ANP-10275NP-A
Revision 0

U.S. EPR Instrument Setpoint Methodology Topical Report

December 2007

AREVA NP Inc.

nrc·ic·07·072

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

December 20, 2007

Mr. Ronnie L. Gardner, Manager
AREVA NP
3315 Old Forrest Road
P.O. Box 10935
Lynchburg, VA 24506-0935

SUBJECT: FINAL SAFETY EVALUATION REPORT FOR ANP-10275P, "U.S. EPR INSTRUMENT SETPOINT METHODOLOGY TOPICAL REPORT" (TAC NO. MD4976)

Dear Mr. Gardner:

By letter dated March 26, 2007, U.S. Nuclear Regulatory Commission's ADAMS Accession Number (ML070880714), as supplemented by letters dated August 24, 2007 (ML072400032), and October 11, 2007 (ML073030202), AREVA NP (AREVA) submitted for U.S. Nuclear Regulatory Commission (NRC) staff review Topical Report (TR) ANP-10275P, "U.S. EPR Instrument Setpoint Methodology Topical Report", ADAMS Accession Number (ML070880719) (non-proprietary) and with a proprietary copy. By letter dated October 30, 2007, ADAMS Accession Number (ML072950546) a draft Safety Evaluation (SE) regarding our approval of ANP-10275(P) was provided for your review and comments. The staff's disposition of AREVA's comments ADAMS Accession Number (ML073440073) on the draft SE are discussed in the attachment to the final SE enclosed with this letter.

The staff has found that ANP-10275(P), Revision 0, is acceptable for referencing in licensing applications for U.S. EPR to the extent specified and under the limitations delineated in the TR and in the enclosed SE. The SE defines the basis for acceptance of the TR.

Our acceptance applies only to material provided in the subject TR. 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. Regulatory applications that deviate from this TR will be subject to further review in accordance with applicable review standards.

In accordance with the guidance provided on the NRC website, we request that AREVA publish the accepted version of this TR within three 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. The accepted versions shall include a "-A" (designating accepted) following the TR identification symbol.

If future changes to the NRC's regulatory requirements affect the acceptability of this TR, AREVA will be expected to revise the TR appropriately, or justify its continued applicability for subsequent referencing.

If you have any questions, please contact me at gxt2@nrc.gov or (301) 415-3361.

Sincerely,

Getachew Tesfaye

Getachew Tesfaye, Sr. Project Manager
EPR Projects Branch
Division of New Reactor Licensing
Office of New Reactors

Project No. 733

Enclosure: Final Safety Evaluation

cc w/encl: U.S. EPR Service List

DC AREVA - EPR Mailing List

cc:

Mr. Glenn H. Archinoff
AECL Technologies
481 North Frederick Avenue
Suite 405
Gaithersburg, MD 20877

Marty Bowling
NUMARK Project Manager
86 WestBay Drive
Kilmarnock, VA 22482

Ms. Michele Boyd
Legislative Director
Energy Program
Public Citizens Critical Mass Energy
and Environmental Program
215 Pennsylvania Avenue, SE
Washington, DC 20003

W. Craig Conklin, Director
Chemical and Nuclear Preparedness &
Protection Division (CNPPD)
Office of Infrastructure Protection
Department of Homeland Security
Washington, DC 20528

Mr. Marvin Fertel
Senior Vice President
and Chief Nuclear Officer
Nuclear Energy Institute
1776 I Street, NW
Suite 400
Washington, DC 20006-3708

Mr. Ray Ganthner
AREVA, Framatome ANP, Inc.
3315 Old Forest Road
P.O. Box 10935
Lynchburg, VA 24506-0935

Mr. Gary Wright, Director
Division of Nuclear Facility Safety
Illinois Emergency Management Agency
1035 Outer Park Drive
Springfield, IL 62704

Mr. Paul Gaukler
Pillsbury, Winthrop, Shaw, Pittman
2300 N Street, NW
Washington, DC 20037

Dr. Charles L. King
Licensing Manager, IRIS Project
Westinghouse Electric Company
Science and Technology Department
20 International Drive
Windsor, CT 06095

Ms. Sherry McFaden
Framatome NP, Inc.
3315 Old Forest Road, OF-16
Lynchburg, VA 24501

Vanessa E. Quinn, Acting Director
Technological Hazards Division
National Preparedness Directorate
Federal Emergency Management Agency
500 C Street, NW
Washington, DC 20472

Mr. Steve Seitz
AREVA
100 Dean Road
East Lyme, CT 06333

Mr. Robert E. Sweeney
IBEX ESI
4641 Montgomery Avenue
Suite 350
Bethesda, MD 20814

Email

APH@NEI.org (Adrian Heymer)
awc@nei.org (Anne W. Cottingham)
bennettS2@bv.com (Steve A. Bennett)
bob.brown@ge.com (Robert E. Brown)
BrinkmCB@westinghouse.com (Charles Brinkman)
carey.fleming@constellation.com (Carey Fleming)
chris.maslak@ge.com (Chris Maslak)
cwaltman@roe.com (C. Waltman)
david.hinds@ge.com (David Hinds)
david.lewis@pillsburylaw.com (David Lewis)
dlochbaum@UCSUSA.org (David Lochbaum)
erg-xl@cox.net (Eddie R. Grant)
frankq@hursttech.com (Frank Quinn)
gcesare@enercon.com (Guy Cesare)
greshaja@westinghouse.com (James Gresham)
james.beard@gene.ge.com (James Beard)
jcurtiss@winston.com (Jim Curtiss)
jgutierrez@morganlewis.com (Jay M. Gutierrez)
jim.riccio@wdc.greenpeace.org (James Riccio)
JJD1@nrc.gov (John Donohue)
JJNesrsta@cpsenergy.com (James J. Nesrsta)
john.o'neil@pillsburylaw.com (John O'Neil)
Joseph.savage@ge.com (Joseph Savage)
Joseph_Hegner@dom.com (Joseph Hegner)
junichi_uchiyama@mnes-us.com (Junichi Uchiyama)
KSutton@morganlewis.com (Kathryn M. Sutton)
kwaugh@impact-net.org (Kenneth O. Waugh)
Margaret.Bennet@dom.com (Margaret Bennet)
maria.webb@pillsburylaw.com (Maria Webb)
mark.beaumont@wsms.com (Mark Beaumont)
matias.travieso-diaz@pillsburylaw.com (Matias Travieso-Diaz)
media@nei.org (Scott Peterson)
mike_moran@fpl.com (Mike Moran)
mwetterhahn@winston.com (M. Wetterhahn)
nirsnet@nirs.org (Michael Mariotte)
patriciaL.campbell@ge.com (Patricia L. Campbell)
paul.gaukler@pillsburylaw.com (Paul Gaukler)
Paul@beyondnuclear.org (Paul Gunter)
pshastings@duke-energy.com (Peter Hastings)
RJB@NEI.org (Russell Bell)
RKTemple@cpsenergy.com (R.K. Temple)
roberta.swain@ge.com (Roberta Swain)
rod.krich@constellation.com (Mr. Rod Krich)
ronald.hagen@eia.doe.gov (Ronald Hagen)
Ronda.pederson@areva.com (Ronda Pederson)
sandra.sloan@areva.com (Sandra Sloan)
sfrantz@morganlewis.com (Stephen P. Frantz)

steven.hucik@ge.com (Steven Hucik)
tkkibler@scana.com (Tria Kibler)
tom.miller@hq.doe.gov (Tom Miller)
trsmith@winston.com (Tyson Smith)
VictorB@bv.com (Bill Victor)
vijukrp@westinghouse.com (Ronald P. Vijuk)
waraksre@westinghouse.com (Rosemarie E. Waraks)
wayne.marquino@ge.com (Wayne Marquino)
whorin@winston.com (W. Horin)

FINAL SAFETY EVALUATION BY THE OFFICE OF NEW REACTORS
ANP-10275(P), "U.S. EPR INSTRUMENT SETPOINT METHODOLOGY TOPICAL REPORT" (TAC NO. MD4976)
PROJECT NO. 733

1.0 INTRODUCTION AND BACKGROUND

By letter dated March 26, 2007, U.S. Nuclear Regulatory Commission's ADAMS Accession Number (ML070880714), as supplemented by letters dated August 24, 2007 (ML072400032), and October 11, 2007 (ML073030202), AREVA NP (AREVA) submitted for U.S. Nuclear Regulatory Commission (NRC) staff review Topical Report (TR) ANP-10275P, "[United States Evolutionary Power Reactor] U.S. EPR Instrument Setpoint Methodology Topical Report," Revision 0, ADAMS Accession Number (ML070880719 (non-proprietary and proprietary copy)]. AREVA requested that the NRC issue a safety evaluation report which approves the use of the correlation.

AREVA states that Topical Report ANP-10275P, Revision 0 (Reference 1) documents the instrument setpoint methodology applied to the U.S. EPR protection system. The protection system is a digital, integrated reactor protection system (RPS) and engineered safety features actuation system (ESFAS) implemented for the U.S. EPR. AREVA further states that the methodology described in this report will be used to establish technical specification setpoints for the U.S. EPR protection system.

The setpoint methodology is used to determine instrument setpoints for the protection system to detect plant conditions that indicate the occurrence of design basis events, and initiate the plant safety features required to mitigate the event. Reconciliation of the final trip setpoint calculation for each plant cannot be performed until the design for the plant is finalized. Prior to initial fuel load, a reconciliation of this setpoint study against the final design for each plant will be performed, as required by the Inspection, Test, and Analysis Acceptance Criteria (ITAAC).

Topical Report ANP-10275P uses the latest industry guidance provided by American National Standards Institute (ANSI), and Instrument Society of America (ISA), ANSI/ISA-67.04.01-2006, "Setpoint for Nuclear Safety-Related Instrumentation," May, 2006. The basic uncertainty algorithm is the square-root-sum-of-squares (SRSS) of the applicable uncertainty terms, which is endorsed by the ISA standard. This setpoint methodology utilized ISA-RP67.04.02-2000 as a general guideline. The latest version of Regulatory Guide 1.105, Revision 3, "Setpoint for Safety-Related Instrumentation," endorses the 1994 version of ISA S67.04, Part 1. The setpoint methodology and calculations for the RPS/ESFAS functions are consistent with the guidance contained in Regulatory Guide 1.105.

2.0 REGULATORY EVALUATION

The following regulatory requirements and guidance documents are applicable to the staff's review of the ANP-10275P:

Pursuant to 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 and that controls be provided to maintain these variables and systems within prescribed operating ranges.

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

Paragraph (c)(ii)(A) of 10 CFR 50.36, "Technical Specifications," requires that the technical specifications include limiting safety system settings. This paragraph specifies, in part, that "where a limiting safety system setting is specified for a variable on which a safety limit has been placed, the setting must be chosen so that automatic protective action will correct the abnormal situation before a safety limit is exceeded." Accordingly, the setpoints for instrument channels that initiate protective functions must be properly established in this setpoint methodology.

Regulatory Guide 1.105, "Setpoint for Safety-Related Instrumentation," describes a method acceptable to the NRC staff for complying with the NRC's regulations for ensuring that setpoints for safety-related instrumentation are initially within and remain within the safety limit.

The NRC staff's review was based on the evaluation of the technical merit of the submittal and compliance with any applicable regulations associated with reviews of TR and its supplements (Reference 1, 2, and 3).

3.0 TECHNICAL EVALUATION

The establishment of setpoints and the relationships between trip setpoints, allowable value (AV), as-left, as-found, and analytical limit, and safety limit 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 safety limits are chosen to protect the integrity of physical barriers that guard against the uncontrolled release of radioactivity. The safety limits are typically provided in the plant safety analyses. The analytical limit is established to ensure that the safety limit is not exceeded. The analytical limit is developed from event analyses models that consider parameters such as process delays, rod insertion times, reactivity changes, instrument response times, etc.

The AV is a value that the instrument channel should be evaluated for operability to protect the safety limit when the test is performed. An "as-found value (setpoint)" within the AV ensures that sufficient margin allocation exists between this as-found value and analytical limit to account for instrument uncertainties that are not measured during periodic testing (channel operational test, calibration test). This periodic test provides assurance that the analytical limit will not be exceeded if the AV is satisfied. The AV also provides a means to identify unacceptable instrument performance that may require corrective action.

In 10 CFR 50.36(c)(1)(ii)(A) states that the limiting safety system settings (LSSS) are settings for automatic protective devices related to those variable having significant safety functions. Where an LSSS 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. In the AREVA methodology, the trip setpoint is established to ensure that an instrument channel trip signal occurs before the safety limit is reached and to minimize spurious trips close to the normal operating point of the process.

The AREVA setpoint methodology combines the uncertainty of the components to determine the overall Channel Uncertainty (CU) for the functions of the RPS/ESFAS. All appropriate and applicable uncertainties have been considered for each RPS/ESFAS function. The methodology used to combine the uncertainty components for a channel is an appropriate combination of those groups which are statistically and functionally independent. Those uncertainties which are not independent are conservatively treated by arithmetic summation and then systematically combined with the independent terms. It includes instrument (sensor and process rack) uncertainties and non-instrument related effects (process measurement accuracy). The methodology used the SRSS technique which is approved by the NRC. Also, ANSI/ANS and ISA approve the use of the same probabilistic and statistical techniques for the various standards in determining the setpoints.

The CU calculation is based on the followings:

I. Random 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.

II. Dependent uncertainties are combined algebraically to create a larger independent uncertainty that is eligible for SRSS combination.

III. Bias 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 in the worst direction. These are classified as bias with an unknown sign.

The CU value is established at a 95 percent probability and a 95 percent confidence level, which are consistent with the requirement of RG 1.105. This CU value is compared with the total allowance (TA) for determination of instrument channel margin. The TA is established by adding margin to the CU. The vendor provides acceptable commitment that the margin is large enough for AV assurance that the purpose of the AV is still satisfied by providing a large enough allowance to account for those uncertainties not measured during the test. Having determined the safety analytical limit (SAL) and TA, the nominal trip setpoint (NTSP) can be calculated by subtracting (adding) TA from (to) SAL, depending on the direction of process variable change when approaching the SAL.

The “as-left” value is established by the required accuracy band (calibration accuracy) that a device or instrument channel must be calibrated to the NTSP within during surveillance. The “as-left” condition is the state which the instrument channel is left after calibration or trip setpoint verification. Additionally, if the “as-found” value is within the “as-left” tolerance then recalibration is not required. The AVs are set equal to the Performance Test Acceptance Criteria, referred to as the "as-found" tolerance in the U.S. EPR instrument setpoint methodology. The AV defines the maximum possible value at which the analytical limit is protected. These acceptance criteria are established to provide reasonable assurance that the protection system performs as required and that there is no degradation of the protection system. The determination of the AV tolerance shall include those effects expected during the test such as the rack accuracy, instrument uncertainties during normal operation including drift, and measurement & test equipment uncertainties. Periodic testing is required to verify that safety-related or important-to-safety instrumentation performs as required. The capability of the racks to be calibrated to within these tolerances defines channel operability as the AV. If the "as-found" value exceeds the AV during surveillance testing, the channel is declared inoperable. The associated criteria included in technical specification will be determined at time of the plant specific design. If this TR is referenced in a design certification application, the application needs to include ITAAC for the plant specific setpoint analysis which details the procedures for establishing the setpoints including the margins. The staff will review the proposed ITAAC during the design certification review.

4.0 CONCLUSION

The staff has reviewed the U.S. EPR Instrument Setpoint Methodology Topical Report and the associated supplements (References 1, 2, 3) and found that this methodology provides assurance for the margins such that the AV is satisfied by providing large enough allowance to account for those uncertainties not measured during the surveillance tests to protect the safety limit. Therefore, the staff concludes that the proposed ANP-10275P "U.S. EPR Instrument Setpoint Methodology Topical Report," is acceptable. If this TR is referenced in the design certification application, the plant specific setpoint analysis including margins and associated criteria in accordance with the 10 CFR 50.36 will be verified by the ITAAC.

5.0 REFERENCES

1. U.S. EPR Instrument Setpoint Methodology Topical Report (ANP-10275P, Revision 0), dated March 2007 (AREVA Proprietary)

2. Letter from R. L. Gardner (AREVA) to NRC, dated August 24, 2007, Response to a Request for Additional Information Regarding ANP-10275P "U.S. EPR Instrument Setpoint Methodology Topical Report" (TAC No. MD4976)

3. Letter from R. L. Gardner (AREVA) to NRC, dated October 11, 2007, Revised Response to a Request for Additional Information Regarding ANP-10275P "U.S. EPR Instrument Setpoint Methodology Topical Report" (TAC No. MD4976)

Principal Contributor: Sang Rhow

The Staff's Disposition of AREVA's Comments on the Draft SE

1. Page 1, Section 1.0: ANSI/ISA-67.04.01-2000 has been revised. AREVA NP requests a revision to the DSER since AREVA NP is using the latest revision to the standard which is ANSI/ISA-67.04.01-2006.

