the AV never exceeds the LSSS.

> 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. The margin applied adds conservatism to move the NTSP farther from the AL and must always be greater than or equal to the as-found tolerance to guarantee the allowable value will never exceed the LSSS. By definition, the NTSP is equal to or more conservative than the LTSP.

The determination of the AFT_{TOT} in section 4.2.4 (page 19) has been revised by removing the margin term in the determination of the AV, and includes the proper mathematical operator (±) to ensure the double-sided band is correctly applied as shown below:

4.2.4 Allowable Value

$AV = NTSP \pm AFT_{TOT}$

Where:

AV	=	Allowable value.
NTSP	=	Trip setpoint.
AFT_{TOT}	=	Total as-found tolerance for the entire instrument channel.

To protect against potential masking of equipment degradation during periodic surveillance testing, no margin is included as part of the AV determination and the AFT_{TOT} is applied as a double-sided band around the NTSP.

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;

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

Where:

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

Section 4.2.7 (page 22) has been revised to clarify that the margin must be greater than or equal to the as-found tolerance to ensure the AV never exceeds the LSSS as shown below:

> Safety margin is a discretionary value determined by engineering judgment. Margin is applied to accommodate normal expected conditions between surveillance intervals (e.g., drift). The applied margin must ensure that NTSP + AFT_{TOT} does not exceed the allowable value. The minimum margin prevents expected channel drift from exceeding the AV.

Figure 5.1 has been updated to properly illustrate the application of a double-sided band for the AFT_{TOT} as applied to the NTSP to ensure consistency with revisions to equation 4.2.4 described above. Additional revisions and enhancements to Figure 5.1 (page 24) include the following bulleted items. The revised figure is shown on the following page.

- Addition of a double-sided band for the ALT to aid in determination of channel operability and be consistent with Figure 1 in RG. 1.105.
- Illustration of regions of different conditions that may exist during periodic surveillance testing to clarify status of channel operability and required actions (if any).
- Removal of the margin applied to the AFT_{TOT} and its associated note (Note 2). (To protect against the potential for masking of equipment degradation during periodic surveillance testing.)
- Identification that the margin must be greater than or equal to AFT_{TOT} to ensure the AV remains less than or equal to the LSSS (Note 1).

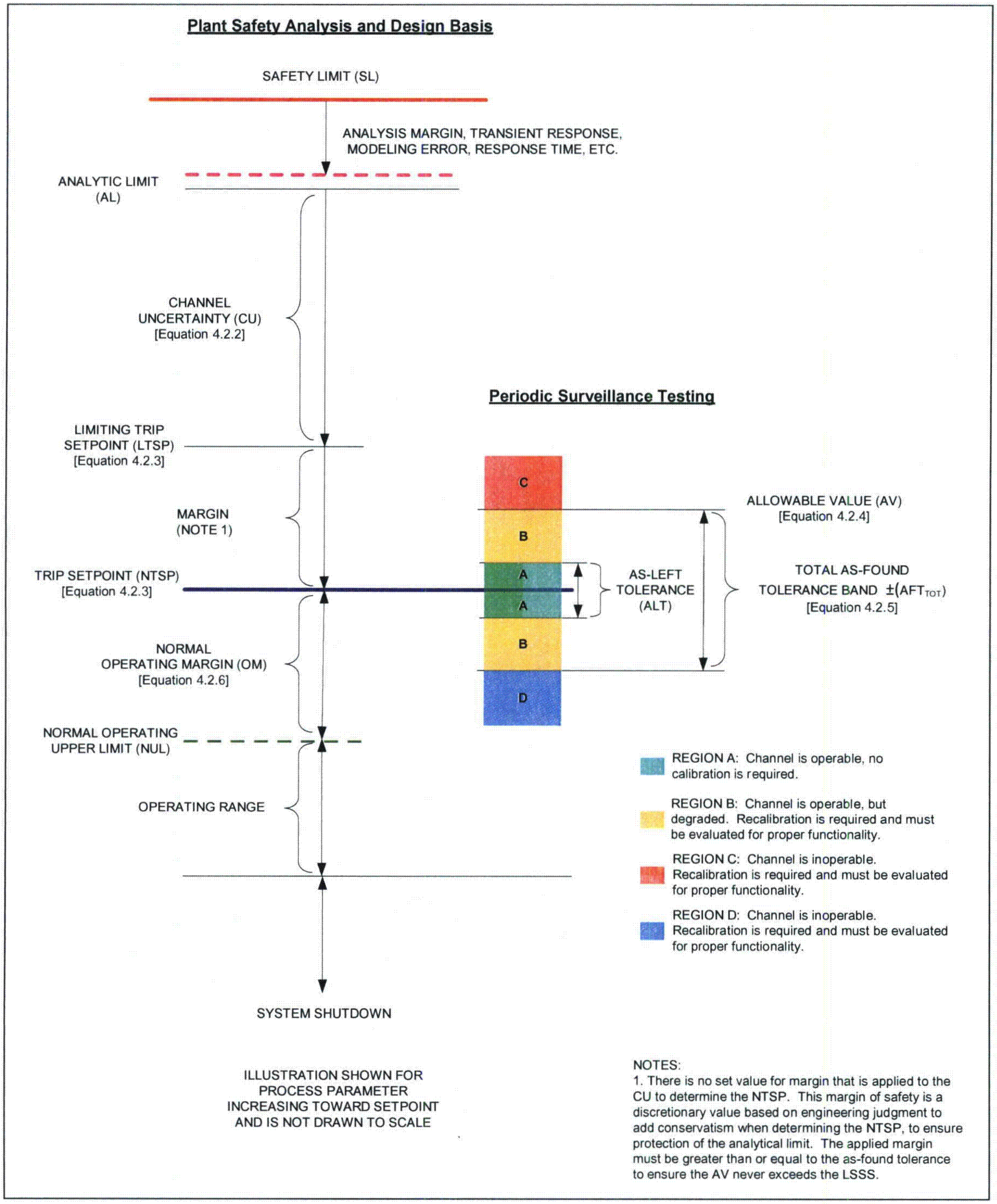

Figure 5.1: Setpoint Relationships – For Increasing Setpoint (Similar for decreasing setpoint, but process is decreasing towards the setpoint).

Question 07.01-C Appendix-11
Appendix A Figure A.2 *- The staff requests the applicant to respond to the following:*

- *Is margin correctly shown as 5.5 psig?*
- *Using example problem and Notes 1& 2 from Figure 5.1, what would AV, Margin 2 and AFT^{TOT} be if Margin 1 is 5.5 psig (allowed by note 1) versus 55 psig?*

B&W NE Response

Appendix A Figure A.2 contains a typographical error where the margin was incorrectly shown as 5.5 psig. The proper value for the margin as determined in this example is 5.0% of the span which is 55.0 psig.

Based on the revision to Figure 5.1 and section 4.2.4 discussed in response to Question 07.01-C Appendix-9, the relationship between the allowable value, as-found and as-left tolerances is more clearly understood. Figure A.2 has been revised to more clearly illustrate the relationships in the example between the AFT and ALT as shown below. Additionally, clarification has been added to indicate that the applied margin must be greater than or equal to the as-found tolerance to ensure than the AV never exceeds the LSSS.