   DISPOSITION
   The text is revised to reflect ANSI/ISA-67.04.01-2006.

2. Page 1, Section 1.0: AREVA NP is using the guidance provided in RIS 2006-17 in addition to Regulatory Guide 1.105 to comply with the latest industry and NRC concerns regarding performance test acceptance criteria.

   DISPOSITION
   The SE wording pointed to in this request remains unchanged.

3. Page 3, Section 3.0: ANP-10275P does not make the statements currently shown in the DSER. AREVA NP requests that Items I, II, and III be re-written to summarize the treatment of random, dependant, and bias terms as stated in Section 2.1.3 of ANP-10275P.

   AREVA NP requests replacing the DSER statements in Items I, II, and III after "The CU calculation is based on the following" with:

   I. "Random 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."

   II. "Dependent uncertainties are combined algebraically to create a larger independent uncertainty that is eligible for SRSS combination."

   III. "Bias 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 in the worst direction. These are classified as bias with an unknown sign."

   DISPOSITION
   The text is revised to reflect AREVA's requests I, II, and III as written above.

4. Page 3, Section 3.0: AREVA NP requests rewording the second to last paragraph as follows to remove terms that are not used by AREVA NP and add terms used in ANP-10275P to comply with ANSI/ISA-67.04.01-2006 and RIS 2006-17:

   The CU value is established at a 95 percent probability and a 95 percent confidence level, which are consistent with the requirement of RG 1.105. This CU value is compared with the analytical limit (AL) for determination of the limiting trip setpoint (LTSP). The nominal trip setpoint (NTSP) is established by adding margin to the CU. The vendor provides acceptable commitment that the margin is large enough for AV assurance that the purpose of the AV is still satisfied by providing a large enough allowance to account for those uncertainties not measured during the test. Having determined the AL and CU, the LTSP can be calculated by subtracting (adding) CU from (to) AL, depending on the direction of process variable change when approaching the AL.

DISPOSITION
The SE wording pointed to in this request remains unchanged.

5. Page 3 **[4]**, Section 3.0: AREVA NP requests the following rewording change to the beginning of the last paragraph for clarification.

   The "as-left" value is established by the required accuracy band (calibration accuracy) that a device or instrument channel must be calibrated to the NTSP within during surveillance. The "as-left" condition is the state which the instrument channel is left after calibration or trip setpoint verification. Additionally, if the "as-found" value is within the "as-left" tolerance then re-calibration is not required. The AVs are set equal to the Performance Test Acceptance Criteria, referred to as the "as-found" tolerance in the EPR instrument setpoint methodology. The AV defines the maximum possible value at which the analytical limit is protected. These...

   DISPOSITION
   The text is revised to reflect AREVA's request and match the paragraph above.

6. Page 3 **[4]**, Section 3.0: AREVA NP requests replacing "calibrated" with "perform" and adding the following sentence "The digital protection system modules (DPS) cannot be calibrated; therefore, the "as found" and "as-left" tolerance are equal" to the last paragraph.

   AREVA's digital protection system cannot be calibrated; therefore, the "capability of the racks to be *calibrated* within these tolerances" needs to be replaced with the "capability of the racks to *perform* within these tolerances".

   DISPOSITION
   The SE wording pointed to in this request remains unchanged.

7. Page 3 **[4]**, Section 3.0: AREVA NP requests deleting "as the AVs along with the NTSP" in the last paragraph.

   It is the intent of AREVA's technical specifications to use "LTSP", not "AV or NTSP". AREVA NP prefers not to provide technical specifications details in ANP-10275P.

   DISPOSITION
   The text is revised to reflect AREVA's request.

March 26, 2007
NRC:07:009

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Request for Review and Approval of ANP-10275P, "U.S. EPR Instrument Setpoint Methodology Topical Report"

Ref. 1: Letter, Ronnie L. Garder (AREVA NP) to Document Control Desk (NRC), "Proposed Plan for the Pre-Application Review of the U.S. EPR," NRC 06:036, September 8, 2006.

Ref. 2: Letter, Ronnie L. Gardner (AREVA NP) to Document Control Desk (NRC), "Proposed Plan for the Pre-Application Review of the U.S. EPR," NRC:07:007, February 14, 2007.

AREVA NP Inc. (AREVA NP) requests the NRC's review and approval of the enclosure, ANP-10275P, "U.S. EPR Instrument Setpoint Methodology Topical Report." This report was identified as a pre-application submittal for the U.S. EPR in Attachment 3 of Reference 1 and Attachment 1 of Reference 2.

The U.S. EPR Instrument Setpoint Methodology Topical Report documents the instrument setpoint methodology applied to the U.S. EPR protection system. The protection system is a digital, integrated reactor protection system and engineered safety features actuation system implemented for the U.S. EPR. The methodology described in this report will be used to establish technical specification setpoints for the U.S. EPR protection system.

AREVA NP requests that the NRC issue a Safety Evaluation Report (SER) that approves this topical report, which will be used to support AREVA NP's U.S. EPR design. AREVA NP plans to reference this topical report in its Design Control Document for the U.S. EPR. Therefore, AREVA NP requests that the NRC provide timely feedback and interactions to inform development of the DCD. AREVA NP requests that the NRC complete its review of the enclosed report and issue the SER by March 2008.

AREVA NP considers some of the material contained in the topical report to be proprietary. As required by 10 CFR 2.390(b), an affidavit is enclosed to support the withholding of the information from public disclosure. Proprietary and non-proprietary versions of the topical report are provided on the enclosed CDs.

D077

If you have any questions related to this submittal, please contact Ms. Sandra M. Sloan, Regulatory Affairs Manager for New Plants Deployment. She may be reached by telephone at 434-832-2369 or by e-mail at sandra.sloan@areva.com.

Sincerely,

Ronnie L. Gardner

Ronnie L. Gardner, Manager
Site Operations and Regulatory Affairs
AREVA NP Inc.

Enclosures

cc: L. Burkhart
G. Tesfaye
Project 733

AFFIDAVIT

STATE OF North Carolina)
) ss.
COUNTY OF Mecklenburg)

1. My name is David Noxon. I am a Principal Engineer in Regulatory Affairs, New Plants Deployment, for AREVA NP Inc. and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by AREVA NP to determine whether certain AREVA NP information is proprietary. I am familiar with the policies established by AREVA NP to ensure the proper application of these criteria.

3. I am familiar with the AREVA NP information contained in the report ANP-10275P, *U.S. EPR Instrument Setpoint Methodology Topical Report*, dated March 2007, and referred to herein as "Document." Information contained in this Document has been classified by AREVA NP as proprietary in accordance with the policies established by AREVA NP for the control and protection of proprietary and confidential information.

4. This Document contains information of a proprietary and confidential nature and is of the type customarily held in confidence by AREVA NP and not made available to the public. Based on my experience, I am aware that other companies regard information of the kind contained in this Document as proprietary and confidential.

5. This Document has been made available to the U.S. Nuclear Regulatory Commission in confidence with the request that the information contained in this Document be withheld from public disclosure. The request for withholding of proprietary information is made in accordance with 10 CFR 2.390. The information for which withholding from disclosure is

requested qualifies under 10 CFR 2.390(a)(4) "Trade secrets and commercial or financial information".

6. The following criteria are customarily applied by AREVA NP to determine whether information should be classified as proprietary:

(a) The information reveals details of AREVA NP's research and development plans and programs or their results.

(b) Use of the information by a competitor would permit the competitor to significantly reduce its expenditures, in time or resources, to design, produce, or market a similar product or service.

(c) The *information includes* test *data or analytical* techniques *concerning* a process, methodology, or component, the application of which results in a competitive advantage for AREVA NP.

(d) The information reveals certain distinguishing aspects of a process, methodology, or component, the exclusive use of which provides a competitive advantage for AREVA NP in product optimization or marketability.

(e) The information is vital to a competitive advantage held by AREVA NP, would be helpful to competitors to AREVA NP, and would likely cause substantial harm to the competitive position of AREVA NP.

The information in the Document is considered proprietary for the reasons set forth in paragraphs 6(b) and 6(c) above.

7. In accordance with AREVA NP's policies governing the protection and control of information, proprietary information contained in this Document have been made available, on a limited basis, to others outside AREVA NP only as required and under suitable agreement providing for nondisclosure and limited use of the information.

8. AREVA NP policy requires that proprietary information be kept in a secured file or area and distributed on a need-to-know basis.

9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

David B. Noxon

STATE OF NORTH CAROLINA
COUNTY OF MECKLENBERG

SUBSCRIBED before me this 23rd

day of March, 2007.

Karen F. Davis

Karen F. Davis

NOTARY PUBLIC, STATE OF North Carolina
MY COMMISSION EXPIRES: 02/22/2009

KAREN F. DAVIS

nrc·ic·07·044

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

July 25, 2007

Mr. Ronnie L. Gardner
AREVA NP Inc.
3315 Old Forest Road
P.O. Box 10935
Lynchburg, VA 24506-0935

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION REGARDING ANP-10275P, "U.S. EPR INSTRUMENT SETPOINT METHODOLOGY TOPICAL REPORT" (TAC NO. MD4976)

Dear Mr. Gardner:

By letter dated March 26, 2007 (ML070880714), AREVA NP (AREVA) submitted for U.S. Nuclear Regulatory Commission (NRC) staff review Topical Report (TR) ANP-10275P, "U.S. EPR Instrument Setpoint Methodology Topical Report" [ML070880724 (proprietary) and ML070880719 (non-proprietary)]. The NRC staff has reviewed the application and has determined that additional information is required. Our questions are provided in the enclosure.

A draft of the request for additional information (RAI) was provided to you on June 19, 2007 (ML071770483), and discussed with your staff in a post submittal telephone conference on June 26, 2007. As a result of that discussion the staff agreed to remove Draft RAI 2. Your staff has agreed that your response would be provided within 30 days of the date of this letter.

If you have any questions regarding this matter, I may be reached at 301-415-3361.

Sincerely,

Getachew Tesfaye, Sr. Project Manager
EPR Projects Branch 1
Division of New Reactor Licensing
Office of New Reactors

Project No. 733

Enclosure: Request for Additional Information

cc: DC AREVA - EPR Mailing List

REQUEST FOR ADDITIONAL INFORMATION (RAI)

ANP-10275P, "U.S. EPR INSTRUMENT SETPOINT METHODOLOGY TOPICAL REPORT" (TAC NO. MD4976)

PROJECT NUMBER 733

RAI 1) The setpoint methodology added a margin to the instrument channel uncertainty (CU) to derive the nominal trip setpoint (NTSP) from the analytical limit (AL). Provide the criteria regarding how much the margin has been added to the CU.

RAI 2) This topical report states that the instrument is declared inoperable if the As-Found (AF) value exceeds the Allowable Value (AV). Difference between AF and AV is a value of the margin. Justify why the AF tolerance is not used to determine the operability of the channel (instrument).

Enclosure

cc:

Mr. Glenn H. Archinoff
AECL Technologies
481 North Frederick Avenue
Suite 405
Gaithersburg, MD 20877

Ms. Michele Boyd
Legislative Director
Energy Program
Public Citizens Critical Mass Energy
and Environmental Program
215 Pennsylvania Avenue, SE
Washington, DC 20003

Mr. Marvin Fertel
Senior Vice President
and Chief Nuclear Officer
Nuclear Energy Institute
1776 I Street, NW
Suite 400
Washington, DC 20006-3708

Mr. Ray Ganthner
AREVA, Framatome ANP, Inc.
3315 Old Forest Road
P.O. Box 10935
Lynchburg, VA 24506-0935

Dr. Charles L. King
Licensing Manager, IRIS Project
Westinghouse Electric Company
Science and Technology Department
20 International Drive
Windsor, CT 06095

Ms. Sherry McFaden
Framatome NP, Inc.
3315 Old Forest Road, OF-16
Lynchburg, VA 24501

Mr. John O'Neill
Pillsbury, Winthrop, Shaw, Pittman
2300 N Street, NW
Washington, DC 20037

Mr. Steve Seitz
AREVA
100 Dean Road
East Lyme, CT 06333

Mr. Robert E. Sweeney
IBEX ESI
4641 Montgomery Avenue
Suite 350
Bethesda, MD 20814

Mr. Gary Wright
Director
Division of Nuclear Facility Safety
Illinois Emergency Management Agency
1035 Outer Park Drive
Springfield, IL 62704

Email

APH@NEI.org (Adrian Heymer)
awc@nei.org (Anne W. Cottingham)
bob.brown@ge.com (Robert E. Brown)
BrinkmCB@westinghouse.com (Charles Brinkman)
carey.fleming@constellation.com (Carey Fleming)
chris.maslak@ge.com (Chris Maslak)
cwaltman@roe.com (C. Waltman)
david.hinds@ge.com (David Hinds)
david.lewis@pillsburylaw.com (David Lewis)
dlochbaum@UCSUSA.org (David Lochbaum)
erg-xl@cox.net (Eddie R. Grant)
frankq@hursttech.com (Frank Quinn)
gcesare@enercon.com (Guy Cesare)
greshaja@westinghouse.com (James Gresham)
james.beard@gene.ge.com (James Beard)
jgutierrez@morganlewis.com (Jay M. Gutierrez)
jim.riccio@wdc.greenpeace.org (James Riccio)
JJNesrsta@cpsenergy.com (James J. Nesrsta)
john.o'neil@pillsburylaw.com (John O'Neil)
Joseph.savage@ge.com (Joseph Savage)
Joseph_Hegner@dom.com (Joseph Hegner)
junichi_uchiyama@mhi.co.jp (Junichi Uchiyama)
KSutton@morganlewis.com (Kathryn M. Sutton)
kwaugh@impact-net.org (Kenneth O. Waugh)
maria.webb@pillsburylaw.com (Maria Webb)
mark.beaumont@wsms.com (Mark Beaumont)
matias.travieso-diaz@pillsburylaw.com (Matias Travieso-Diaz)
media@nei.org (Scott Peterson)
mike_moran@fpl.com (Mike Moran)
mwetterhahn@winston.com (M. Wetterhahn)
mwl@nei.org (Melanie Lyons)
patriciaL.campbell@ge.com (Patricia L. Campbell)
paul.gaukler@pillsburylaw.com (Paul Gaukler)
Petrovb@westinghouse.com (Bojan Petrovic)
PGunter@NIRS.org (Paul Gunter)
pshastings@duke-energy.com (Peter Hastings)
RJB@NEI.org (Russell Bell)
RKTemple@cpsenergy.com (R.K. Temple)
roberta.swain@ge.com (Roberta Swain)
rod.krich@constellation.com (Mr. Rod Krich)
Ronda.Daflucas@areva.com (Ronda Daflucas)
ronald.hagen@eia.doe.gov (Ronald Hagen)
sandra.sloan@areva.com (Sandra Sloan)
sfrantz@morganlewis.com (Stephen P. Frantz)
steven.hucik@ge.com (Steven Hucik)
tkkibler@scana.com (Tria Kibler)
tom.miller@hq.doe.gov (Tom Miller)

tom.miller@nuclear.energy.gov (Thomas P. Miller)
trsmith@winston.com (Tyson Smith)
vijukrp@westinghouse.com (Ronald P. Vijuk)
waraksre@westinghouse.com (Rosemarie E. Waraks)
wayne.marquino@ge.com (Wayne Marquino)
whorin@winston.com (W. Horin)

AREVA

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U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Response to a Request for Additional Information Regarding ANP-10275P "U.S. EPR Instrument Setpoint Methodology Topical Report" (TAC No. MD4976)

Ref. 1: Letter, Ronnie L. Gardner (AREVA NP Inc.) to Document Control Desk (NRC), "Request for Review and Approval of ANP-10275P, 'U.S. EPR Instrument Setpoint Methodology Topical Report'," NRC:07:009, March 26, 2007.

Ref. 2: Letter, Getachew Tesfaye (NRC) to Ronnie L. Gardner (AREVA NP Inc.), "Request for Additional Information Regarding ANP-10275P, 'U.S. EPR Instrument Setpoint Methodology Topical Report' (TAC No. MD4976)," July 25, 2007.

Ref. 3: Letter, Getachew Tesfaye (NRC) to Ronnie L. Gardner (AREVA NP Inc.), "Acceptance for Review of ANP-10275P, 'U.S. EPR Instrument Setpoint Methodology Topical Report' (TAC No. MD4976)," May 3, 2007.

AREVA NP Inc. (AREVA NP) requested the NRC's review and approval of ANP-10275P, "U.S. EPR Instrument Setpoint Methodology Topical Report" in Reference 1. The NRC provided a Request for Additional Information (RAI) regarding this topical report in Reference 2. The response to this RAI is enclosed with this letter, ANP-10275Q1, "Response to a Request for Additional Information ANP-10275P, 'U.S. EPR Instrument Setpoint Methodology Topical Report'."

The RAI response does not contain any information that AREVA NP considers to be proprietary.

AREVA NP plans to reference the topical report ANP-10275P in its Design Control Document (DCD) for the U.S. EPR. Reference 3 states that the NRC plans to complete its review of the topical report and issue the draft safety evaluation by October 31, 2007. AREVA NP understands that this timely response to the RAI supports the scheduled deliverable of the draft safety evaluation.

D077

AREVA NP INC.
An AREVA and Siemens company

3315 Old Forest Road, P.O. Box 10935 Lynchburg, VA 24506-0935
Tel.: 434 832 3000 - Fax: 434 832 3840 - www.areva.com

NRO

If you have any questions related to this submittal, please contact Ms. Sandra M. Sloan, Regulatory Affairs Manager for New Plants Deployment. She may be reached by telephone at 434-832-2369 or by e-mail at sandra.sloan@areva.com.

Sincerely,

Ronnie L. Gardner

Ronnie L. Gardner, Manager
Site Operations and Corporate Regulatory Affairs
AREVA NP Inc.

Enclosures

cc: L. Burkhart
G. Tesfaye
Project 733

Response to a Request for Additional Information – ANP-10275P
"U.S. EPR Instrument Setpoint Methodology Topical Report"
(TAC No. MD4976)

***RAI 1**: The setpoint methodology added a margin to the instrument channel uncertainty (CU) to derive the nominal trip setpoint (NTSP) from the analytical limit (AL). Provide the criteria regarding how much the margin has been added to the CU.*

Response 1:

The amount of margin added to the channel uncertainty calculation is discretionary. There is no set value (e.g. 5% or 10%). Reasons for including margin range from simply rounding to the nearest engineering unit on the conservative side to a larger rounding of several engineering units. It takes into consideration the operating parameter values to avoid spurious trips. It may include room for some of the assumptions used for the development of initial uncertainty calculations. Calculations developed during detailed design will determine the plant specific values for the AL, limiting trip setpoint (LTSP), NTSP, and margin.

***RAI 2**: This topical report states that the instrument is declared inoperable if the As-Found (AF) value exceeds the Allowable Value (AV). Difference between AF and AV is a value of the margin. Justify why the AF tolerance is not used to determine the operability of the channel (instrument).*

Response 2:

The statement in the topical report is consistent with the following guidance in RIS 2006-17 (starting in the last paragraph of page 3):

> "The acceptance criteria band should be derived from the licensee's setpoint methodology, including use of generic or plant-specific data. If the as-found TSP exceeds the AV in TSs the channel is inoperable and the associated action requirements are followed. If the change in the measured TSP exceeds the predefined limits but the measured TSP is conservative with respect to the AV, and the licensee determines during the surveillance that the instrument channel is functioning as expected and can reset the channel to within the setting tolerance (amount by which as-left setting value is permitted to differ from NSP) of the NSP, then the licensee may restore the channel to service and the condition is entered into the licensee's corrective action program for further evaluation. However, if during the surveillance the change in the measured TSP exceeds the predefined limits and the licensee cannot determine that the instrument channel is functioning as required, then the instrument is declared inoperable and the associated TS actions are followed. It is NRC staff's position that verifying that the as-found TSP is within the acceptance band limits during test or calibration is part of the determination that an instrument is functioning as required."

The guidance cited in the above paragraph does not require the AF tolerance to be used for operability determination unless the licensee cannot determine that the instrument channel is functioning as required.

As proposed by the Combustion Engineering owners group, the following is the proposed bases change for technical specifications task force document TSTF 493, Rev. 2:

> "However, use of the [LTSP] to define OPERABILITY in Technical Specifications would be an overly restrictive requirement if it were applied as an OPERABILITY limit for the "as -found" value of a protective device setting during a Surveillance. This would result in Technical Specification compliance problems, as well as reports and corrective actions required by the rule which are not necessary to ensure safety. For example, an automatic protective device with a setting that has been found to be different from the [LTSP] due to some drift of the setting may still be OPERABLE since drift is to be expected. This expected drift would have been specifically accounted for in the setpoint methodology for calculating the [LTSP] and thus the automatic protective action would still have ensured that the SL would not be exceeded with the "as -found" setting of the protective device. Therefore, the device would still be OPERABLE since it would have performed its safety function and the only corrective action required would be to reset the device to the trip setpoint to account for further drift during the next surveillance interval."

AREVA NP's proposed requirements are in accordance with those contained in TSTF 493, Rev. 2. AREVA NP will continue to monitor industry progress on the generic resolution of this issue. In addition, AREVA NP will evaluate the final TSTF change related to resolution of the setpoint issue within 90 days after its approval by the NRC. The determination of the as-found tolerance is based on a 95/95 tolerance limit; therefore, the instrument channel cannot be expected to perform within the calculated as-found tolerance 100% of the time. The 95/95 confidence limit is acceptable, in part, due to the inherent redundancy in the U.S. EPR Protection System. By entering the condition into the corrective action program, the licensee can perform an evaluation including checking for any similar performance failures. If multiple performance failures are observed, the channel would then be declared inoperable and maintenance personnel would troubleshoot and repair or replace the appropriate module(s).

The accident analysis assumes operation of the plant within the AL. The LTSP is the minimal setpoint that can be chosen to protect the AL. The AV is based on the uncertainties during testing; therefore, if the channel actuates at or below the AV as established from the LTSP, it satisfies the analysis and is operable. There is no requirement to add margin; however, the addition of any margin is conservative provided that operating margin is not compromised.

AREVA

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U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Revised Response to a Request for Additional Information Regarding ANP-10275P "U.S. EPR Instrument Setpoint Methodology Topical Report" (TAC No. MD4976)

Ref. 1: Letter, Ronnie L. Gardner (AREVA NP Inc.) to Document Control Desk (NRC), "Request for Review and Approval of ANP-10275P, 'U.S. EPR Instrument Setpoint Methodology Topical Report'," NRC:07:009, March 26, 2007.

Ref. 2: Letter, Getachew Tesfaye (NRC) to Ronnie L. Gardner (AREVA NP Inc.), "Request for Additional Information Regarding ANP-10275P, 'U.S. EPR Instrument Setpoint Methodology Topical Report' (TAC No. MD4976)," July 25, 2007.

Ref. 3: Letter, Getachew Tesfaye (NRC) to Ronnie L. Gardner (AREVA NP), "Acceptance for Review of ANP-10275P, 'U.S. EPR Instrument Setpoint Methodology Topical Report' (TAC No. MD4976)," May 3, 2007.

Ref. 4: Letter, Ronnie L. Gardner (AREVA NP Inc.) to Document Control Desk (NRC), "Response to a Request for Additional Information Regarding ANP-10275P 'U.S. EPR Instrument Setpoint Methodology Topical Report' (TAC No. MD4976)," NRC:07:041, August 24, 2007.

AREVA NP Inc. (AREVA NP) requested the NRC's review and approval of ANP-10275P, "U.S. EPR Instrument Setpoint Methodology Topical Report" in Reference 1. The NRC provided a Request for Additional Information (RAI) regarding this topical report in Reference 2. The original response to this RAI was provided in Reference 4.

The response to RAI 2 has been revised to reflect a telephone discussion of this response with the NRC on October 2, 2007. The revised response, which includes revised pages to the topical report, is enclosed with this letter, ANP-10275Q1 Revision 1, "Response to a Request for Additional Information Regarding ANP-10275P 'U.S. EPR Instrument Setpoint Methodology Topical Report'."

AREVA NP plans to reference the topical report ANP-10275P in its Design Control Document (DCD) for the U.S. EPR. Reference 3 states that the NRC plans to complete its review of the topical report and issue the draft safety evaluation by October 31, 2007. AREVA NP understands that this timely response to the RAI supports the scheduled deliverable of the draft safety evaluation.

AREVA NP INC.
An AREVA and Siemens company

3315 Old Forest Road, P.O. Box 10935, Lynchburg, VA 24506-0935
Tel.: 434 832 3000 - Fax: 434 832 3840 - www.areva.com

D077
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Sincerely,

Ronnie L. Gardner

Ronnie L. Gardner, Manager
Site Operations and Corporate Regulatory Affairs
AREVA NP Inc.

Enclosure

cc: L. Burkhart
G. Tesfaye
Project 733

Revised Response to a Request for Additional Information – ANP-10275P "U.S. EPR Instrument Setpoint Methodology Topical Report" (TAC No. MD4976)

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The amount of margin added to the channel uncertainty calculation is discretionary. There is no set value (e.g. 5% or 10%). Reasons for including margin range from simply rounding to the nearest engineering unit on the conservative side to a larger rounding of several engineering units. It takes into consideration the operating parameter values to avoid spurious trips. It may include room for some of the assumptions used for the development of initial uncertainty calculations. Calculations developed during detailed design will determine the plant specific values for the AL, limiting trip setpoint (LTSP), NTSP, and margin.

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Response 2:

The topical report will be revised to reflect that the AV equals the AF tolerance. See attached revised pages to the topical report.

Attachment: Response to RAI 2 - Revised topical report pages 4-4 and 4-5.

Total loop calibration

$$PTAC_{LOOP} = [(RA)^2 + (M\&TE)^2 + (M\&TEr)^2 + (DR)^2 + (RA_{DPS\ Module1})^2$$

$$+ (RA_{DPS\ Module2})^2 + (\ldots\ldots)^2]^{1/2}$$

For loops with additional components prior to the DPS racks, the additional components will be treated like the sensor calibration for an individual component calibration. If a loop calibration is performed, the RA and DR of the extra components will be included in the SRSS equation.

The AVs represent the upper limit of the PTAC per ANSI/ISA-67.04.01-2006. The following formulas will be used for the determination of the AV:

Increasing Process

$$AV = NTSP + PTAC$$

Decreasing Process

$$AV = NTSP - PTAC$$

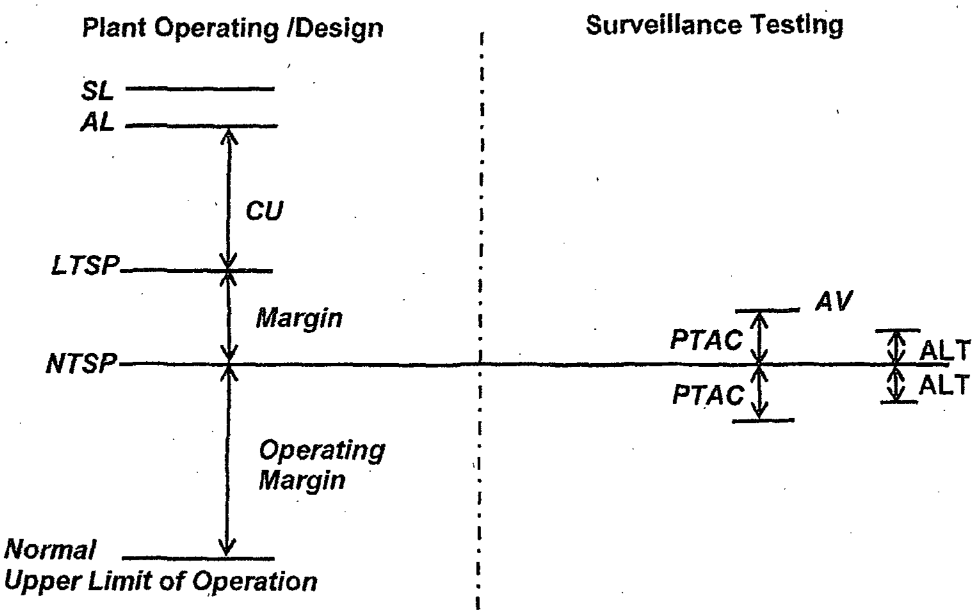
Providing that the NTSP is reset or left within the ALT at the end of each surveillance, and the NTSP is more conservative than the LTSP, the LTSP would protect the safety limit since the CU is calculated based on all uncertainties, including the ones used for the determination of the PTAC and the AV. This is consistent with RIS 2006-17 which states "the LTSP protects the Safety Limit". The following concept (#5) from TSTF-493 is applicable:

The AV (defined as the least conservative acceptable as-found surveillance value) defines the maximum possible value for process measurement at which the AL is protected. The AV verifies that the AL and Safety Limit are still protected at the time of the surveillance. Since OPERABILITY of the instrument channel is determined at the time of the surveillance performance, the fact that the tested trip point occurred conservative to the AV ensures that at that point in time the channel would have functioned to protect the AL and is OPERABLE. With the implementation of these concepts, calculation of the AV using any of the ISA S67.04 Part II methods is acceptable.

Figure 4.2-1 illustrates the relationships between setpoint terms.

Figure 4.2-1 Setpoint Relationships

(for Increasing Process)



ANP-10275NP
Revision 0

U.S. EPR Instrument Setpoint Methodology Topical Report

March 2007

AREVA NP Inc.

Non-Proprietary

ABSTRACT

This report documents the instrument setpoint methodology applied to the U.S. EPR protection system. The protection system is a digital, integrated reactor protection system and engineered safety features actuation system implemented for the U.S. EPR. The primary purpose of the protection system is to detect plant conditions that indicate the occurrence of a design basis event and initiate the plant safety features required to mitigate the event. These safety features consist primarily of the automatic actuation of reactor trips and engineered safety features systems.

The methodology described in this topical report will be used to establish technical specification setpoints for the U.S. EPR protection system. To demonstrate the application of the setpoint methodology, a sample group of U.S. EPR protection system functions is analyzed.

Nature of Changes

Item	Section(s) or Page(s	Description and Justification

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Nomenclature

Acronym	**Definition**
AIM	Analog Input Module for the A/D conversion
AF	As-found
AL	Analytical Limit
ARE	Accident Radiation Effect
ASM	Analog Signal Module
ASME	American Society of Mechanical Engineers
ATE	Accident Temperature Effect
ALT	As-Left Tolerance
AV	Allowable Value
B	Bias
CT	Calibration Tolerance
CU	Channel Uncertainty
CVCS	Chemical and Volume Control System
COL	Combined License
DNBR	Departure from Nucleate Boiling Ratio
DPS	Digital Protection System
DR	Drift
EFWS	Emergency Feedwater System
GDC	General Design Criteria
HCPL	High Core Power Level
HLPD	High Linear Power Density
IR	Insulation Resistance Effect
ISA	Instrumentation, Systems and Automation Society
LOCA	Loss-of-Coolant Accident
LOOP	Loss of Off-Site Power
LTSP	Limiting Trip Setpoint
LSSS	Limiting Safety System Setting
ME	Miscellaneous Effects
MFWS	Main Feedwater System
MSIV	Main Steam Isolation Valve
MSRCV	Main Steam Relief Control Valve
MSRT	Main Steam Relief Train
M&TE	Measurement and Test Equipment
M&TEr	Measurement and Test Equipment Readability

Acronym	**Definition**
MTE	Measurement and Test Equipment Effect
NR	Narrow Range
NTSP	Nominal Trip Setpoint
PE	Primary Element
PM	Process Measurement
PRZ	Pressurizer
PSRV	Pressurizer Safety Relief Valve
PTAC	Performance Test Acceptance Criteria
RA	Reference Accuracy
RCCA	Rod Cluster Control Assembly
RCP	Reactor Coolant Pump
RCS	Reactor Coolant System
RE	Radiation Effect
RPMS	Rod Position Measurement System
RT	Reactor Trip
RTD	Resistance Temperature Detector
SE	Seismic Effect
SER	Safety Evaluation Report
SG	Steam Generator
SH	Self Heating Error
SIS	Safety Injection Signal
SMM	Standard Signal Multiplier Module
SP	Static Pressure Effect
SPND	Self-powered Neutron Detectors
SRSS	Square Root of the Sum of the Squares
TE	Temperature Effect
WR	Wide Range

1.0 INTRODUCTION

This topical report describes the AREVA NP Inc. instrument setpoint methodology used for the U.S. EPR. Instrument setpoints are analyzed by determining the applicable contributors to instrumentation loop errors, the method in which they are combined, and the method in which these errors are applied to the design analytical limits (ALs).

The methodology used to determine instrument uncertainties is addressed in Section 2.0. The methodology is applicable to U.S. EPR protection system functions that have associated setpoints. To demonstrate the application of this methodology, a sample of the functions associated with the U.S. EPR protection system is analyzed.

The protection system is a digital, integrated reactor protection system and engineered safety features actuation system implemented for the U.S. EPR. Its primary purpose is to detect plant conditions that indicate the occurrence of a design basis event, and initiate the plant safety features required to mitigate the event. These safety features consist primarily of the automatic actuation of reactor trips (RTs) and the automatic actuation of engineered safety features systems.

Section 3.1 provides a sample of the various inputs into the protection system and details of the statistical method of error combination. The majority of protection system trips or protection functions is based on single channel inputs; therefore, the uncertainties identified in Section 3.1 are applicable for the trip. Section 3.2 addresses the protection system trips or protection functions that are based on multiple inputs. The discussion of these complex functions includes the combination of inputs and associated errors that are determined in Section 3.1.