The text on page A-3 has been revised as shown below:

> 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 in accordance with Section 4.2.3 to the NTSP, which is based on engineering judgment to include room for initial assumptions used in the calculation uncertainties and to account for rounding errors. The LTSP is the LSSS used in the plant technical specifications that protects the AL to satisfy 10 CFR 50.36. The applied margin must ensure that NTSP + AFT_{TOT} does not exceed the allowable value. The minimum margin prevents expected channel drift from exceeding the AV.

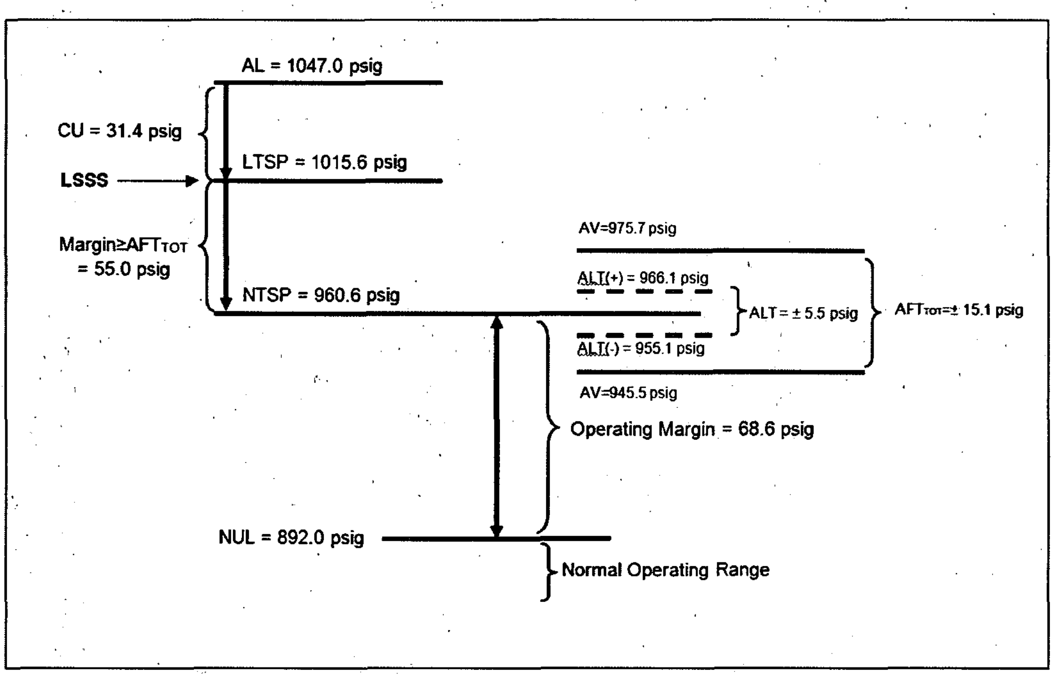

Figure A.2: Relationships between analytical limit and calculated setpoints

Question 07.01-C Appendix-13
Figure 4.1 *- The portion of the figure that shows the setpoint calculation for a harsh environment does not specify seismic effects as described in section 4.3.1.1 paragraph 2 and equation 4.2.1. Is seismic considered in figure 4.1 and if so how would this be applied to the setpoint calculation for normal, seismic, and other postulated accident conditions, as applicable?*

B&W NE Response

The flow path presented in Figure 4.1(page 9) is provided for illustrative purposes to demonstrate how, for instrument channels in harsh environments, the additional evaluation of uncertainties is required. It was not intended to list all uncertainty contributions for instrument channels subject to harsh conditions during normal or postulated design basis accident conditions in this figure.

The method for treating channel uncertainties for portions of the instrument channel that are subject to harsh environments during normal, seismic and other postulated design basis accidents is included in the current text in section 4.1.3.1 (pages 13-14) in the topical report.

Section 4.1.3.1 has been revised, as shown below, to add clarification and indicate the most limiting uncertainty will be applied for portions of an instrument channel subject to a harsh environment during postulated DBAs.

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. The most limiting uncertainities (temprature, radition, etc.) wil be applied. 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.

Enclosure 2
B&W NE's revised response to the RAI No. 6236
Appendices 5, 6, 9, 11 and 13
(Markup)

Enclosure 2
Babcock & Wilcox Nuclear Energy, Inc. Revised Response to
Requests for Additional Information No. 6236
RAI Letter No. 4 for Appendices 5, 6, 9, 11, 13

B&W mPower Pre-Application Activities
Docket No. PROJ 0776
Topical Report 08-002089-001

Question 07.01-C Appendix-5
Figure 4.1 *- The setpoint steps at the bottom of the figure (below the step "Determine the Setpoint and Allowable Value"), deviate from ANSI/ISA 67.04.02 Figure 2. Explain how this meets the guidance in RG 1.105 Rev 3.*

B&W NE Response

Figure 4.1 of the B&W Instrument Setpoint Methodology is similar to Figure 2 in ANSI/ISA 67.04.02-2000, slightly amplified to provide more prescriptive guidance for obtaining the trip setpoint (NTSP) from the analytical limit (AL) based upon either an increasing or decreasing direction of the process variable. ~~The amplified portion of Figure 4.1 refers to section 4.2.3 for the mathematical equation to use for calculating of the trip setpoint and provides guidance on the use of the equations based upon the direction of the process variable.~~ *Figure 4.1 contains additional information not contained in Figure 2 of ANSI/ISA 67.04.02-2000, this additional information has been removed.*

The equation in section 4.2.3 for calculating the trip setpoint (NTSP) and limiting trip setpoint (LTSP) is shown below in its current form:

LTSP = AL ± CU

NTSP = AL ± (CU + Margin)

Therefore, when following the guidance illustrated in Figure 4.1, and applying the mathematical expressions from equation 4.2.3, for cases where the process signal increases towards the analytical limit, NTSP and LTSP calculated as follows:

LTSP = AL - CU (increasing process)
NTSP = AL - (CU + Margin) (increasing process)

For cases where the process signal ~~increases~~ *decreases* towards the analytical limit, NTSP and LTSP calculated as follows:

LTSP = AL + CU (decreasing process)
NTSP = AL + (CU + Margin) (decreasing process)

To summarize these steps, <u>for an increasing process</u> the channel uncertainty (CU) is subtracted from the AL to obtain the LTSP, and the CU plus margin (if any) is subtracted from the AL to obtain the NTSP. <u>For a decreasing process</u>, the CU is added to the AL to obtain the LTSP, and the CU plus margin (if any) is added to the AL to obtain the NTSP. This is consistent with and identical to the methods described in section 7.2 of ISA/ANSI-67.04.02-2000.

These methods are consistent with the guidance in RG 1.105 for establishment of the LTSP as the LSSS. The LTSP is determined by subtracting the CU from the AL for an increasing process, and adding the CU to the AL for a decreasing process. To determine the NTSP, a value for safety margin may be added to the CU to add conservatism when establishing the trip setpoint. The CU is determined using accepted statistical methods. The AV is determined as the limiting value that the NTSP may have when tested periodically and ensure that both the AL and the SL are protected.

~~No changes to Figure 4.1 will be made; however~~ *E*equation 4.2.3 (page 18) of the topical report ~~will be~~*has been* slightly modified to more clearly show ~~this~~ *the* mathematical relationship *for calculation of the LTSP and NTSP explicitly for increasing and decreasing processes* ~~with changes highlighted in shaded text~~ *as shown below*:

4.2.3 Trip Setpoint

LTSP = AL - CU (increasing process)
LTSP = AL + CU (decreasing process)

NTSP = AL - (CU + Margin) (increasing process)
NTSP = AL + (CU + Margin) (decreasing process)

Figure 4.1 has been revised as shown on the following page.