This report addresses the uncertainty methodology for the inputs to complex functions, with the exception of the self-powered neutron detectors (SPNDs). Incore instrumentation, high linear power density (HLPD), high core power level (HCPL), low saturation margin, anti-dilution, and departure from nucleate boiling ratio (DNBR) are outside the scope of this report because they use a statistical methodology other than square root sum of the sum of the squares (SRSS), such as an approved safety analysis code.

This methodology was developed in accordance with Regulatory Guide 1.105 (Reference 3), complies with ANSI/ISA-67.04-01-2006 (Reference 7), and is consistent with error combinations guidance established by ISA-RP67.04.02-2000 (Reference 8). In addition, this methodology addresses the latest developments under RIS 2006-17 (Reference 4) and TSTF-493 (Reference 9).

The limiting trip setpoint (LTSP) is the limiting safety system setting (LSSS) since all known errors are appropriately combined in the total loop uncertainty calculation (TSTF-493). The nominal trip setpoint (NTSP) is derived from the AL and accounts for total loop uncertainties and margin. Section 4.1 provides the relationship between the AL, LTSP, NTSP, and channel uncertainty (CU). Section 4.2 addresses the performance test acceptance criteria (PTAC). Section 4.3 provides a summary table for all of the sample protection functions, and Section 4.4 discusses assumptions made during the development of this report. Section 5 discusses the summary and conclusions.

AREVA NP requests that the NRC issue a Safety Evaluation Report (SER) that approves the use of the setpoint methodology presented in this topical report. The U.S. EPR Setpoint Methodology Topical Report will be used to develop setpoints associated with the protection system. AREVA NP plans to reference this topical report in its Design Control Document for the U.S. EPR.

2.0 METHODOLOGY DESCRIPTION

2.1 *Background*

2.1.1 *Regulatory Basis for the Methodology*

10 CFR 50.36(c)(1)(ii)(A) (Reference 1) and General Design Criteria (GDC) 13 and 20 of 10 CFR 50, Appendix A (Reference 2) apply to instrument setpoints.

10 CFR 50.36(c)(1)(ii)(A) requires that, where an LSSS is specified for a variable on which a safety limit has been placed, the setting must be chosen so that automatic protective action will correct the most severe abnormal situation anticipated without exceeding a safety limit. LSSSs are settings for automatic protective devices related to those variables having significant safety functions. A setpoint found to exceed technical specification limits is considered a malfunction of an automatic safety system. Such an occurrence can challenge the integrity of the reactor core, reactor coolant pressure boundary, containment, and associated systems.

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 operation of appropriate systems to assure that specified acceptable fuel design limits are not exceeded.

To meet 10 CFR 50.36(c)(1)(ii)(A), GDC 13 and GDC 20 requirements, Standard Review Plan Appendix 7.1-A (Reference 5) provides a reference to Branch Technical Position HICB-12 (Reference 6) and Draft Regulatory Guide DG-1045 (later issued as Regulatory Guide 1.105) for guidance on establishing and maintaining instrument setpoints. Instrumentation, Systems, and Automation Society (previously the Instrument Society of America) ISA S67.04-1994 (Reference 13) was prepared to provide the nuclear industry with guidelines for addressing instrument uncertainties and their associated impact on plant setpoints. Regulatory Guide 1.105 was subsequently revised to endorse ISA S67.04-1994 part I and its discussion of nuclear instrumentation setpoints.

Branch Technical Position HICB-12 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 (Note: This guidance is outside of the scope of this document).
- To confirm that calibration intervals and methods established are consistent with safety analysis assumptions.

2.1.2 *Latest Industry Issues*

An allowable value (AV) is established as a limiting value that the trip setpoint can have when periodically tested. If the value is exceeded during testing, appropriate action is required. The latest developments included in ANSI/ISA-67.04.01-2006 introduce the terms LTSP and as-found (AF) limits, and no longer use the term allowable value.

TSTF-493 was developed to address NRC concerns that the technical specification requirements for LSSSs may not be in full compliance with 10 CFR 50.36. The LTSP is calculated based on plant-specific methodology so that the trip or actuation will occur before the AL is reached. The NTSP may be used to include margin between the AL and the setpoint; however, predefined AF and as-left tolerances (ALTs) for surveillance testing must be maintained around the more conservative NTSP. The intent of these changes is to provide reasonable assurance that realistic values are used to verify that the plant protection system instrumentation is performing as expected during the surveillance testing. Therefore, degradation would not be masked due to excessive tolerances. RIS 2006-17 was issued to resolve concerns that TSTF-493 did not sufficiently address all of the issues, including the test acceptance criteria band for AF instrument values.

The U.S. EPR methodology adopts the use of an NTSP-based assessment of AF values based on the specific conditions stated in RIS 2006-17. Those conditions are:

- The setting tolerance band is less than or equal to the SRSS of reference accuracy, measurement and test equipment (M&TE), and readability uncertainties.
- The setting tolerance is included in the total loop uncertainty.
- The pre-defined test acceptance criteria band for the AF value includes either the setting tolerance or the uncertainties associated with the setting tolerance band, but not both of these.

To meet these conditions and be consistent with RIS 2006-17 and Revision 1 of TSTF-493, the U.S. EPR plant AF acceptance criteria will be assessed based on the NTSP and utilize no more than the SRSS combination of the reference accuracy (RA), M&TE error, measurement and test equipment readability (M&TEr), and drift (DR). Further PTAC details are provided in Section 4.2.

Regulatory Guide 1.105 endorses the use of ISA 67.04-1994 part I. To be consistent with RIS 2006-17, the U.S. EPR uses the latest industry guidance provided by ANSI/ISA 67.04.01-2006, and ISA 67.04.02-2000.

2.1.3 *Statistics*

Instrument uncertainties are categorized as random, bias (B), or random abnormally distributed bias. A random uncertainty is a normally distributed variable that will fall between ± 2 sigma 95.6 percent of the time. These independent uncertainties are 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 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. Some uncertainties possess a significant correlation and are classified as dependent uncertainties. These dependent uncertainties are combined algebraically to create a larger independent uncertainty that is eligible for SRSS combination.

Bias 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 in the worst direction. These are classified as bias with an unknown sign.

Abnormally distributed uncertainties are not eligible for SRSS combination since they do not have a normal distribution. Even if they are as likely to be positive or negative with respect to a given value, they are treated as a bias since they are non-normal.

Regulatory Guide 1.105 states that:

“The 95/95 tolerance limit is an acceptable criterion for uncertainties. That is, there is a 95 percent probability that the constructed limits contain 95 percent of the population of interest for the surveillance interval selected.”

Although the 95/95 tolerance limit has an actual confidence level of 1.96 sigma, 2 sigma is used to simplify calculations. Three sigma confidence levels may be reduced to 2 sigma by multiplying the uncertainty values by two-thirds. If a single value of a process parameter is approached from one direction, ± 1.645 sigma is the appropriate limit to use for 95 percent probability. These instrument uncertainties may use a reduction factor of 1.645 divided by the appropriate sigma value (1.96 or 2 depending on the original symmetric value). However, these error reduction techniques must also be applied to the determination of the PTAC if used to determine the instrument loop CU.

2.2 *General Methodology*

The general methodology used to combine instrument loop uncertainties is a combination of statistical and algebraic methods. Random and independent instrument loop uncertainties are combined using the statistical SRSS approach with abnormally distributed and bias uncertainties combined algebraically in accordance with ISA-RP67.04.02-2000.

The ISA-RP67.04.02-2000 methodology is used in this report with minor changes to the nomenclature to facilitate the presentation. Instrumentation uncertainty for most of the protection system loops is determined by the following equation:

$$\begin{aligned}CU = \pm\ [&(PM_R)^2 + (PE)^2 + (RA_{SENSOR})^2 + (DR_{SENSOR})^2 + (TE_{SENSOR})^2 + (SP_{SENSOR})^2\\ &+ (SE_{SENSOR})^2 + (ARE_{SENSOR})^2 + (ATE_{SENSOR})^2 + (CT_{SENSOR})^2 + (MTE_{SENSOR})^2\\ &+ (DR_{DPS})^2 + (TE_{DPS})^2 + (CT_{DPS})^2 + (MTE_{DPS})^2]^{½} + PM_B + IR_B + B\end{aligned}$$

where:

CU = Channel Uncertainty

PM_R = Process Measurement Uncertainty (random)

PE = Primary Element

RA_{SENSOR} = Sensor Reference Accuracy

DR_{SENSOR} = Sensor Drift

TE_{SENSOR} = Sensor Temperature Effect

SP_{SENSOR} = Sensor Static Pressure Effect

SE_{SENSOR} = Sensor Seismic Effect

ARE_{SENSOR} = Sensor Accident Radiation Effect

ATE_{SENSOR} = Sensor Accident Temperature Effect

CT_{SENSOR} = Sensor Calibration Tolerance

MTE_{SENSOR} = Sensor Measurement and Test Equipment

DR_{DPS} = Digital Protection System Drift Effect

TE_{DPS} = Digital Protection System Temperature Effect

CT_{DPS} = Digital Protection System Calibration Tolerance

MTE_{DPS} = Digital Protection System Measurement and Test Equipment

PM_B = Process Measurement Uncertainty (bias)

IR_B = Insulation Resistance Effects (bias)

B = Bias (others)

Note that the preceding equation is a general example and may not be all inclusive. It is generally valid for protection loops that have only one input. If the measured parameter is calculated from several inputs, a specific approach may be necessary. See Section 3.2 for more details.

The equation accounts for worst case conditions resulting from a harsh environment such as accident radiation effects (AREs) and accident temperature effects (ATEs), insulation resistance effects (IRs), and increased process measurement (PM) uncertainties. Since the error caused by the ATE bounds the normal temperature effect (TE) error, only the ATE_{SENSOR} error would be applied. For some protective setpoints, the process may reach the setpoint and the instrument loop may actuate before accident environmental conditions are reached. For those protective setpoints, the ARE_{SENSOR}, ATE_{SENSOR}, and IR_B terms may not need to be included in the setpoint determination, and the TE_{SENSOR} would be substituted for the ATE_{SENSOR}. Each protective setpoint must be evaluated for the projected process and environmental conditions at the time the protective feature is actuated.

Seismic uncertainties are considered in U.S. EPR protection system setpoint calculations. The overall CU is calculated for a safe shutdown earthquake for the U.S. EPR protection system setpoints.

Only the general error combination technique is described in this general methodology because of the various types of inputs to the protection system and their associated accident considerations. Section 3.1 provides calculation summary tables with the various types of instrument errors for a sampling of inputs to the U.S. EPR protection system. In lieu of actual instrument uncertainty values, which will be available later, applicable parameters are shown as “x.xx.” Instrument uncertainty values shown as “0” do not apply to the application. The specific uncertainty equation for the applicable parameters of each loop is provided at the bottom of each table. In some cases, both normal uncertainty and accident uncertainty for the same instrument loop are provided in separate tables. For example, some pressurizer (PRZ) pressure setpoints are required to mitigate a loss-of-coolant accident (LOCA), but there is also a high pressure setpoint for RT due to the inadvertent closure of one main steam isolation valve (MSIV). Accident uncertainties may be required for analysis of LOCA mitigation; however, only normal uncertainties would be considered in the analysis of an inadvertent closure of one MSIV. Only normal uncertainties will be applied if it is later determined that a trip will occur prior to instrumentation degradation.

2.3 *Sensor Uncertainties*

Eight or seven uncertainty effects are provided in the general equation for the typical transducers for accident and normal conditions, respectively. However, there may be other less common effects provided in the calculation summary tables of Section 3.1. As a general rule, these effects are considered random unless the specifications from the manufacturer state otherwise. Zero and span static pressure effects for differential pressure applications with high operating pressures are expected to be minimized by compensating for them during scaling and calibration, especially if the transmitter is subjected to high static pressure and if there is a large turndown ratio. However, any of these effects that are not removed during the scaling or calibration process must be accounted for in the determination of CU. This error may be considered as a bias for a transmitter whose static pressure effect is in a predictable direction. Power supply effects are typically insignificant because of the excellent voltage regulation and current stability of modern power supply designs. Accident radiation effects are typically considered where high radiation exists during accident conditions. In general, during normal operation, instruments are located in low radiation environments, and normal radiation effects are not applicable to instrument calibration. However, consideration will be given to the effect between the calibration periods if a transmitter is installed in an area where radiation levels are extremely high. Though the larger value of RA or calibration tolerance (CT) may be used instead of including both terms, both values are usually included since the calibration practices sometimes do not repeat point checks enough to provide adequate assurance that the CT encompasses all of the attributes of the RA.

The calibration process involves the errors associated with the process device(s) being calibrated, the M&TE used to measure the input and output of the device(s), the readability of the M&TE (normally included in the M&TE accuracy), and the ability of the technician setting the device(s). The error associated with the devices is usually defined as the RA. RA is based on the capability of the instrument to repeat an output given an identical input for multiple tests. Depending on the number of samples in the test, this term is random approaching a normal distribution. The accuracy of the M&TE is normally verified to be within acceptable bounds 100 percent of the time. The M&TE error is random and the readability is normally defined as random (plus or minus significant digits). The error associated with the actual adjustment of the process instrument may cause a bias for a given calibration. However, over several calibrations, both for a given channel and for all channels associated with a function, the resultant distribution should be random, provided the technicians have been trained to set it as close to the cardinal point without prejudice to either below or above the point.

Multiple random normally distributed errors, even when occurring at the same time, can not be dependent by definition. Only where an abnormal distribution is included can there be dependent conditions. There may be conditions for a given instrument where the specific change as a result to stimuli is predictable. However, the error values are based on groups of instruments and if the groups of instruments respond to stimuli in a random manner, the error used in the calculation is considered random.

For the first calibration of an instrument, the setting of the input is assumed to be exact and the only error is associated with the ability of the instrument to correctly convert that input signal into an output signal. Each subsequent calibration value may be different from the preceding calibration by the RA, the accuracy of the M&TE, the M&TEr, or any bias introduced by the setting of the device and DR. Other environmental or process conditions may also cause a change in the instrument input-to-output relationship. Therefore, procedures and training provide adequate assurance that the setting tolerance is maintained as a random value.

2.4 *Instrumentation and Controls Digital Protection System Uncertainties*

The digital protection system (DPS) modules cannot be calibrated; however, automated self-checking is performed periodically to verify that the DPS modules are functioning as expected. This approach is common to digital systems and discussed in TXS topical report EMF-2341(P) (Reference 14), which was accepted by the NRC in the SER. Since the DPS module calibration check will require that the ALT for each analog module be less than or equal to the specified acceptance criteria, the CT will be considered in lieu of the RA for the module. The CTs of the individual modules are combined as a random term to provide a total uncertainty value for the digital conversion. Likewise, the DR and TE for the different modules are combined to provide a total uncertainty value for the digital conversion. Though there may be some variations in the modules used for the various inputs, the basic determination of the uncertainty components can be demonstrated as follows:

$$CT_{DPS} = \pm (CT_{ASM}^2 + CT_{SMM}^2 + CT_{AIM}^2)^{1/2}$$

$$DR_{DPS} = \pm (DR_{ASM}^2 + DR_{SMM}^2 + DR_{AIM}^2)^{1/2}$$

$$TE_{DPS} = \pm (TE_{ASM}^2 + TE_{SMM}^2 + TE_{AIM}^2)^{1/2}$$

where: ASM is the Analog Signal Module

SMM is the Standard Signal Multiplier Module

AIM is the Analog Input Module for the A/D conversion

Components inside the DPS cabinets are subject to higher temperatures than the ambient room temperature. Thus, a maximum heat rise inside the DPS cabinets will be assumed and used, along with the ambient temperature, to determine the TE on these instruments.

Any significant additional errors such as digital calculation errors, sampling rate uncertainty, and truncation and rounding uncertainty will be considered based on guidance in the determination of uncertainties associated with digital signal processing provided in ISA 67.04.02-2000 Annex H.

2.5 *Miscellaneous Uncertainties*

2.5.1 *Bias Errors*

Although the uncertainty equations depict bias errors as positive errors, they may have a positive or negative value. The positive random and bias values are considered for decreasing process conditions and the negative random and bias values are considered for increasing process conditions. Bias terms in the opposite direction are generally ignored with relation to the AL, but are considered to establish the setpoint in relation to the operating limit. For instance, the negative uncertainties represent the worst case for increasing level; therefore, negative PM uncertainties are used. Although the potential exists for a positive insulation resistance error under harsh environmental conditions, this error would not be used to reduce the negative errors since it may or may not exist. The bounding case for the increasing level example is to combine the negative bias uncertainty with the random uncertainties and ignore the positive uncertainty. However, in some cases a positive bias can cancel out or offset a negative bias and vice versa. This method is only practiced when the direction and magnitude of the biases are known and when both biases are present at the same time.