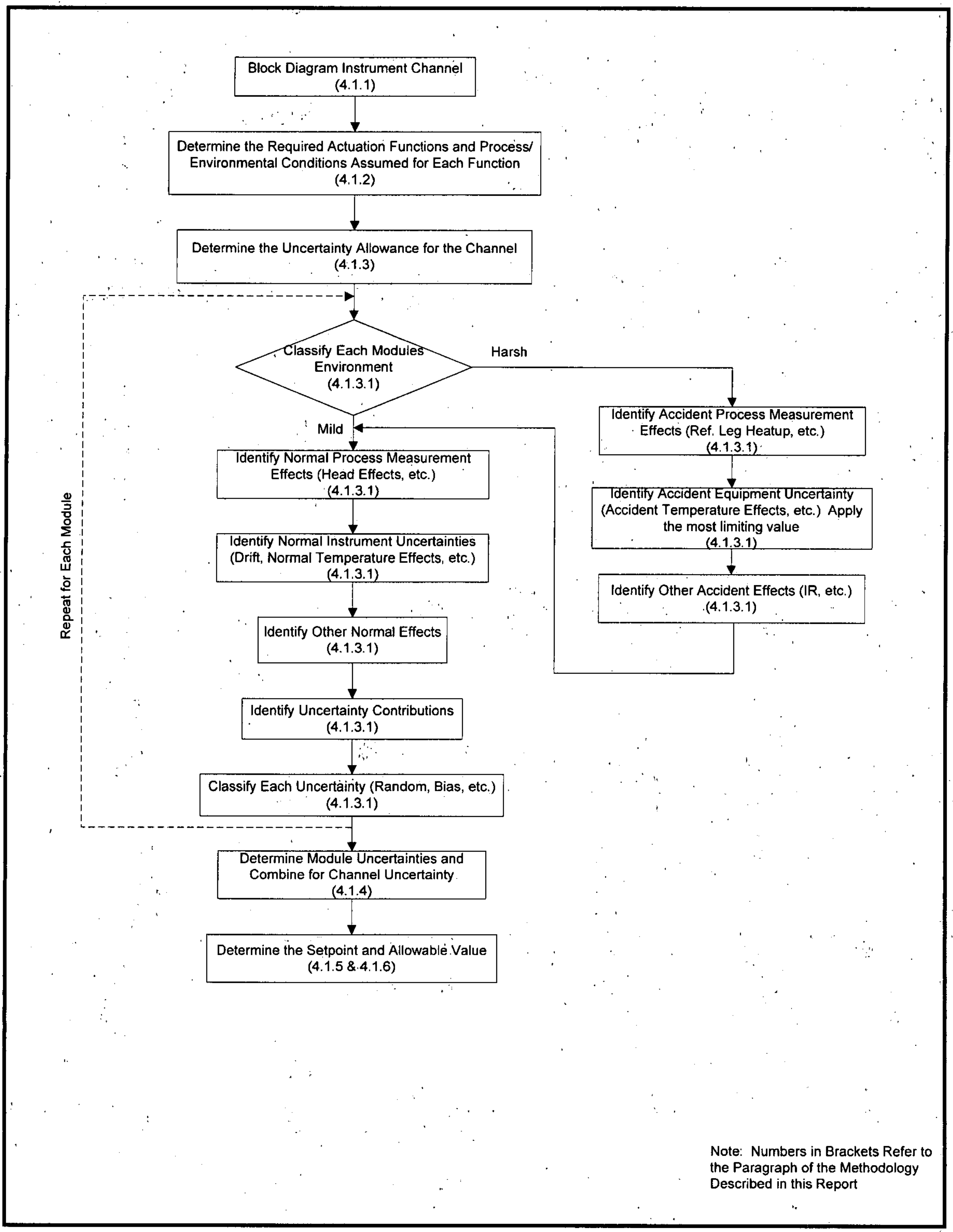

Figure 4.1: Setpoint Calculation Flow

Question 07.01-C Appendix-6

Section 4.1.3.1 *- The last paragraph in this section lists the "elements of uncertainty for any module" and further specifies the definitions are provided in Appendix B. Two of the elements the "as-left tolerance specification" and "as-found specification" are not defined in Appendix B. The staff requests the applicant clarify the definitions of these elements.*

B&W NE Response

The list in section 4.1.3.1 lists the various elements of uncertainty for a module *and is not intended to be all inclusive, but typical for an instrument channel*. The terms "as-left tolerance specification" and "as-found specification" should have matched the terms defined in Appendix B. B&W recognizes that confusion was introduced since the names for the terms do not exactly match those definitions provided in Appendix B. Therefore, the list in paragraph 5 of section 4.1.3.1 (pages 13-14)*, as shown below,* ~~will be~~*has been* revised to exactly match the defined terms provided in Appendix B as shown ~~with changes highlighted in shaded text~~ below *and provide clarification that the list is not all inclusive but is typical for an instrument channel*.

Elements of uncertainty for any module that are considered are listed below (not all of the uncertainties listed apply to every measurement channel). *This list is not intended to be all inclusive but is typical for the instrument 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
- as-found tolerance
- propagation of uncertainty through modules

Question 07.01-C Appendix-9

Figure 5.1 *- This figure shows Margin (Note 2) added to the setpoint calculation.*
The staff requests that the applicant clarify the use of margin in the figure and revise the figure to reflect both the +/- of AFT, ALT, and the location of Margin (Note 2) in relationship to NTSP, AFT and AV (see below).

Sections 4.2.4, 4.2.5 and Figure 5.1:

- *Section 4.2.4 - How is AFT^{TOT} calculated as a +/- value and shown on both sides of NTSP on Figure 5.1?*
- *Section 4.2.5 - How is AFTn calculated as a +/- value?*
- *Section 4.2.4 - Explain why the definition of Margin is different from Note 2 on Figure 5.1.*
- *Is Margin (Note 2) correctly shown on Figure 5.1? see bullet 1 above.*
- *What value of ALT would be used in Figure 5.1? (Refer to RG 1.105 Rev. 3 Figure 1, "E. Region of Calibration Tolerance")*

B&W NE Response

To clarify the relationship between Margin and NTSP, AFT and AV a number of changes were made to Figure 5.1 and the text contained in Sections *4.1.5,* 4.2.4*,* ~~and~~ 4.2.5*, and 4.2.7* of the topical report.

The as-found tolerance is used, when applied to the NTSP, to determine the allowable value for the instrument channel. The AV is the limiting value of an instrument's as-found trip setting during surveillance testing while still ensuring the AL and SL are protected. If the as-found value for the NTSP is non-conservative with respect to the AV, actions are required to restore the NTSP. Additionally, RIS 2006-17 raised concerns about conditions where the as-found NTSP may be more conservative than the AV, indicating that abnormally large changes in the trip setpoint have occurred which could be signs of the channel malfunctioning. Thus a concept of a double-sided acceptance criteria band for the measured trip setpoint during surveillance testing was introduced.

Section 4.1.5 (page 15) has been revised, as shown below, to clarify that the margin must be greater than or equal to the as-found tolerance to ensure the AV never exceeds the LSSS.

> *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. The margin applied adds conservatism to move the NTSP farther from the AL and must always be greater than or equal to the as-found tolerance to guarantee the allowable value will never exceed the LSSS. By definition, the NTSP is equal to or more conservative than the LTSP.*

The determination of the AFT_{TOT} in section 4.2.4 (page 19) has been revised by removing the margin term in the determination of the AV, and includes the proper mathematical operator (±) to ensure the double-sided band is correctly applied as shown below ~~with the changes highlighted in the shaded text~~:

4.2.4 Allowable Value

$AV = NTSP \pm AFT_{TOT}$

Where:

AV	=	Allowable value.
NTSP	=	Trip setpoint.
AFT_{TOT}	=	Total as-found tolerance for the entire instrument channel.

To protect against ~~identification of~~ potential masking of equipment degradation during periodic surveillance testing, no margin is included as part of the AV determination and the AFT_{TOT} is applied as a double-sided band around the NTSP.

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;

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

Where:

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

Section 4.2.7 (page 22) has been revised to clarify that the margin must be greater than or equal to the as-found tolerance to ensure the AV never exceeds the LSSS as shown below:

> *Safety margin is a discretionary value determined by engineering judgment. Margin is applied to accommodate normal expected conditions between surveillance intervals (e.g., drift). The applied margin must ensure that NTSP + AFT_{TOT} does not exceed the allowable value. The minimum margin prevents expected channel drift from exceeding the AV.*

Figure 5.1 has been updated to properly illustrate the application of a double-sided band for the AFT_{TOT} as applied to the NTSP to ensure consistency with revisions to equation 4.2.4 described above. Additional revisions and enhancements to Figure 5.1 (page 24) include the following *bulleted items. The* revised figure is shown *on the following page.*

- Addition of a double-sided band for the ALT to aid in determination of channel operability and be consistent with Figure 1 in RG. 1.105.
- Illustration of regions of different conditions that may exist during periodic surveillance testing to clarify status of channel operability and required actions (if any).
- Removal of the margin applied to the AFT_{TOT} and its associated note (Note 2). (To protect against the potential for masking of equipment degradation during periodic surveillance testing.)
- *Identification that the margin must be greater than or equal to AFT_{TOT} to ensure the AV remains less than or equal to the LSSS (Note 1).*

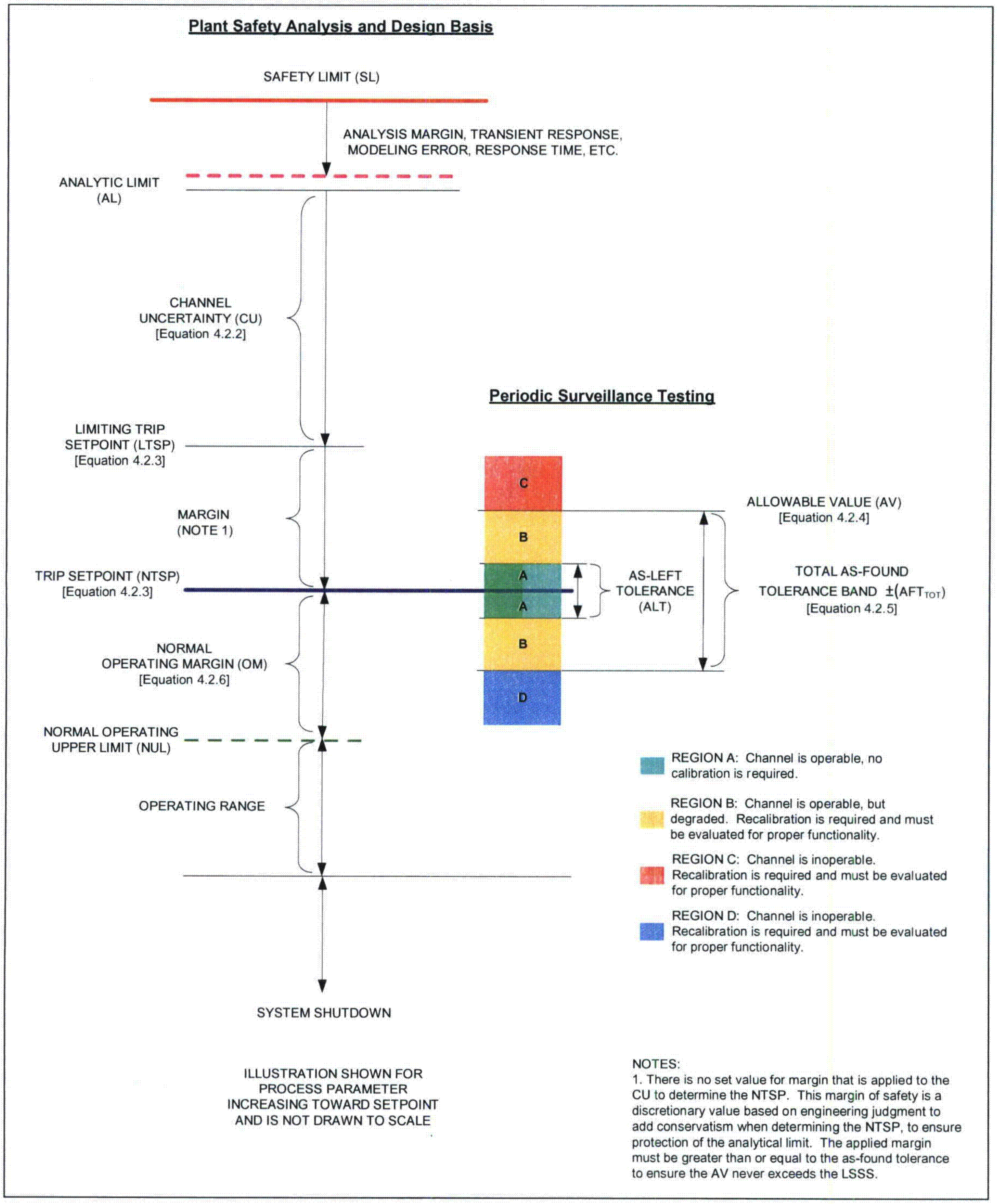

Figure 5.1: Setpoint Relationships – For Increasing Setpoint (Similar for decreasing setpoint, but process is decreasing towards the setpoint).

Question 07.01-C Appendix-11
Appendix A Figure A.2 *- The staff requests the applicant to respond to the following:*

- *Is margin correctly shown as 5.5 psig?*
- *Using example problem and Notes 1& 2 from Figure 5.1, what would AV, Margin 2 and AFT^{TOT} be if Margin 1 is 5.5 psig (allowed by note 1) versus 55 psig?*

B&W NE Response

Appendix A Figure A.2 contains a typographical error where the margin was incorrectly shown as 5.5 psig. The proper value for the margin as determined in this example is 5.0% of the span which is 55.0 psig.