2.5.2 *Process Measurement Uncertainty*

PM uncertainty includes non-instrument influences such as temperature stratification, and density variations from calibrated conditions. PM uncertainties from density changes because of temperature variations can be reduced by scaling compensation during calibration. Typically, for a flow or level calculation, PM uncertainties that cannot be eliminated are considered to be bias. PM uncertainties for pressure applications are generally not considered since they are typically considered insignificant. PM uncertainty also applies to other influences such as nuclear instrumentation system and calorimetric power, and may be treated as a random error in some cases.

2.5.3 *Primary Element Uncertainty*

The primary element (PE) uncertainty is contained in some instrument loops and converts the measured variable energy into a form that is suitable for measurement. The uncertainty associated with this device is typically considered to be random unless explicitly stated otherwise by the vendor. Examples of this type of element are a flow nozzle, orifice plate, or venturi.

2.5.4 *Miscellaneous Effects*

Miscellaneous effects (ME) are not shown in the example in Section 2.2 since they are only applicable for flow loops. Bends, fittings, and valves in piping systems can cause turbulence in fluid flow. The PM uncertainties created by this turbulence can be minimized by following the guidance of the American Society of Mechanical Engineers (ASME) on acceptable straight piping length recommendations upstream and downstream of the flow elements. The resultant flow measurement error due to piping configuration shall be assumed to be ± 0.5 percent of the discharge coefficient (± 0.5 percent reading) provided the minimum pipe lengths are met. If the minimum criteria cannot be met, an additional tolerance of ± 0.5 percent of reading must be applied to the flow measurement error allowance (Reference 8, 10, 11).

2.5.5 *Measurement and Test Equipment Uncertainties*

ISA S51.1-1979 (Reference 12) states that the uncertainty of M&TE with an accuracy of one-tenth or less of the device under test is mathematically insignificant. Because of the high accuracy of most modern instrumentation, it is becoming increasingly difficult to achieve this ratio; therefore, M&TE uncertainties will be included in all the calculations. The U.S. EPR calibration procedures will be written to specify the appropriate M&TE accuracy for each device or function (Section 4.4). In cases where multiple M&TE devices are used to calibrate a sensor, DPS modules or total loop, the individual M&TE uncertainties will be combined under the SRSS method to establish the M&TE uncertainty.

2.6 *Differential Pressure to Flow Conversion*

Differential pressure (ΔP) transmitters are often used for the measurement of flow. The associated ΔP errors must be expressed in the same base as the flow errors. The following conversion represents the square root relationship between flow and ΔP after removal of the constant terms:

$$F = (\Delta P)^{1/2} \quad \text{and} \quad F^2 = \Delta P$$

therefore:

$$2F\delta F = \delta\Delta P$$

and:

$$\delta F = \delta\Delta P / 2F$$

where δF represents the accuracy of the differential transmitter in terms of flow.

Consider an application with a ΔP error of 2 percent with the flow of interest being 75 percent:

$$\delta F = \delta\Delta P / 2F$$

$$\delta F = 2\% / (2 * 0.75)$$

$$\delta F = 1.33\%$$

where F is flow rate stated as (% flow rate/100)

It shall be noted that the following method example used in ISA 67.04.02-2000 Annex L shall be used at flow rates below 50 percent.

For example, consider an application with a ΔP error of 2 percent with the flow of interest being 15 percent:

$\delta F = \delta\Delta P / 2F$

$\delta F = 2\% / (2 * 0.15)$

$\delta F = 6.67\%$

versus:

$\% \text{ Flow} = 10\ (\%\Delta P)^{1/2}$

therefore:

$\%\ \Delta P = (\% \text{ Flow})^2/100$

$= (15\%)^2/100$

$= 2.25\%$

$\% \text{ Flow} = 10\ (\Delta P\% - \delta\Delta P\%)^{1/2}$

$= 10\ (2.25\% - 2\%)^{1/2}$

$= 5\%$

therefore:

$\delta F = 15\% - 5\%$

$= 10\%$

It is preferable to use a narrow range transmitter in this case.

2.7 *Definitions*

Abnormally Distributed Uncertainties. Uncertainties that do not have a normal distribution and are not eligible for SRSS combination.

Accident Conditions. The worst case environmental conditions expected during or after a design basis event in which the harsh environment may cause degradation to plant instrumentation (e.g. seismic effects, radiation effects, elevated temperatures effects).

Allowable Value (AV). A limiting value that the trip setpoint may have when tested periodically, beyond which appropriate action shall be taken (ISA-RP67.04.02-2000).

Analytical Limit (AL). The limit of a measured or calculated variable established by the safety analysis to ensure that a safety limit is not exceeded (ISA-RP67.04.02-2000).

As-found (AF). The condition in which a channel, or portion of a channel, is found after a period of operations and before recalibration, if necessary (ISA-RP67.04.02-2000).

As-left Tolerance (ALT). The condition in which a channel, or portion of a channel, is left after calibration or final setpoint device setpoint verification (ISA-RP67.04.02-2000).

Bias (B). An uncertainty component that consistently has the same algebraic sign and is expressed as an estimated limit of error (ISA-RP67.04.02-2000). Biases that are fixed and that can be removed (such as static head effect, line loss effect, etc.) will not be accounted for in the uncertainty determination since they will be compensated for in the scaling of the instrumentation. Other bias effects such as process measurement uncertainties for flow and level applications can be reduced during the scaling. Any bias effects that cannot be calibrated out will be accounted for in the uncertainty determination.

Calibration Tolerance (CT). The tolerance allowed during the calibration of a device. This is typically a tolerance provided on both sides of a desired setting or reading.

Channel Uncertainty (CU). The combined uncertainties of an instrument loop including the process, sensing equipment, and digital conversion of the signal.

Conformity. The closeness to which a curve approximates a specified curve.

Drift (DR). An undesired change in output over a period of time where change is unrelated to the input, environment, or load (ISA-RP67.04.02-2000).

Error. The algebraic difference between the indication and the ideal value of the measured signal (ISA-RP67.04.02-2000).

Full Scale. The highest value (100 percent) of the measured parameter that the device is adjusted to measure. Full scale is equal to the span for instruments that are zero-based.

Hysteresis. The variation between the upscale and downscale readings of the measured signal during a full scale traverse for the same input.

Insulation Resistance Effect (IR). The change in measurement signal due to an increase in leakage current between the conductors of instrument signal transmission components such as cables, connectors, splices, etc. The increased leakage is caused by the decrease of component insulation resistance due to extreme changes in environmental conditions and is treated as a bias. Guidance in the determination of IR is provided in ISA 67.04.02-2000 Annex D.

Limiting Trip Setpoint (LTSP). The limiting value for the nominal trip setpoint so that the trip or actuation will occur before the AL is reached, regardless of the process or environmental condition affecting the instrumentation (ANSI/ISA-67.04.01-2006). The term used in the Plant Technical Specifications is the same as the LSSS since the calculation of the LTSP considers all known errors and the appropriate combination of these errors. Margin is not included in the determination of this value.

Limiting Safety System Setting (LSSS). Settings for automatic protective devices related to those variables having significant safety functions (10 CFR 50.36).

Linearity. A specific type of conformity (the deviation between the actual calibration curve and the specified curve).

Lower Range Limit. The minimum lower limit of the span that the device can be adjusted to during calibration.

Margin. In setpoint determination, margin is an allowance added to the instrument CU. It moves the setpoint farther away from the AL and is the difference between the LTSP and the NTSP (ISA-RP67.04.02-2000).

Measurement and Test Equipment Effect (MTE). Uncertainties of the measurement and test equipment utilized during the calibration of a device or multiple devices in an instrument loop.

Nominal Trip Setpoint (NTSP). A predetermined value for actuation of a final setpoint device to initiate a protective action (ANSI/ISA-67.04.01-2006). This is the actual setting value programmed for the protective trip function which accounts for the various instrumentation loop uncertainties including margin for conservatism to ensure the AL is not exceeded.

Normal Conditions. The normal process, plant, and environmental conditions expected during the normal operation of the plant such as process fluid temperatures and pressures, humidity, ambient temperature, and radiation levels.

Performance Test Acceptance Criteria (PTAC). The acceptance criteria for performance tests known as the AF and ALT limits. This term is now used in lieu of “allowable value” in ISA-S67.04-01-2006. The purpose of this terminology change is to keep degradation of instrumentation from being masked due to excessive tolerances during performance testing.

Primary Element (PE). The system element that quantitatively converts the measured variable energy into a form suitable for measurement (ISA-RP67.04.02-2000).

Process Measurement (PM) Uncertainty. Uncertainties which are inherent in the method of measurement of a parameter, or which are caused by changing process or measurement apparatus conditions from a reference condition assumed for the measurement validity. Process effects are not instrument related but are due to characteristics of the process signal received by a sensor. This term may also be known as process allowance or process considerations.

Radiation Effect (RE). The degradation of the instrument as a result of radiation exposure. During normal operating conditions, this effect is assumed to be negligible since it is removed by the calibration process.

Reference Accuracy (RA). A number or quantity that defines a limit that errors will not exceed when a device is used under specified operating conditions (ISA-RP67.04.02-2000). RA for analog devices typically includes the combined three attributes of conformity, hysteresis, and repeatability.

Repeatability. The closeness of agreement among a number of consecutive measurements of the output for the same input value. The measurements must be taken under the same operating conditions, approaching from the same direction, for the full range traverses.

Safety Limits. Limits placed on an important process variables that are found to be necessary to reasonably protect the integrity of certain physical barriers that guard against uncontrolled release of radioactivity (10 CFR 50.36).

Seismic Effect (SE). The uncertainties caused by the vibration associated with an earthquake.

Self Heating Error (SH). The internal heating as a result of the electric energy dissipated from a device such as a resistance temperature detector (RTD).

Sensor. The portion of an instrument channel that responds to changes in a plant variable or condition and converts the measured process variable into a signal; electric or pneumatic (ISA-RP67.04.02-2000),for example.

Span. The algebraic difference between the upper and lower values of a calibrated range (ISA-RP67.04.02-2000).

Static Pressure Effect (SP). The error induced due to the process static pressure differences between calibration and operating conditions.

Temperature Effect (TE). TE accounts for the uncertainties due to the change in ambient temperature from the calibration base temperature to the operating conditions of the same device.

Tolerance. The allowable variation from a specified or true value (ISA-RP67.04.02-2000).

Turndown Ratio. The ratio of the upper range limit to the actual calibrated span of an instrument.

Uncertainty. The amount to which the output of an instrument channel is in doubt (or the allowance made therefore) due to possible errors, either random or systematic, that have not been corrected. The uncertainty is generally identified within a probability and confidence level (ISA-RP67.04.02-2000).

Upper Range Limit. The maximum upper limit of the span to which the device can be adjusted during calibration.

3.0 U.S. EPR PROTECTION SYSTEM

3.1 *System Inputs*

To demonstrate the application of the generic setpoint methodology, a sample of the U.S. EPR protection system functions is analyzed. The protection system functions consist of the RT system and functions related to engineered safety features actuation.

The following is a sample list of the U.S. EPR protection system functions used to demonstrate the general setpoint methodology.

- Pressurizer Pressure (Normal Conditions).
- Pressurizer Pressure (Accident Conditions).
- Pressurizer Level (Normal Conditions).
- Steam Generator Pressure (Normal Conditions).
- Steam Generator Pressure (Accident Conditions).
- Steam Generator Minimum Narrow Range (NR) Level (Accident Conditions).
- Steam Generator Maximum Narrow Range Level (Normal Conditions).
- Steam Generator Minimum Wide Range Level (Accident Conditions).
- Steam Generator Maximum Wide Range Level (Normal Conditions).
- Containment Pressure – Stage 1 (NR).
- Containment Pressure – Stage 2 (WR).
- Hot Leg Pressure (Accident Conditions).
- Power Range Excore Detectors (Accident Conditions).
- Intermediate Range Excore Detectors – High Flux (Accident Conditions).
- Intermediate Range Excore Detectors – Low Doubling Time.
- Narrow Range Hot Leg Temperature (Accident Conditions).

- Narrow Range Cold Leg Temperature (Accident Conditions).
- Wide Range Hot Leg Temperature (Accident Conditions).
- Wide Range Cold Leg Temperature (Accident Conditions).
- Reactor Coolant Pump Speed (Normal Conditions).
- Reactor Coolant Pump Speed (Accident Conditions).
- Reactor Coolant System Flow.
- Rod Cluster Control Assembly Position Primary Coil.
- Rod Cluster Control Assembly Position Secondary Coil.
- Reactor Coolant Pump Differential Pressure (Accident Conditions).

Table 3.1-1 Pressurizer Pressure Input (Normal Conditions)

RT on PRZ Pressure > Max2

Normal Environment	Uncertainty (% Span)
Process & Misc. Effects	
Process Measurement (PM)	
Primary Element (PE)	
Insulation Resistance Error (IR_B)	
Sensor	
Sensor Reference Accuracy (RA_{SENSOR})	
Sensor Drift (DR_{SENSOR})	
Sensor Temperature Effect (TE_{SENSOR})	
Sensor Static Pressure Effect (SP_{SENSOR})	
Sensor Accident Radiation Effect (ARE_{SENSOR})	
Sensor Seismic Effect (SE_{SENSOR})	
Sensor Accident Temperature Effect (ATE_{SENSOR})	
Sensor Calibration Tolerance (CT_{SENSOR})	
Sensor Measurement and Test Equipment (MTE_{SENSOR})	
Digital Protection System (DPS)	
DPS Drift (DR_{DPS})	
DPS Temperature Effect (TE_{DPS})	
DPS Calibration Tolerance (CT_{DPS})	
DPS Measurement and Test Equipment (MTE_{DPS})	

Loop Accuracy

CU =

CU =

CU = $x.xx_{Random} + 0_{Bias}$

CU = x.xx % Span

Table 3.1-2 Pressurizer Pressure Input (Accident Conditions)

RT on PRZ Pressure < Min2; RT on Low DNBR; and SIS on PRZ Pressure < Min 3 with inputs to RT Confirmation, RCP Trip, EFWS Actuation on SIS and LOOP, Containment Isolation, and MSRT Signal

Harsh Environment **Uncertainty (% Span)**

Process & Misc. Effects

Process Measurement (PM)
Primary Element (PE)
Insulation Resistance Error (IR_B)

Sensor

Sensor Reference Accuracy (RA_{SENSOR})
Sensor Drift (DR_{SENSOR})
Sensor Temperature Effect (TE_{SENSOR})
Sensor Static Pressure Effect (SP_{SENSOR})
Sensor Accident Radiation Effect (ARE_{SENSOR})
Sensor Seismic Effect (SE_{SENSOR})
Sensor Accident Temperature Effect (ATE_{SENSOR})
Sensor Calibration Tolerance (CT_{SENSOR})
Sensor Measurement and Test Equipment (MTE_{SENSOR})

Digital Protection System (DPS)

DPS Drift (DR_{DPS})
DPS Temperature Effect (TE_{DPS})
DPS Calibration Tolerance (CT_{DPS})
DPS Measurement and Test Equipment (MTE_{DPS})

Loop Accuracy

CU =

CU =

CU = $x.xx_{Random} + x.xx_{Bias}$

CU = x.xx % Span

Table 3.1-3 Pressurizer Level Input (Normal Conditions)

RT on PRZ Level > Max1 and Shutdown CVCS Charging Line on PRZ Level > Max2

Normal Environment	Uncertainty (% Span)
Process & Misc. Effects	
Process Measurement	
Primary Element (PE)	
Insulation Resistance Error (IR_B)	
Sensor	
Sensor Reference Accuracy (RA_{SENSOR})	
Sensor Drift (DR_{SENSOR})	
Sensor Temperature Effect (TE_{SENSOR})	
Sensor Static Pressure Effect (SP_{SENSOR})	
Sensor Accident Radiation Effect (ARE_{SENSOR})	
Sensor Seismic Effect (SE_{SENSOR})	
Sensor Accident Temperature Effect (ATE_{SENSOR})	
Sensor Calibration Tolerance (CT_{SENSOR})	
Sensor Measurement and Test Equipment (MTE_{SENSOR})	
Digital Protection System (DPS)	
DPS Drift (DR_{DPS})	
DPS Temperature Effect (TE_{DPS})	
DPS Calibration Tolerance (CT_{DPS})	
DPS Measurement and Test Equipment (MTE_{DPS})	

Loop Accuracy

CU =

CU =

CU = $x.xx_{Random} + x.xx_{Bias}$

CU = x.xx % Span

Table 3.1-4 Steam Generator Pressure Input (Normal Conditions)