Based on the revision to Figure 5.1 and section 4.2.4 discussed in response to Question 07.01-C Appendix-9, the relationship between the allowable value, as-found and as-left tolerances is more clearly understood. Figure A.2 has been revised to more clearly illustrate the relationships in the example between the AFT and ALT as shown below. *Additionally, clarification has been added to indicate that the applied margin must be greater than or equal to the as-found tolerance to ensure than the AV never exceeds the LSSS.*

The text on page A-3 has been revised as shown below:

> *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 in accordance with Section 4.2.3 to the NTSP, which is based on engineering judgment to include room for initial assumptions used in the calculation uncertainties and to account for rounding errors. The LTSP is the LSSS used in the plant technical specifications that protects the AL to satisfy 10 CFR 50.36. The applied margin must ensure that NTSP + AFT_{TOT} does not exceed the allowable value. The minimum margin prevents expected channel drift from exceeding the AV.*

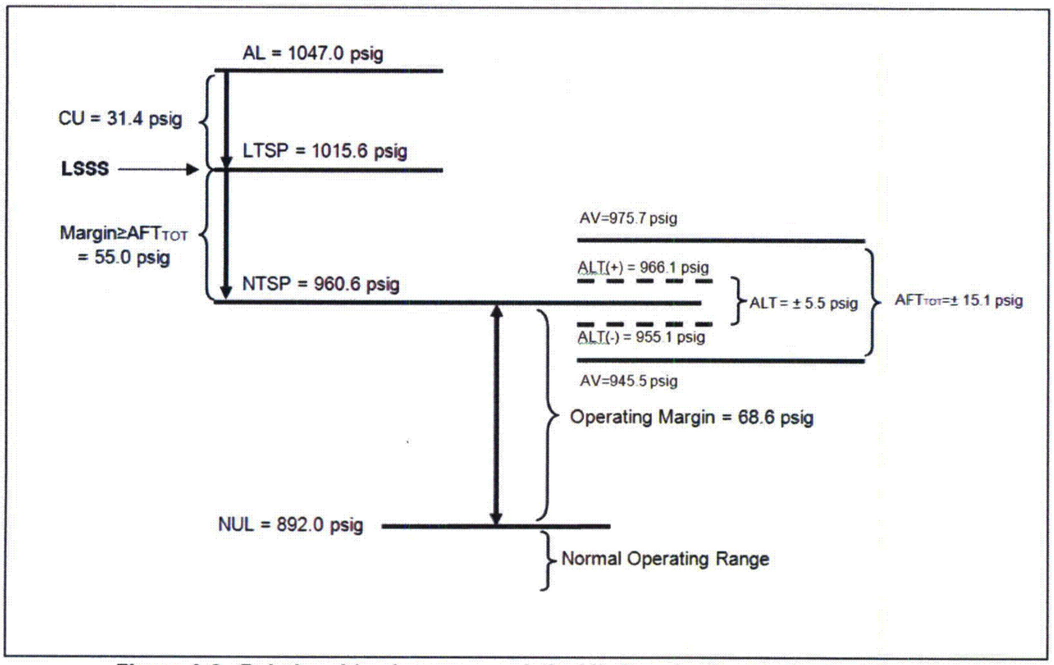

Figure A.2: Relationships between analytical limit and calculated setpoints

Question 07.01-C Appendix-13

***Figure 4.1** - The portion of the figure that shows the setpoint calculation for a harsh environment does not specify seismic effects as described in section 4.3.1.1 paragraph 2 and equation 4.2.1. Is seismic considered in figure 4.1 and if so how would this be applied to the setpoint calculation for normal, seismic, and other postulated accident conditions, as applicable?*

B&W NE Response

The flow path presented in Figure 4.1(page 9) is provided for illustrative purposes to demonstrate how, for instrument channels in harsh environments, the additional evaluation of uncertainties is required. It was not intended to list all uncertainty contributions for instrument channels subject to harsh conditions during normal or postulated design basis accident conditions in this figure.

The method for treating channel uncertainties for portions of the instrument channel that are subject to harsh environments during normal, seismic and other postulated design basis accidents is included in the current text in section 4.1.3.1 (pages 13-14) in the topical report. ~~The applicable portions of this section that explicitly include the uncertainties due to seismic effects are highlighted below.~~

Section 4.1.3.1 has been revised, as shown below, to add clarification and indicate the most limiting uncertainty will be applied for portions of an instrument channel subject to a harsh environment during postulated DBAs.

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. The most limiting uncertainities (temprature, radition, etc.) wil be applied. 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.

Section G

Document No:	Title:	Rev:
R0003-08-002089-A	Instrument Setpoint Methodology Topical Report	003

SIGNATURES

Prepared By:	**Iftikhar Rana**	[signature]	
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Reviewed By:	**Rodger Magness**	[signature]	05/09/2012
		Signature	**Date**
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		Signature	**Date**

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.

2	1/12/2012	B.K. Arnholt	Incorporate revisions to address requests for additional information (RAIs) received from the NRC (Ref. RAI No. 6236 Ltr. No. 4). 1. Several editorial changes to add clarity. 2. Clarify regulatory and standards compliance. 3. Explicitly demonstrate the relationships between as-found, as-left tolerances including the application of a double-sided acceptance band. 4. Add specific criteria for evaluation of channel operability during periodic surveillance testing. 5. Update Appendix A to include determination of the as-left band and operating margin.
3	5/01/2012	I.A.Rana	Incorporate revisions to address requests for additional information (RAIs) received from the NRC (Ref. RAI No. 6236 Ltr. No. 4). 1. Revise Figure 4.1 to delete the branch flow paths for increase/decrease processes. 2. Revise section 4.1.3.1 list of example uncertainties to clarify that the list is not intended to be all-inclusive, but is typical for instrument channels. 3. Clarify application of margin in calculating the allowable value. The margin must always be greater than or equal to the as-found tolerance to guarantee the AV will never exceed the LSSS. 4. Clarify the treatment of accident environment effects and seismic uncertainties. The most-limiting uncertainties will apply

TABLE OF CONTENTS

LIST OF APPENDICES

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, and to ensure the issues identified in RIS 2006-17 (Ref. 6.2.4) are addressed, 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 ISA 67.04-1994, Part I 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. These combined dependent uncertainties are then treated as an additional independent random uncertainty, which can then be combined with other independent terms using the SRSS method in the overall uncertainty calculation.

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:

- 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 based on the ambient conditions in which the instrumentation components are expected to operate and specified in the plant calibration procedures. The temperature effect (TE) for the instrumentation accounts for possible differences between the temperature associated with the instrument calibration and the ambient conditions of the installed equipment and 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 (Ref. 6.3.2).

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. Table 4.1 includes a comprehensive list of all uncertainties that must be considered for inclusion in the total channel uncertainty (CU) calculation.