RT on SG Pressure > Max1 and Partial Cooldown Signals

Normal Environment	Uncertainty (% Span)
Process & Misc. Effects	
Process Measurement (PM)	
Primary Element (PE)	
Insulation Resistance Error (IR_{B})	
Sensor	
Sensor Reference Accuracy ($\mathrm{RA}_{\mathrm{SENSOR}}$)	
Sensor Drift ($\mathrm{DR}_{\mathrm{SENSOR}}$)	
Sensor Temperature Effect ($\mathrm{TE}_{\mathrm{SENSOR}}$)	
Sensor Static Pressure Effect ($\mathrm{SP}_{\mathrm{SENSOR}}$)	
Sensor Accident Radiation Effect ($\mathrm{ARE}_{\mathrm{SENSOR}}$)	
Sensor Seismic Effect ($\mathrm{SE}_{\mathrm{SENSOR}}$)	
Sensor Accident Temperature Effect ($\mathrm{ATE}_{\mathrm{SENSOR}}$)	
Sensor Calibration Tolerance ($\mathrm{CT}_{\mathrm{SENSOR}}$)	
Sensor Measurement and Test Equipment ($\mathrm{MTE}_{\mathrm{SENSOR}}$)	
Digital Protection System (DPS)	
DPS Drift ($\mathrm{DR}_{\mathrm{DPS}}$)	
DPS Temperature Effect ($\mathrm{TE}_{\mathrm{DPS}}$)	
DPS Calibration Tolerance ($\mathrm{CT}_{\mathrm{DPS}}$)	
DPS Measurement and Test Equipment ($\mathrm{MTE}_{\mathrm{DPS}}$)	

Loop Accuracy

CU =

CU =

CU = $x.xx_{\mathrm{Random}} + 0_{\mathrm{Bias}}$

CU = x.xx % Span

Table 3.1-5 Steam Generator Pressure Input (Accident Conditions)

RT on SG Pressure Drop > Max1, MSIV Closure on SG Pressure Drop > Max1, RT on SG Pressure < Min1, MSIV Closure on SG Pressure < Min1, MSRT Opening on SG Pressure > Max1, MFWS Isolation on SG Pressure < Min2, MSRT Closure on SG Pressure < Min3, MFWS Isolation on SG Pressure Drop > Max2 and MSRCV Control on SG Pressure Input

Harsh Environment	**Uncertainty (% Span)**
Process & Misc. Effects	
Process Measurement (PM)	
Primary Element (PE)	
Insulation Resistance Error (IR_B)	
Sensor	
Sensor Reference Accuracy (RA_{SENSOR})	
Sensor Drift (DR_{SENSOR})	
Sensor Temperature Effect (TE_{SENSOR})	
Sensor Static Pressure Effect (SP_{SENSOR})	
Sensor Accident Radiation Effect (ARE_{SENSOR})	
Sensor Seismic Effect (SE_{SENSOR})	
Sensor Accident Temperature Effect (ATE_{SENSOR})	
Sensor Calibration Tolerance (CT_{SENSOR})	
Sensor Measurement and Test Equipment (MTE_{SENSOR})	
Digital Protection System (DPS)	
DPS Drift (DR_{DPS})	
DPS Temperature Effect (TE_{DPS})	
DPS Calibration Tolerance (CT_{DPS})	
DPS Measurement and Test Equipment (MTE_{DPS})	

Loop Accuracy

CU =

CU =

CU = $x.xx_{Random} + x.xx_{Bias}$

CU = x.xx % Span

Table 3.1-6 Steam Generator Minimum Narrow Range Level Input (Accident Conditions)

RT on SG Level < Min1

Harsh Environment	Uncertainty (% Span)
Process & Misc. Effects	
Process Measurement	
Insulation Resistance Error (IR_B)	
Sensor	
Sensor Reference Accuracy (RA_{SENSOR})	
Sensor Drift (DR_{SENSOR})	
Sensor Temperature Effect (TE_{SENSOR})	
Sensor Static Pressure Effect (SP_{SENSOR})	
Sensor Accident Radiation Effect (ARE_{SENSOR})	
Sensor Seismic Effect (SE_{SENSOR})	
Sensor Accident Temperature Effect (ATE_{SENSOR})	
Sensor Calibration Tolerance (CT_{SENSOR})	
Sensor Measurement and Test Equipment (MTE_{SENSOR})	
Digital Protection System (DPS)	
DPS Drift (DR_{DPS})	
DPS Temperature Effect (TE_{DPS})	
DPS Calibration Tolerance (CT_{DPS})	
DPS Measurement and Test Equipment (MTE_{DPS})	

Loop Accuracy

CU =

CU =

CU = $x.xx_{Random} + x.xx_{Bias}$

CU = x.xx % Span

Table 3.1-7 Steam Generator Maximum Narrow Range Level Input (Normal Conditions)

RT on SG Level > Max1, MFWS Full Load Closure on SG Level > Max1, MFWS Train Isolation on SG Level > Max0, MSIV Closure on SG Level > Max2, Shutdown of CVCS Charging on SG Level > Max 2, MSRT Setpoint Increase on SG Level > Max 2, and Partial Cooldown on SG Level > Max 2

Normal Environment — **Uncertainty (% Span)**

Process & Misc. Effects

Process Measurement

[ ]

Insulation Resistance Error (IR_B)

Sensor

Sensor Reference Accuracy (RA_{SENSOR})
Sensor Drift (DR_{SENSOR})
Sensor Temperature Effect (TE_{SENSOR})
Sensor Static Pressure Effect (SP_{SENSOR})
Sensor Accident Radiation Effect (ARE_{SENSOR})
Sensor Seismic Effect (SE_{SENSOR})
Sensor Accident Temperature Effect (ATE_{SENSOR})
Sensor Calibration Tolerance (CT_{SENSOR})
Sensor Measurement and Test Equipment (MTE_{SENSOR})

Digital Protection System (DPS)

DPS Drift (DR_{DPS})
DPS Temperature Effect (TE_{DPS})
DPS Calibration Tolerance (CT_{DPS})
DPS Measurement and Test Equipment (MTE_{DPS})

[ ]

Loop Accuracy

CU = [

CU =]

CU = $x.xx_{Random} + x.xx_{Bias}$

CU = x.xx % Span

Table 3.1-8 Steam Generator Minimum Wide Range Level Input (Accident Conditions)

RCP Trip on SG WR Level < Min2, EFWS Actuation Signal on SG WR Level < Min2, and SG Blowdown Isolation on SG WR Level < Min2

Harsh Environment | **Uncertainty (% Span)**

Process & Misc. Effects

Process Measurement
[ ]
Insulation Resistance Error (IR_B)

Sensor

Sensor Reference Accuracy (RA_{SENSOR})
Sensor Drift (DR_{SENSOR})
Sensor Temperature Effect (TE_{SENSOR})
Sensor Static Pressure Effect (SP_{SENSOR})
Sensor Accident Radiation Effect (ARE_{SENSOR})
Sensor Seismic Effect (SE_{SENSOR})
Sensor Accident Temperature Effect (ATE_{SENSOR})
Sensor Calibration Tolerance (CT_{SENSOR})
Sensor Measurement and Test Equipment (MTE_{SENSOR})

Digital Protection System (DPS)

DPS Drift (DR_{DPS})
DPS Temperature Effect (TE_{DPS})
DPS Calibration Tolerance (CT_{DPS})
DPS Measurement and Test Equipment (MTE_{DPS})

[ ]

Loop Accuracy

CU = [

CU =]

CU = $x.xx_{Random} + x.xx_{Bias}$

CU = x.xx % Span

Table 3.1-9 Steam Generator Maximum Wide Range Level Input (Normal Conditions)

EFWS Isolation Signal on SG WR Level > Max1

Normal Environment	Uncertainty (% Span)
Process & Misc. Effects	
Process Measurement	[
[ ]	
Insulation Resistance Error (IR_B)	
Sensor	
Sensor Reference Accuracy (RA_{SENSOR})	
Sensor Drift (DR_{SENSOR})	
Sensor Temperature Effect (TE_{SENSOR})	
Sensor Static Pressure Effect (SP_{SENSOR})	
Sensor Accident Radiation Effect (ARE_{SENSOR})	
Sensor Seismic Effect (SE_{SENSOR})	
Sensor Accident Temperature Effect (ATE_{SENSOR})	
Sensor Calibration Tolerance (CT_{SENSOR})	
Sensor Measurement and Test Equipment (MTE_{SENSOR})	
Digital Protection System (DPS)	
DPS Drift (DR_{DPS})	
DPS Temperature Effect (TE_{DPS})	
DPS Calibration Tolerance (CT_{DPS})	
DPS Measurement and Test Equipment (MTE_{DPS})	]

Loop Accuracy

CU = [

CU =]

CU = $x.xx_{Random} + x.xx_{Bias}$

CU = x.xx % Span

Table 3.1-10 Containment Pressure Stage 1 Narrow Range Input

RT on Containment Pressure > Max1 and Containment Isolation on Containment Pressure > Max1

Normal Environment	Uncertainty (% Span)
Process & Misc. Effects	
Process Measurement (PM)	
Primary Element (PE)	
Insulation Resistance Error (IR_B)	
Sensor	
Sensor Reference Accuracy (RA_{SENSOR})	
Sensor Drift (DR_{SENSOR})	
Sensor Temperature Effect (TE_{SENSOR})	
Sensor Static Pressure Effect (SP_{SENSOR})	
Sensor Accident Radiation Effect (ARE_{SENSOR})	
Sensor Seismic Effect (SE_{SENSOR})	
Sensor Accident Temperature Effect (ATE_{SENSOR})	
Sensor Calibration Tolerance (CT_{SENSOR})	
Sensor Measurement and Test Equipment (MTE_{SENSOR})	
Digital Protection System (DPS)	
DPS Drift (DR_{DPS})	
DPS Temperature Effect (TE_{DPS})	
DPS Calibration Tolerance (CT_{DPS})	
DPS Measurement and Test Equipment (MTE_{DPS})	

Loop Accuracy

CU =

CU =

CU = $x.xx_{Random} + 0_{Bias}$

CU = x.xx % Span

Table 3.1-11 Containment Pressure Stage 2 Wide Range Input

Containment Isolation on Containment Pressure > Max2

Normal Environment	Uncertainty (% Span)
Process & Misc. Effects	
Process Measurement (PM)	
Primary Element (PE)	
Insulation Resistance Error (IR_B)	
Sensor	
Sensor Reference Accuracy (RA_{SENSOR})	
Sensor Drift (DR_{SENSOR})	
Sensor Temperature Effect (TE_{SENSOR})	
Sensor Static Pressure Effect (SP_{SENSOR})	
Sensor Accident Radiation Effect (ARE_{SENSOR})	
Sensor Seismic Effect (SE_{SENSOR})	
Sensor Accident Temperature Effect (ATE_{SENSOR})	
Sensor Calibration Tolerance (CT_{SENSOR})	
Sensor Measurement and Test Equipment (MTE_{SENSOR})	
Digital Protection System (DPS)	
DPS Drift (DR_{DPS})	
DPS Temperature Effect (TE_{DPS})	
DPS Calibration Tolerance (CT_{DPS})	
DPS Measurement and Test Equipment (MTE_{DPS})	

Loop Accuracy

CU =

CU =

CU = $x.xx_{Random} + 0_{Bias}$

CU = x.xx % Span

Table 3.1-12 Hot Leg Pressure Input (Accident Conditions)

RT on Hot Leg Pressure < Min 1, RT on HCPL/Low Saturation Margin, and SIS on ΔP_{sat} with inputs to RT Confirmation, RCP Trip, EFWS Actuation on SIS and LOOP, Containment Isolation, MSRT Signal, and PSRV Opening

Harsh Environment	Uncertainty (% Span)
Process & Misc. Effects	[
Process Measurement (PM)	
Primary Element (PE)	
Insulation Resistance Error (IR_B)	
Sensor	
Sensor Reference Accuracy (RA_{SENSOR})	
Sensor Drift (DR_{SENSOR})	
Sensor Temperature Effect (TE_{SENSOR})	
Sensor Static Pressure Effect (SP_{SENSOR})	
Sensor Accident Radiation Effect (ARE_{SENSOR})	
Sensor Seismic Effect (SE_{SENSOR})	
Sensor Accident Temperature Effect (ATE_{SENSOR})	
Sensor Calibration Tolerance (CT_{SENSOR})	
Sensor Measurement and Test Equipment (MTE_{SENSOR})	
Digital Protection System (DPS)	
DPS Drift (DR_{DPS})	
DPS Temperature Effect (TE_{DPS})	
DPS Calibration Tolerance (CT_{DPS})	
DPS Measurement and Test Equipment (MTE_{DPS})	]

Loop Accuracy

CU = [

CU =]

CU = $x.xx_{Random} + x.xx_{Bias}$

CU = x.xx % Span

Table 3.1-13 Power Range Excore Detectors (Accident Conditions)

RT on Loop High Neutron Flux Rate of Change and RT on Low DNBR

Harsh Environment	Uncertainty (% Span)
Process & Misc. Effects	
Process Measurement	
Insulation Resistance Error (IR_B)	
Sensor	
Sensor Reference Accuracy (RA_{SENSOR}) [1]	
Sensor Drift (DR_{SENSOR}) [2]	
Sensor Temperature Effect (TE_{SENSOR}) [1]	
Sensor Static Pressure Effect (SP_{SENSOR})	
Sensor Power Supply Effect (PS_{SENSOR}) [1]	
Sensor Accident Radiation Effect (ARE_{SENSOR})	
Sensor Seismic Effect (SE_{SENSOR})	
Sensor Accident Temperature Effect (ATE_{SENSOR})	
Sensor Calibration Tolerance (CT_{SENSOR}) [3]	
Sensor Measurement and Test Equipment (MTE_{SENSOR})	
Digital Protection System (DPS)	
DPS Drift (DR_{DPS})	
DPS Temperature Effect (TE_{DPS})	
DPS Calibration Tolerance (CT_{DPS})	
DPS Measurement and Test Equipment (MTE_{DPS})	
DPS Digital Processing of Signal (DP_{DPS})	

Loop Accuracy

CU =

CU =

CU = $x.xx_{Random} + x.xx_{Bias}$

CU = x.xx % Span

---

[1] Use of a rate derivative eliminates steady state errors.
[2] Zeroed out by calorimetric.
[3] Included in calorimetric.

Table 3.1-14 Intermediate Range Excore Detectors - High Flux (Accident Conditions)

RT on High Neutron Flux

Harsh Environment **Uncertainty (% Span)**

Process & Misc. Effects

Process Measurement
Insulation Resistance Error (IR_B)

Sensor

Sensor Reference Accuracy (RA_{SENSOR})
Sensor Drift (DR_{SENSOR}) [4]
Sensor Temperature Effect (TE_{SENSOR})
Sensor Static Pressure Effect (SP_{SENSOR})
Sensor Power Supply Effect (PS_{SENSOR})
Sensor Accident Radiation Effect (ARE_{SENSOR})
Sensor Seismic Effect (SE_{SENSOR})
Sensor Accident Temperature Effect (ATE_{SENSOR})
Sensor Calibration Tolerance (CT_{SENSOR}) [1]
Sensor Measurement and Test Equipment (MTE_{SENSOR}) [1]

Digital Protection System (DPS)

DPS Drift (DR_{DPS})
DPS Temperature Effect (TE_{DPS})
DPS Calibration Tolerance (CT_{DPS})
DPS Measurement and Test Equipment (MTE_{DPS})
DPS Digital Processing of Signal (DP_{DPS})

Loop Accuracy

CU =

CU =

CU = $x.xx_{Random} + x.xx_{Bias}$

CU = x.xx % Span

---

[1] Included in PM.

Table 3.1-15 Intermediate Range Excore Detectors - Low Doubling Time

RT on Low Doubling Time

Normal Environment **Uncertainty (% Span)**

Process & Misc. Effects

Process Measurement

[ ] [ ]

Sensor

Sensor Reference Accuracy (RA_{SENSOR})
Sensor Drift (DR_{SENSOR}) [5]
Sensor Temperature Effect (TE_{SENSOR})
Sensor Static Pressure Effect (SP_{SENSOR})
Sensor Power Supply Effect (PS_{SENSOR})
Sensor Accident Radiation Effect (ARE_{SENSOR})
Sensor Seismic Effect (SE_{SENSOR})
Sensor Accident Temperature Effect (ATE_{SENSOR})
Sensor Calibration Tolerance (CT_{SENSOR}) [1]
Sensor Measurement and Test Equipment (MTE_{SENSOR}) [1]

Digital Protection System (DPS)

DPS Drift (DR_{DPS})
DPS Temperature Effect (TE_{DPS})
DPS Calibration Tolerance (CT_{DPS})
DPS Measurement and Test Equipment (MTE_{DPS})
DPS Digital Processing of Signal (DP_{DPS})

Loop Accuracy

CU = [

CU =]

CU = $x.xx_{Random} + x.xx_{Bias}$

CU = x.xx % Span

---

[1] Included in PM.