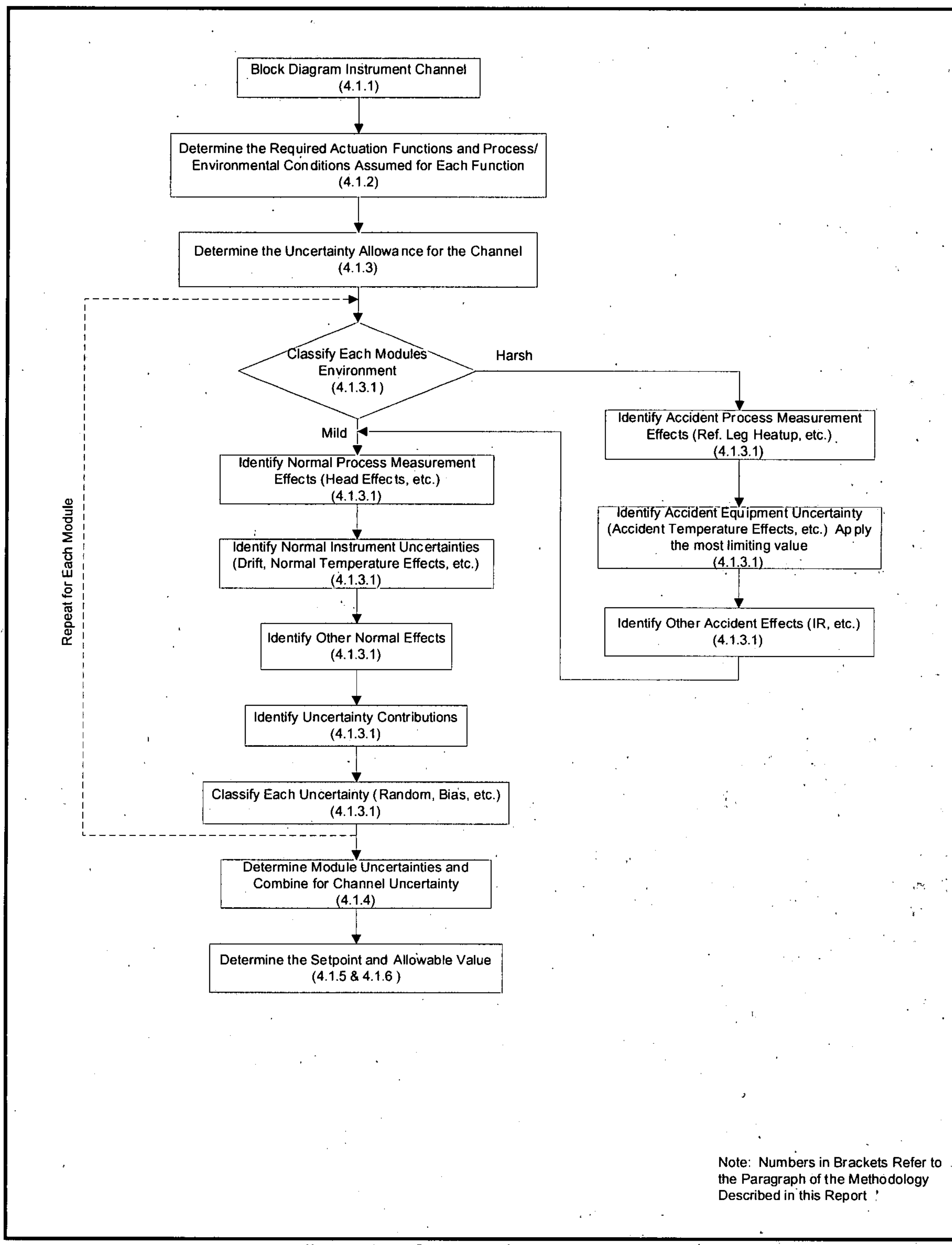

Figure 4.1: Setpoint Calculation Flow

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

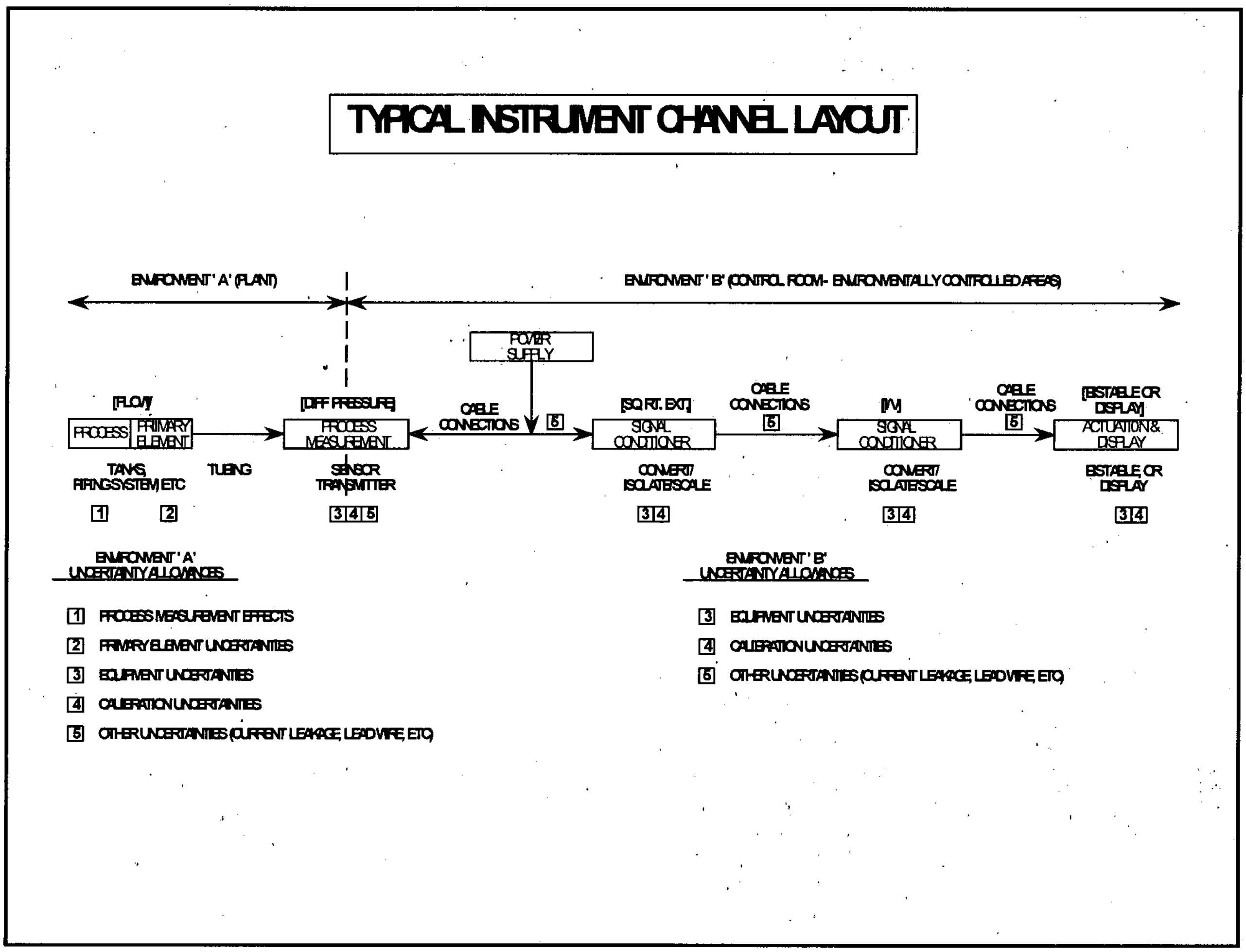

Figure 4.2: Typical Instrument Channel Layout

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. The most limiting uncertainties (temperature, radiation, etc.) wil be applied. 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). This list is not intended to be all inclusive but is typical for the instrument 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
- as-found tolerance
- 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 summed algebraically creating a new, larger independent uncertainty that are eligible for combination with other independent terms using the SRSS method described in this report.

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 (Ref. 6.3.2).

4.1.5 Trip Setpoint

The nominal trip setpoint (NTSP) and limiting trip setpoint (LTSP) are calculated using equation 4.2.3.

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. The margin applied adds conservatism to move the NTSP farther from the AL and must always be greater than or equal to the as-found tolerance to guarantee the allowable value will never exceed the LSSS. 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 is declared inoperable and an evaluation of acceptable channel functionality is performed. The channel is required to be calibrated to return the setpoint within the acceptable tolerance range. Plant-specific procedures will maintain and track the results of the periodic surveillance test procedures and the historical as-found and as-left data obtained during surveillance testing. These data will be evaluated to confirm the assumptions for instrument channel drift and uncertainty data remain valid.

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 (Ref. 6.3.2). 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 - CU (increasing process)
LTSP = AL + CU (decreasing process)

NTSP = AL - (CU + Margin) (increasing process)
NTSP = AL + (CU + Margin) (decreasing process)

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. The applied margin must always be greater than or equal to the as-found tolerance to guarantee the AV will never exceed the LSSS

4.2.4 Allowable Value

$AV = NTSP \pm AFT_{TOT}$

Where:

AV = Allowable value.

NTSP = Trip setpoint.

AFT_{TOT} = Total as-found tolerance for the entire instrument channel

To protect against potential masking of equipment degradation during periodic surveillance testing, no margin is included as part of the AV determination and the AFT_{TOT} is applied as a double-sided band around the NTSP.

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;

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

Where:

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

4.2.5 As-Found Tolerance

The as-found tolerance (AFT) 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. AFT includes consideration at a minimum of reference accuracy (RA), drift (DR), and as-left tolerance (ALT) uncertainties. The as-left tolerance (ALT) is also referred to as "calibration tolerance" in ANSI/ISA-S67.04.01-2000 (Ref. 6.3.1) or "setting tolerance" in RIS 2006-17 (Ref. 6.2.4).

The ALT is specified as a double-sided band around the NTSP. Depending on the condition of the as-found values for the NTSP, plant specific procedures will direct the operability determination and requirements for channel calibration or maintenance. The ALT typically is based on the reference accuracy of the module being calibrated; however, depending on the particular instrument loop in question, the limitations of the calibration procedure or need to minimize maintenance time, the magnitude of the ALT may be specified as a smaller or larger value in the specific calibration procedure. In this case, if the ALT used in the procedure differs from the reference accuracy specified by the vendor, the ALT would be included as a separate, explicit term in the setpoint calculation. Thus, in the equation to determine AFT_n, the as-left term is included as a bounding method to account for cases where not all attributes of the reference accuracy may verified in the particular calibration procedure.

Determination of the AFT may also 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:

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

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 evaluated 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. In accordance with RG 1.105 (Ref. 6.2.1) and BTP 7-12 (Ref. 6.2.2), plant specific procedures are required to track, trend and maintain the results of periodic surveillance testing (i.e., the as-found and as-left values for sensors (as applicable) and modules associated with the instrument loop) for proper management of instrument uncertainties including drift.

Table 4.2 shows the various conditions to consider during surveillance testing of the instrumentation channel and are consistent with RIS 2006-17 (Ref. 6.2.4).

Table 4.2: Instrument Operability During Periodic Surveillance Testing

As-found NTSP During Surveillance Testing	Status of Channel Operability and Required Actions
As-found NTSP within ALT (Region A of Figure 5.1)	Channel is operable, no action required. The results are tracked by plant procedures for historical trending.
As-found NTSP outside of ALT band, but within AFT band (Region B of Figure 5.1)	Channel is operable, recalibration is necessary to restore the NTSP within the ALT.
Increasing process: As-found NTSP is conservative with respect to the AV (NTSP < AV) but outside AFT band (Region D of Figure 5.1); or Decreasing process: As-found NTSP is conservative with respect to the AV (NTSP > AV) but outside AFT band.	Channel is inoperable. Recalibration is necessary to restore the NTSP within the ALT, and evaluation of channel functionality is required.
As-found NTSP non-conservative to the AV (Region C of Figure 5.1)	Channel is inoperable. Recalibration is necessary to restore NTSP within the ALT, and evaluation of channel functionality is required to return channel to an operable status.

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 (Ref. 6.3.2) applies in calculating the SRSS of the individual drift periods between calibrations as shown in the example provided below:

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

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. Plant-specific procedures will contain required methods to evaluate the historical performance of the drift for each instrument channel and confirm the surveillance and calibration intervals do not exceed the assumptions in the plant safety analysis. The guidance contained in Generic Letter 91-04 (Ref. 6.2.5) may be used to evaluate and determine the acceptable surveillance and calibration intervals for each instrument channel.

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. Margin is applied to accommodate normal expected conditions between surveillance intervals (e.g., drift). The applied margin must ensure that NTSP + AFT_{TOT} does not exceed the allowable value. The minimum margin prevents expected channel drift from exceeding the AV.

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.

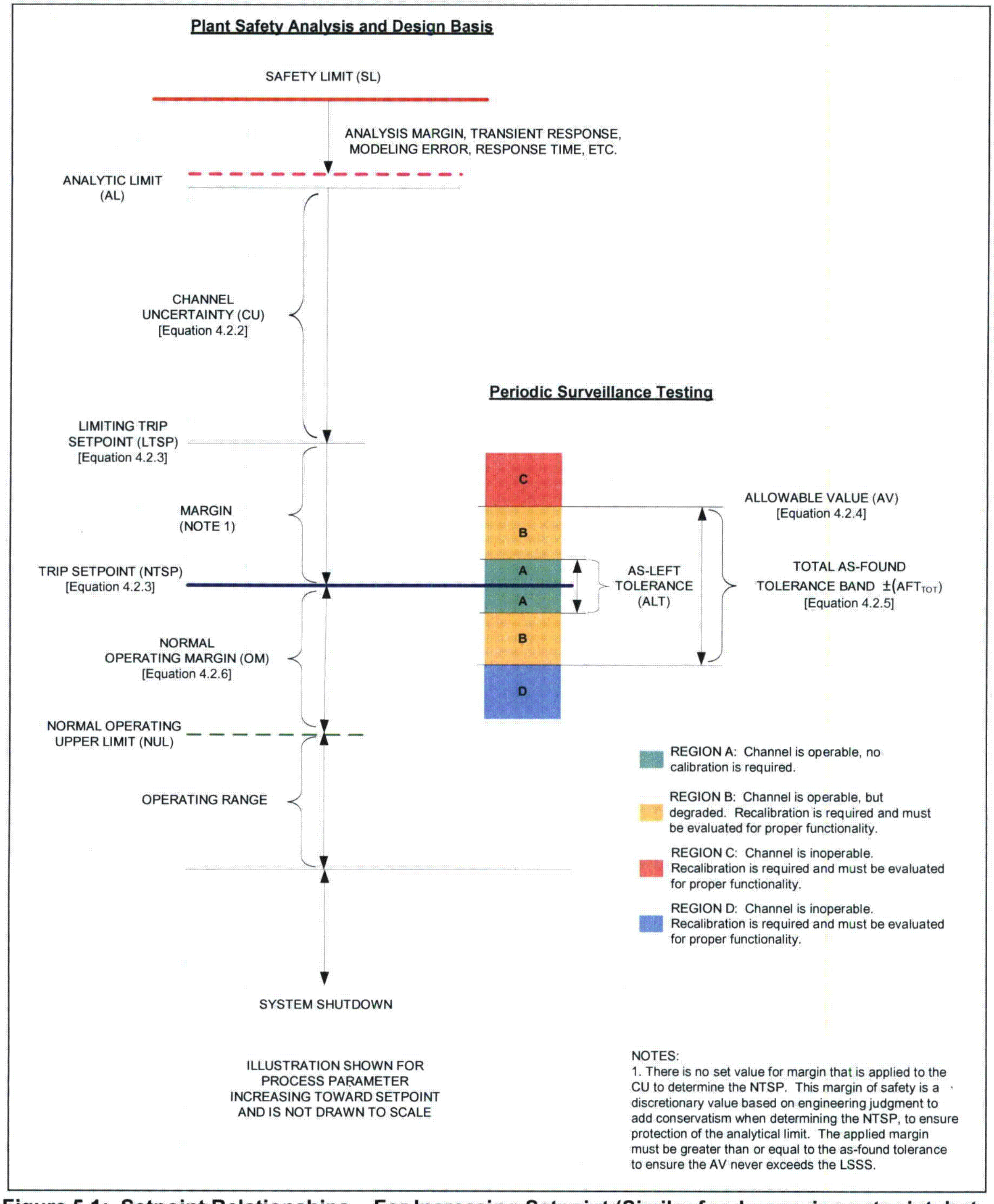

Figure 5.1: Setpoint Relationships – For Increasing Setpoint (Similar for decreasing setpoint, but process is decreasing towards the setpoint).