Table 3.1-16 Narrow Range Hot Leg Temperature Input (Accident Conditions)

RT on HCPL / Low Saturation Margin

Harsh Environment	Uncertainty (% Span)
Process & Misc. Effects	
Process Measurement [ ]	[
RTD [ ]	
Insulation Resistance Error (IR_B)	
Sensor	
Sensor Reference Accuracy (RA_{SENSOR})	
Sensor Drift (DR_{SENSOR})	
Sensor Temperature Effect (TE_{SENSOR})	
Sensor Static Pressure Effect (SP_{SENSOR})	
Sensor Accident Radiation Effect (ARE_{SENSOR})	
Sensor Seismic Effect (SE_{SENSOR})	
Sensor Accident Temperature Effect (ATE_{SENSOR}) (see Section 4.4)	
Sensor Calibration Tolerance (CT_{SENSOR})	
Sensor Measurement and Test Equipment (MTE_{SENSOR})	
Digital Protection System (DPS)	
DPS Drift (DR_{DPS})	
DPS Temperature Effect (TE_{DPS})	
DPS Calibration Tolerance (CT_{DPS})	
DPS Measurement and Test Equipment (MTE_{DPS})	]

Loop Accuracy

CU = [

CU =]

CU = $x.xx_{Random} \pm x.xx_{Bias}$

CU = x.xx % Span

$CU_{AVG} = (CU_{Random}^2 / \text{Number of Loops})^{½} + CU_{Bias}$

CU_{AVG} = x.xx % Span

Table 3.1-17 Narrow Range Cold Leg Temperature Input (Accident Conditions)

RT on Low DNBR

Harsh Environment | **Uncertainty (% Span)**

Process & Misc. Effects

Process Measurement (PM_B)

RTD

Insulation Resistance Error (IR_B)

Sensor

Sensor Reference Accuracy (RA_{SENSOR})
Sensor Drift (DR_{SENSOR})
Sensor Temperature Effect (TE_{SENSOR})
Sensor Static Pressure Effect (SP_{SENSOR})
Sensor Accident Radiation Effect (ARE_{SENSOR})
Sensor Seismic Effect (SE_{SENSOR})
Sensor Accident Temperature Effect (ATE_{SENSOR}) (see Section 4.4)
Sensor Calibration Tolerance (CT_{SENSOR})
Sensor Measurement and Test Equipment (MTE_{SENSOR})

Digital Protection System (DPS)

DPS Drift (DR_{DPS})
DPS Temperature Effect (TE_{DPS})
DPS Calibration Tolerance (CT_{DPS})
DPS Measurement and Test Equipment (MTE_{DPS})

Loop Accuracy

CU =

CU =

CU = $x.xx_{Random} + x.xx_{Bias}$

CU = x.xx % Span

Table 3.1-18 Wide Range Hot Leg Temperature Input (Accident Conditions)

SIS on ΔP_{sat} with inputs to RT Confirmation, RCP Trip, EFWS Actuation on SIS and LOOP, Containment Isolation, and MSRT Signal

Harsh Environment	Uncertainty (% Span)
Process & Misc. Effects	
Process Measurement (PM_B)	
RTD	
Insulation Resistance Error (IR_B)	
Sensor	
Sensor Reference Accuracy (RA_{SENSOR})	
Sensor Drift (DR_{SENSOR})	
Sensor Temperature Effect (TE_{SENSOR})	
Sensor Static Pressure Effect (SP_{SENSOR})	
Sensor Accident Radiation Effect (ARE_{SENSOR})	
Sensor Seismic Effect (SE_{SENSOR})	
Sensor Accident Temperature Effect (ATE_{SENSOR}) (see Section 4.4.3)	
Sensor Calibration Tolerance (CT_{SENSOR})	
Sensor Measurement and Test Equipment (MTE_{SENSOR})	
Digital Protection System (DPS)	
DPS Drift (DR_{DPS})	
DPS Temperature Effect (TE_{DPS})	
DPS Calibration Tolerance (CT_{DPS})	
DPS Measurement and Test Equipment (MTE_{DPS})	

Loop Accuracy

CU =

CU =

CU = $x.xx_{Random} \pm x.xx_{Bias}$

CU = x.xx % Span

Table 3.1-19 Wide Range Cold Leg Temperature Input (Accident Conditions)

RT on HCPL / Low Saturation Margin

Accident Environment — **Uncertainty (% Span)**

Process & Misc. Effects [

Process Measurement (PM$_B$) [ ]

RTD [ ]

Insulation Resistance Error (IR$_B$)

Sensor

Sensor Reference Accuracy (RA$_{SENSOR}$)
Sensor Drift (DR$_{SENSOR}$)
Sensor Temperature Effect (TE$_{SENSOR}$)
Sensor Static Pressure Effect (SP$_{SENSOR}$)
Sensor Accident Radiation Effect (ARE$_{SENSOR}$)
Sensor Seismic Effect (SE$_{SENSOR}$)
Sensor Accident Temperature Effect (ATE$_{SENSOR}$) (see Section 4.4)
Sensor Calibration Tolerance (CT$_{SENSOR}$)
Sensor Measurement and Test Equipment (MTE$_{SENSOR}$)

Digital Protection System (DPS)

DPS Drift (DR$_{DPS}$)
DPS Temperature Effect (TE$_{DPS}$)
DPS Calibration Tolerance (CT$_{DPS}$)
DPS Measurement and Test Equipment (MTE$_{DPS}$)]

Loop Accuracy

CU = [

CU =]

CU = x.xx$_{Random}$ ± x.xx$_{Bias}$

CU = x.xx % Span

Table 3.1-20 Reactor Coolant Pump Speed Input (Normal Conditions)

RT on Low RCP Speed

Normal Environment **Uncertainty (% Span)**

Process & Misc. Effects

Process Measurement (PM)
Primary Element (PE)
Insulation Resistance Error (IR_B)

Sensor

Sensor Reference Accuracy (RA_{SENSOR})
Sensor Drift (DR_{SENSOR})
Sensor Temperature Effect (TE_{SENSOR})
Sensor Static Pressure Effect (SP_{SENSOR})
Sensor Accident Radiation Effect (ARE_{SENSOR})
Sensor Seismic Effect (SE_{SENSOR})
Sensor Accident Temperature Effect (ATE_{SENSOR})
Sensor Calibration Tolerance (CT_{SENSOR})
Sensor Measurement and Test Equipment (MTE_{SENSOR})

Digital Protection System (DPS)

DPS Drift (DR_{DPS})
DPS Temperature Effect (TE_{DPS})
DPS Calibration Tolerance (CT_{DPS})
DPS Measurement and Test Equipment (MTE_{DPS})

Loop Accuracy

CU =

CU =

CU = $x.xx_{Random} + 0_{Bias}$

CU = x.xx % Span

Table 3.1-21 Reactor Coolant Pump Speed Input (Accident Conditions)

RT on Low DBNR

Harsh Environment	Uncertainty (% Span)
Process & Misc. Effects	
Process Measurement (PM)	[
Primary Element (PE)	
Insulation Resistance Error IR_B	
Sensor	
Sensor Reference Accuracy (RA_{SENSOR})	
Sensor Drift (DR_{SENSOR})	
Sensor Temperature Effect (TE_{SENSOR})	
Sensor Static Pressure Effect (SP_{SENSOR})	
Sensor Accident Radiation Effect (ARE_{SENSOR})	
Sensor Seismic Effect (SE_{SENSOR})	
Sensor Accident Temperature Effect (ATE_{SENSOR})	
Sensor Calibration Tolerance (CT_{SENSOR})	
Sensor Measurement and Test Equipment (MTE_{SENSOR})	
Digital Protection System (DPS)	
DPS Drift (DR_{DPS})	
DPS Temperature Effect (TE_{DPS})	
DPS Calibration Tolerance (CT_{DPS})	
DPS Measurement and Test Equipment (MTE_{DPS})	]

Loop Accuracy

CU = [

CU =]

CU = $x.xx_{Random} + x.xx_{Bias}$

CU = x.xx % Span

Table 3.1-22 Reactor Coolant System Flow Input

RT on Low Loop Flow Rate with Inputs to Loss of RCP, RT on Low DNBR, and HCPL; and RT on Low-Low Loop Flow Rate

Normal Environment	**Uncertainty (% Flow Span)**
Process & Misc. Effects	
Process Measurement (PM_B)	[
Primary Element (PE)	
Miscellaneous Effects (ME)	
Insulation Resistance Error (IR_B)	
Sensor	
Sensor Reference Accuracy (RA_{SENSOR})	
Sensor Drift (DR_{SENSOR})	
Sensor Temperature Effect (TE_{SENSOR})	
Sensor Static Pressure Effect (SP_{SENSOR})	
Sensor Accident Radiation Effect (ARE_{SENSOR})	
Sensor Seismic Effect (SE_{SENSOR})	
Sensor Accident Temperature Effect (ATE_{SENSOR})	
Sensor Calibration Tolerance (CT_{SENSOR})	
Sensor Measurement and Test Equipment (MTE_{SENSOR})	
Digital Protection System (DPS)	
DPS Drift (DR_{DPS})	
DPS Temperature Effect (TE_{DPS})	
DPS Calibration Tolerance (CT_{DPS})	
DPS Measurement and Test Equipment (MTE_{DPS})	]

Loop Accuracy

CU = [

CU =]

CU = x.xx$_{Random}$ + x.xx$_{Bias}$

CU = x.xx % Span

Table 3.1-23 Rod Cluster Control Assembly Position Primary Coil Input

RCCA Position Signal for RT on Low DNBR and RT on HLPD

Harsh Environment **Uncertainty (% Span)**

Process & Misc. Effects

Process Measurement (PM)
Primary Element (PE)
Insulation Resistance Error (IR_B)

Sensor

Sensor Reference Accuracy (RA_{SENSOR})
Sensor Drift (DR_{SENSOR})
Sensor Temperature Effect (TE_{SENSOR})
Sensor Static Pressure Effect (SP_{SENSOR})
Sensor Accident Radiation Effect (ARE_{SENSOR})
Sensor Seismic Effect (SE_{SENSOR})
Sensor Accident Temperature Effect (ATE_{SENSOR})
Sensor Calibration Tolerance (CT_{SENSOR})
Sensor Measurement and Test Equipment (MTE_{SENSOR})

Digital Protection System (DPS)

DPS Drift (DR_{DPS})
DPS Temperature Effect (TE_{DPS})
DPS Calibration Tolerance (CT_{DPS})
DPS Measurement and Test Equipment (MTE_{DPS})

Loop Accuracy

CU =

CU =

CU = $x.xx_{Random} + x.xx_{Bias}$

CU = x.xx % Span

Table 3.1-24 Rod Cluster Control Assembly Position Secondary Coil Input

RCCA Position Signal for RT on Low DNBR and RT on HLPD

Harsh Environment **Uncertainty (% Span)**

Process & Misc. Effects

Process Measurement (PM)
Primary Element (PE)
Insulation Resistance Error (IR_B)

Sensor

Sensor Reference Accuracy (RA_{SENSOR})
Sensor Drift (DR_{SENSOR})
Sensor Temperature Effect (TE_{SENSOR})
Sensor Static Pressure Effect (SP_{SENSOR})
Sensor Accident Radiation Effect (ARE_{SENSOR})
Sensor Seismic Effect (SE_{SENSOR})
Sensor Accident Temperature Effect (ATE_{SENSOR})
Sensor Calibration Tolerance (CT_{SENSOR})
Sensor Measurement and Test Equipment (MTE_{SENSOR})

Digital Protection System (DPS)

DPS Drift (DR_{DPS})
DPS Temperature Effect (TE_{DPS})
DPS Calibration Tolerance (CT_{DPS})
DPS Measurement and Test Equipment (MTE_{DPS})

Loop Accuracy

CU =

CU =

CU = $x.xx_{Random} + x.xx_{Bias}$

CU = x.xx % Span

Table 3.1-25 Reactor Coolant Pump Differential Pressure Input (Accident Conditions)

RCP Trip

Harsh Environment **Uncertainty (% Span)**

Process & Misc. Effects

[ ]

Process Measurement (PM)
Primary Element (PE)
Insulation Resistance Error (IR_B)

Sensor

Sensor Reference Accuracy (RA_{SENSOR})
Sensor Drift (DR_{SENSOR})
Sensor Temperature Effect (TE_{SENSOR})
Sensor Static Pressure Effect (SP_{SENSOR})
Sensor Accident Radiation Effect (ARE_{SENSOR})
Sensor Seismic Effect (SE_{SENSOR})
Sensor Accident Temperature Effect (ATE_{SENSOR})
Sensor Calibration Tolerance (CT_{SENSOR})
Sensor Measurement and Test Equipment (MTE_{SENSOR})

Digital Protection System (DPS)

DPS Drift (DR_{DPS})
DPS Temperature Effect (TE_{DPS})
DPS Calibration Tolerance (CT_{DPS})
DPS Measurement and Test Equipment (MTE_{DPS})

Loop Accuracy

CU = [

CU =]

CU = x.xx$_{Random}$ + x.xx$_{Bias}$

CU = x.xx % Span

3.2 *Complex Functions*

Complex functions involve protection system trips or protection functions that are based on multiple inputs. This section addresses two of the complex functions, SIS on ΔP_{sat} < Min 1 and rod position. Other complex functions such as HCPL, low saturation margin, anti-dilution, HLPD, and DNBR will be addressed in a separate topical report, for these functions, uncertainty is determined using another statistical methodology.

3.2.1 *SIS Actuation on ΔP_{sat} < Min1*

The U.S. EPR has an automatic SIS to provide permanent protection against drops in reactor coolant system (RCS) water inventory. This is accomplished by using permissives. When RCS pressure is lowered to the prescribed limit, a permissive changes the automatic SIS input from pressurizer pressure < Min 3 to ΔP_{sat}. When RCS pressure and temperature drop further to the prescribed limits with no reactor coolant pump (RCP) running, another permissive switches the automatic SIS input from ΔP_{sat} protection to protection because of low loop level. The ΔP_{sat} protection inputs are wide range (WR) hot leg temperature and hot leg pressure.

The saturation pressure of the WR hot leg temperature is used for the determination of P_{sat}. The P_{sat} error is based on the associated uncertainty of the temperature measurement. P_{sat} error increases at higher temperatures. The protection system transforms the value of the analog input signal to the characteristics specified by interpolation points. Although the number of points and values may change during the detailed design phase, the methodology for the error determination is still applicable and is demonstrated in the following equation. The Temp (°F) and P_{sat} columns are the X and Y interpolation points in the table and the dT and dP are the differences between the points.

Given:

[ ]

where:

[ ]

and

[ ]

where Temp is in °F

Therefore:

[ ]

where e is error

The ΔP_{sat} error from the summation of the P_{sat} calculation from the WR hot leg temperature sensors input and the WR hot leg pressure sensors input is determined as follows:

[ ]

Note: There is an uncertainty because of the slight difference between the DPS calculation of the interpolation points and the ASME steam tables. This error (e_{calc_bias}) is considered a bias.

Table 3.2-1 provides the interpolation points along with the “a” and “b” values.

Table 3.2-1 Interpolation Points

3.2.2 *Rod Position*

The rod cluster control assembly (RCCA) position primary coil and RCCA position secondary coil input are utilized by the rod position measurement system (RPMS). The DC voltage of the primary coil is used to compensate the variations in measurement of the RPMS resulting from the temperature of the RCCA. The analog rod position (r) is calculated in the DPS as follows:

[ ]

therefore:

[ ]

where:

V_S = voltage derived from secondary coil

V_{S0} = voltage derived from secondary coil when control rod is in lower end position

V_P = voltage derived from primary coil at hot operational

V_{P0} = voltage derived from primary coil at reference cold operational temperature

c = 0.016 = constant for V / cm conversion

K = $1 / 3V_{P0}$ = constant for temperature coefficient

Using partial derivatives the error in centimeters can be demonstrated as follows:

[ ]

where:

[ ]

and

[ ]

To derive the next two errors, the following differential equations are applied:

If [ ]

[ ]

[ ]

Thus:

[ ]

and

[ ]

[ ]

Each of the partial derivatives is then substituted into the overall partial derivative equation for e_r.

4.0 SETPOINT METHODOLOGY APPLICATIONS

The safety limit is a limit placed on a process variable that is necessary to reasonably protect the integrity of physical barriers that guard against an uncontrolled release of radioactivity. The safety analysis models ALs of measured or calculated variables to provide adequate assurance that the safety limit is not exceeded. The LTSP is calculated to provide adequate assurance that the trip or actuation will occur before the AL is reached regardless of the process or environmental conditions affecting the instrumentation. The equations in Section 4.1 illustrate the determination of setpoints.

4.1 *Establishment of Setpoints*

Increasing Process

$$\text{LTSP} = \text{AL} - \text{CU}$$

$$\text{NTSP} = \text{AL} - \text{CU} - \text{Margin}$$

Decreasing Process

$$\text{LTSP} = \text{AL} + \text{CU}$$

$$\text{NTSP} = \text{AL} + \text{CU} + \text{Margin}$$

where:

LTSP = Limiting Trip Setpoint

AL = Analytical Limit

NTSP = Nominal Trip Setpoint

CU = Channel Uncertainty

In most setpoint determinations, an allowance called margin is added to the instrument CU for conservatism or rounding to facilitate calibration. Rounding shall be in the conservative direction. Although adding margin can add conservatism to the setpoint in respect to the AL, caution must be used when reducing the operating margin. Establishing a setpoint too close to the operating range may lead to spurious trips that could degrade plant safety as a result of inadvertent challenges to the equipment in the plant.