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.

6.2.5 Generic Letter 91-04, "Guidance on Preparation of a Licensee Amendment Request for Changes in Surveillance Intervals to Accommodate a 24-Month Fuel Cycle," April 2, 1991.

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 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 process conditions are such that the normal upper limit of the process signal for this loop is 892 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 reference accuracy for the instrument as provided by vendor is 0.25%,which is less than the typical as-left tolerance settings in the specific plant calibration procedures. Therefore, the as-left tolerance of 0.50% will be treated as a separate term (refer to Section 4.2.5) as a bounding case to minimize maintenance time.

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

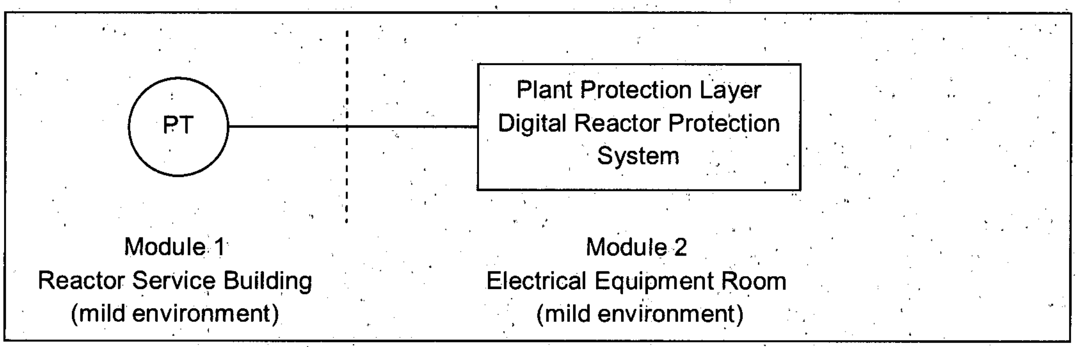

Figure A.1: Example Loop Diagram for Safety-Related Instrument Channel

The applicable uncertainties to the pressure transmitter include reference accuracy, drift, power supply effects, and 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 (see assumptions).

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 in accordance with Section 4.2.3 to the NTSP, which is based on engineering judgment to include room for initial assumptions used in the calculation uncertainties and to account for rounding errors. The LTSP is the LSSS used in the plant technical specifications that protects the AL to satisfy 10 CFR 50.36. The applied margin must ensure that NTSP + AFT_{TOT} does not exceed the allowable value. The minimum margin prevents expected channel drift from exceeding the AV.

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.

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

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

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

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

$AFT_{TOT} = \pm 15.1$ 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 (+); 945.5 psig (-)

The double-sided band for the AV ensures (1) the SL is protected, and (2) ensures any equipment degradation is identified and corrected.

The operating margin is calculated using equation 4.2.6 and ensures that sufficient operating margin exists to minimize and prevent spurious channel trips should the NTSP drift. Margin is applied to accommodate normal expected conditions between surveillance intervals (e.g., drift).

OM = NTSP – NUL (increasing setpoint) = 960.6 psig – 892.0 psig = 68.6 psig.

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

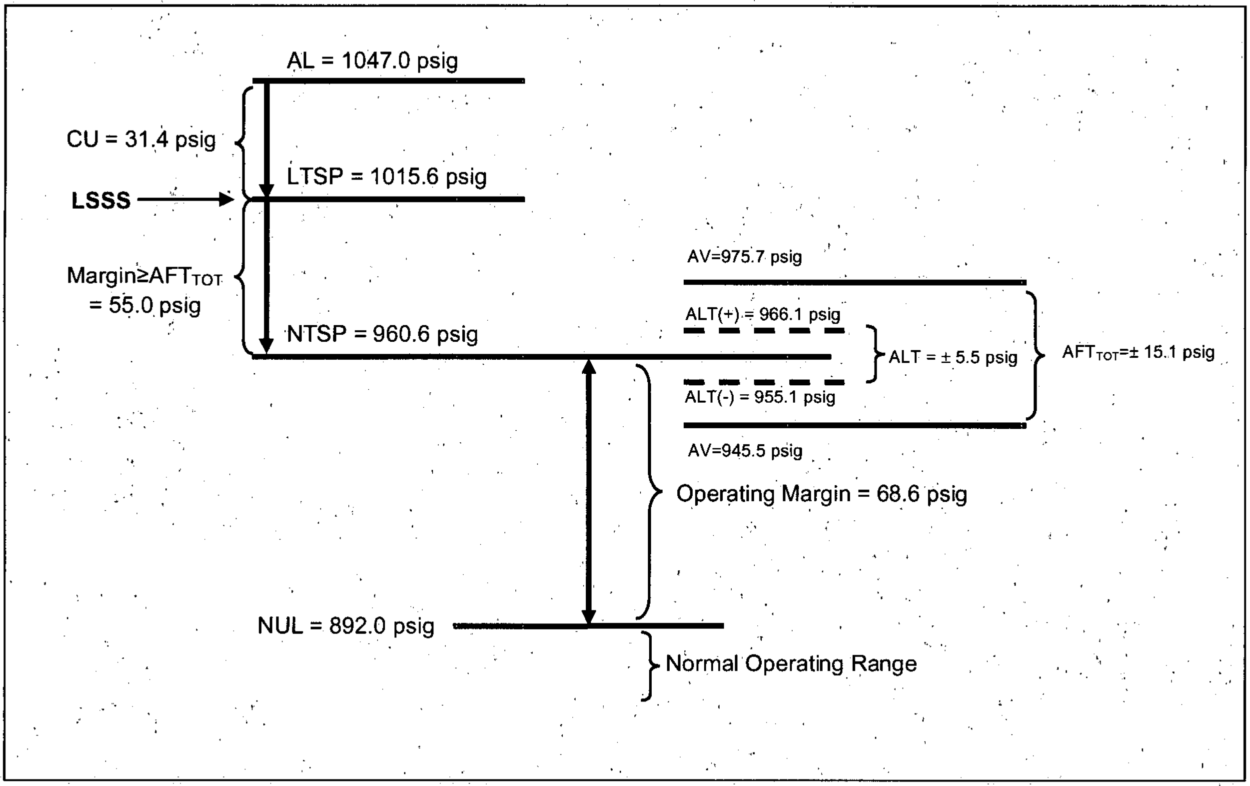

Figure A.2: Relationships between analytical limit and calculated setpoints

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 increases 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.