4.2 *Performance Test Acceptance Criteria*

Periodic testing is required to verify that safety-related or important-to-safety instrumentation performs as expected. This testing is done by checking that the tested portion of the loop functions as required. The setpoints are checked to provide reasonable assurance that the actuation occurs as predicted in the instrument uncertainty calculations. Surveillance requirements are defined in 10 CFR 50.36 as “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.”

The PTAC shall be based on a prediction of the expected performance of the tested instrumentation under the test conditions. These acceptance criteria are established to provide reasonable assurance that the equipment performs as expected and that there is no masking of equipment degradation. The total loop uncertainty calculations shall include the determination of the AF tolerance in addition to the determination of the LTSP. The determination of the AF tolerance shall include those effects expected during the test such as the RA, instrument uncertainties during normal operation including DR, and M&TE uncertainties. If the AF value exceeds the PTAC from the NTSP during surveillance testing, a report will be entered into the corrective action program. The instrument is declared inoperable if the AF value exceeds the AV (RIS 2006-17).

Acceptable methods for performance testing include:

- Testing of the entire loop from sensor input to verification of the protection function actuation.
- Testing the sensor separately from other loop components and the associated DPS function.

The manner in which the instrument loop is tested shall verify the ability of the entire loop to perform its intended safety function (Section 4.4).

AF acceptance criteria will generally utilize no more than the SRSS combination of the RA, M&TE, M&TEr, and DR (References 9 and 4). The performance test verifies that the instruments are performing as expected. To prevent masking equipment degradation the acceptance criteria shall not include any margin. There are some applications in which a sensor or transmitter may be tested during abnormal conditions so that other uncertainty contributors such as TE, radiation effects, vibration effects, apply. These exceptions may require a case-by-case evaluation. Site-specific procedures will establish trending requirements (Section 4.4).

The DPS racks are self-checking and cannot be calibrated. DR is not an expected error for the DPS racks, so the calibration check will require that the modules be less than or equal to the SRSS of the RAs, M&TE, and M&TEr.

The following equations represent the error combination techniques for various calibration methods:

DPS racks

$$PTAC_{DPS} = [(RA_{DPS\ Module1})^2 + (RA_{DPS\ Module2})^2 + (\ldots\ldots)^2 + (M\&TE)^2 + (M\&TEr)^2]^{1/2}$$

Sensor calibration

$$PTAC_{SENSOR} = [(RA)^2 + (M\&TE)^2 + (M\&TEr)^2 + (DR)^2)]^{1/2}$$

Total loop calibration

$$PTAC_{LOOP} = [(RA)^2 + (M\&TE)^2 + (M\&TEr)^2 + (DR)^2 + (RA_{DPS\ Module1})^2$$

$$+ (RA_{DPS\ Module2})^2 + (\ldots\ldots)^2]^{1/2}$$

For loops with additional components prior to the DPS racks, the additional components will be treated like the sensor calibration for an individual component calibration. If a loop calibration is performed, the RA and DR of the extra components will be included in the SRSS equation.

The AVs represent the upper limit of the PTAC per ANSI/ISA-67.04.01-2006. The following formulas will be used for the determination of the AV:

Increasing Process

$$AV = NTSP + PTAC$$

Decreasing Process

$$AV = NTSP - PTAC$$

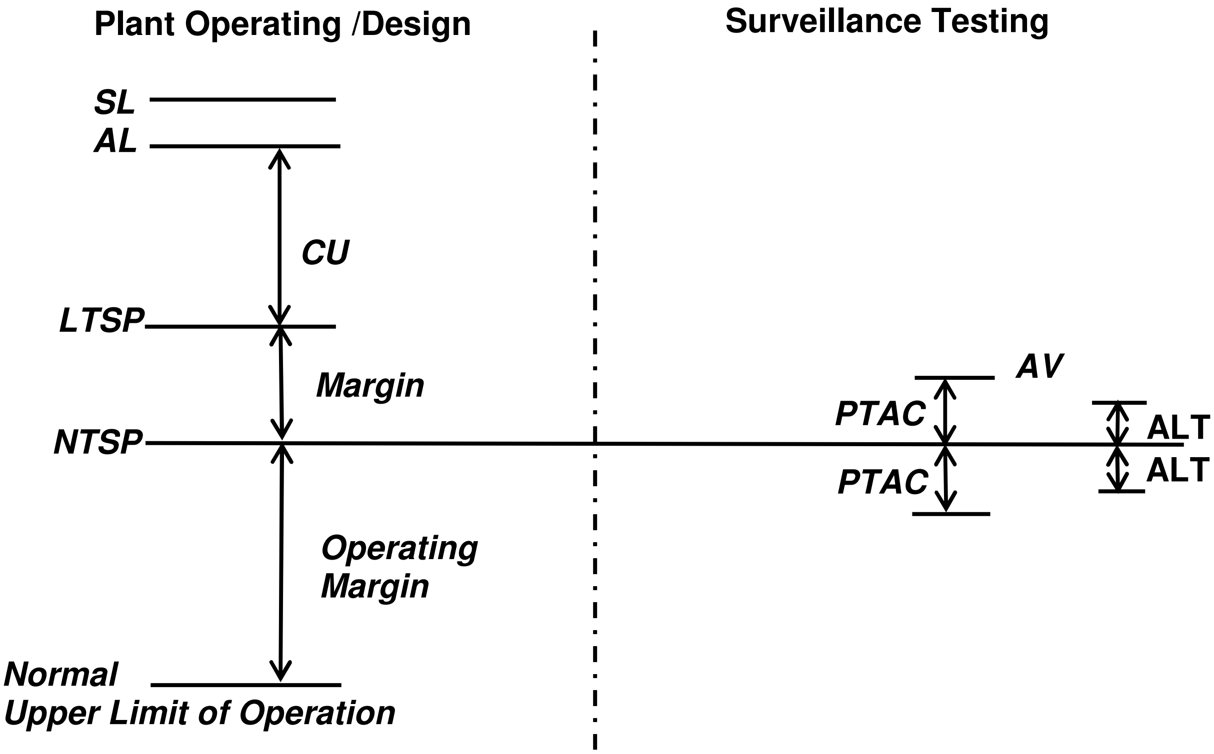
Providing that the NTSP is reset or left within the ALT at the end of each surveillance, and the NTSP is more conservative than the LTSP, the LTSP would protect the safety limit since the CU is calculated based on all uncertainties, including the ones used for the determination of the PTAC and the AV. This is consistent with RIS 2006-17 which states “the LTSP protects the Safety Limit”. The following concept (#5) from TSTF-493 is applicable:

The AV (defined as the least conservative acceptable as-found surveillance value) defines the maximum possible value for process measurement at which the AL is protected. The AV verifies that the AL and Safety Limit are still protected at the time of the surveillance. Since OPERABILITY of the instrument channel is determined at the time of the surveillance performance, the fact that the tested trip point occurred conservative to the AV ensures that at that point in time the channel would have functioned to protect the AL and is OPERABLE. With the implementation of these concepts, calculation of the AV using any of the ISA S67.04 Part II methods is acceptable.

Figure 4.2-1 illustrates the relationships between setpoint terms.

Figure 4.2-1 Setpoint Relationships

(for Increasing Process)



4.3 *Protection Functions Summary*

Using the sample of inputs from the U.S. EPR protection system, Table 4.3-1 provides a sample summary of the results of input and calculation information associated with the setpoints calculation. The table is generated as a result of the application of the setpoint methodology.

Table 4.3-1 Sample Protection Functions Summary

Input Parameter	Protection Function [Note 5]	AL	CU		LTSP	NTSP	AV
			Random	Bias			
Pressurizer Pressure Input	RT on PRZ Pressure < Min2 (A)	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
	RT on PRZ Pressure > Max2	x.xx	x.xx	-	x.xx	x.xx	x.xx
	RT on Low DNBR (A) [Note 1]	-	x.xx	x.xx	-	-	-
	Safety Injection Signal on PRZ Pressure < Min3 (A) with inputs to: RT Confirmation RCP Trip EFWS Actuation on SIS and LOOP Signal Containment Isolation MSRT Signal	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
Pressurizer Level Input	RT on PRZ Level > Max1	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
	Shutdown CVCS Charging Line on PRZ Level> Max2	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
Steam Generator Pressure Input	RT on SG Pressure Drop > Max1 (A) MSIV Closure on SG Pressure Drop > Max1 (A)	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
	RT on SG Pressure < Min1 (A) MSIV Closure on SG Pressure < Min1 (A)	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
	RT on SG Pressure > Max1	x.xx	x.xx	-	x.xx	x.xx	x.xx
	MSRT Opening on SG Pressure > Max1 (A)	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
	MFWS Isolation on SG Pressure < Min2 (A)	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
	MSRT Closure on SG Pressure < Min3 (A)	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
	MFWS Isolation on SG Pressure Drop > Max2 (A)	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
	MSRCV Control on SG Pressure input (A) [Note 4]	-	x.xx	x.xx	-	-	-
	Partial Cooldown Complete	x.xx	x.xx	-	x.xx	x.xx	x.xx

Table 4.3-1 Sample Protection Functions Summary (Continued)

Input Parameter	Protection Function [Note 5]	AL	CU		LTSP	NTSP	AV
			Random	Bias			
Steam Generator Narrow Range Level Input	RT on SG Level < Min1 (A):	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
	RT on SG Level > Max 1 MFWS Full Load Closure on SG Level > Max1	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
	MFWS Train Isolation on SG Level > Max0	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
	MSIV Closure on SG Level > Max2 Shutdown of CVCS Charging on SG Level > Max 2 MSRT Setpoint Increase on SG Level > Max 2 Partial Cooldown on SG Level > Max 2	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
Steam Generator Wide Range Level Input	RCP Trip on SG WR Level < Min2 (A) EFWS Actuation Signal on SG WR Level < Min2 (A) SG Blowdown Isolation on SG WR Level < Min2 (A)	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
	EFWS Isolation Signal on SG WR Level > Max1	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
Containment Pressure Stage 1 (NR) Input	RT on Containment Pressure > Max1 Containment Isolation on Containment Pressure > Max1	x.xx	x.xx	-	x.xx	x.xx	x.xx
Containment Pressure Stage 2 (WR) Input	Containment Isolation on Containment Pressure > Max2	x.xx	x.xx	-	x.xx	x.xx	x.xx
Hot Leg Pressure	RT on Hot Leg Pressure (A)	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
	RT on HCPL / Low Saturation Margin (A) [Note 2]	-	x.xx	x.xx	-	-	-

Table 4.3-1 Sample Protection Functions Summary (Continued)

Input Parameter	Protection Function [Note 5]	AL	CU		LTSP	NTSP	AV
			Random	Bias			
	Safety Injection Signal (on ΔP_{Sat}) (A) [Note 3] with inputs to: RT Confirmation RCP Trip EFWS Actuation on SIS and LOOP Signal Containment Isolation MSRT Signal	-	x.xx	x.xx	-	-	-
	PSRV1 Opening (A)	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
	PSRV2 Opening (A)	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
	PSRV3 Opening (A)	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
Power Range Excore Detectors	RT on Loop High Neutron Flux Rate of Change (A)	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
	RT on Low DNBR (A) [Note 1]	-	x.xx	x.xx	-	-	-
Intermediate Range Excore Detectors	RT on High Neutron Flux (A)	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
	RT on Low Doubling Time	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
Narrow Range Hot Leg Temperature Input	RT on HCPL / Low Saturation Margin (A) [Note 2]	-	x.xx	x.xx	-	-	-
Narrow Range Cold Leg Temperature Input	RT on Low DNBR (A) [Note 1]	-	x.xx	x.xx	-	-	-
Wide Range Hot Leg Temperature Input	Safety Injection Signal (on ΔP_{Sat}) (A) [Note 3] with inputs to: RT Confirmation RCP Trip EFWS Actuation on SIS and LOOP Signal Containment Isolation MSRT Signal	-	x.xx	x.xx	-	-	-

Table 4.3-1 Sample Protection Functions Summary (Continued)

Input Parameter	Protection Function [Note 5]	AL	CU		LTSP	NTSP	AV
			Random	Bias			
Wide Range Cold Leg Temperature Input	RT on HCPL / Low Saturation Margin (A) [Note 2]	-	x.xx	x.xx	-	-	-
Reactor Coolant Pump Speed Input	RT on Low RCP Speed	x.xx	x.xx	-	x.xx	x.xx	x.xx
	RT on Low DBNR (A) [Note 1]	-	x.xx	x.xx	-	-	-
Reactor Coolant System Flow Input	RT on Low Loop Flow Rate with inputs to: Loss of RCP RT on Low DNBR HCPL	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
	RT on Low-Low Loop Flow Rate	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
Rod Cluster Control Assembly Position Input (Primary and Secondary Coils)	RCCA Position (A) with inputs to: RT on Low DNBR [Note 1] RT on HLPD	-	x.xx	x.xx	-	-	-
Reactor Coolant Pump Differential Pressure	RCP Trip (A)	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
ΔP_{sat}	Safety Injection Signal (A) with inputs to: RT Confirmation RCP Trip EFWS Actuation on SIS and LOOP Signal Containment Isolation MSRT Signal	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx

Note 1: This protection function is one of several which provide an input to the DNBR trip. Since the DNBR trip analysis with its associated parameters will be provided in a separate topical report, only the CU is provided.

Note 2: This protection function is one of several which provide an input to the RT on HCPL and low saturation margin. Since this analysis with its associated parameters will be provided in a separate topical report, only the CU is provided.

Note 3: The uncertainty is provided for information only. Data for SIS on ΔPsat is provided under input parameter ΔPsat.

Note 4: The uncertainty provided is for the input signal to the main steam relief control valve (MSRCV) control loop.

Note 5: Protection functions that are required to mitigate an event causing a harsh environment use “(A)” to designate accident conditions.

4.4 *Assumptions*

The calculation summary tables in Section 3.0 are based on the following assumptions:

- For the purpose of the setpoint analyses, the protection system instrumentation will be assumed to be calibrated at the same nominal ambient temperature. TEs for the instrumentation will then be based on the temperature deviation between this assumed calibration temperature and the maximum and minimum ambient temperatures of the specific locations of the actual instrumentation.
- Components inside the DPS cabinets are subject to higher temperatures than the ambient room temperature. Therefore, a maximum heat rise inside the DPS cabinets will be assumed and used, along with the ambient temperature, to determine the TE on these instruments.
- RTD cross calibrations are assumed to be performed for both the hot and cold leg RTDs. The RTD cross calibration acceptance criteria may be used in lieu of drift.
- Temperature transmitters located outside the containment are assumed to be used for the hot and cold leg RTDs.
- Site-specific procedures will be written to comply with the M&TE requirements and testing requirements for this methodology, and to specify trending requirements.

5.0 SUMMARY AND CONCLUSIONS

ALs are established to provide reasonable assurance that the safety limits are not compromised. The LTSP is determined by accounting for the difference between the AL and the total CU. The actual NTSP chosen shall never be any closer to the AL than the calculated LTSP.

The setpoint methodology presented in this topical report conforms to the NRC guidance provided by RG 1.105 with the exceptions noted in RIS 2006-17. It incorporates the latest industry guidance established by ANSI/ISA 67.04.01-2006 and the error combination techniques of ISA 67.04.02-2000. The methodology includes the determination of PTAC based on the guidance provided by RIS 2006-17.

In lieu of actual instrument uncertainty values, applicable parameters are shown as “x.xx”. Instrument uncertainty values shown as “0” do not apply to the application. The specific uncertainty equation for the applicable parameters for each loop and a sample summary of the protection functions is provided in this document.

This U.S. EPR Instrument Setpoint Methodology Topical Report will be used to develop setpoints associated with the protection system for the U.S. EPR. AREVA NP plans to reference the topical report in its Design Control Document for the U.S. EPR.

6.0 REFERENCES

U.S. Regulations

1. 10 CFR 50.36, “Technical Specifications.”
2. 10 CFR 50, Appendix A, “General Design Criteria for Nuclear Power Plants.”

U.S. Regulatory Guidance

3. Regulatory Guide 1.105, Revision 3, “Instrument Setpoints for Safety Related Instrumentation.”
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.”
5. Standard Review Plan Appendix 7.1-A, Rev. 4, “Acceptance Criteria and Guidelines for Instrumentation and Control Systems Important to Safety.”
6. Branch Technical Position HICB-12, Appendix 7-A, Rev. 4, “Guidelines on Establishing and Maintaining Instrument Setpoints.”

U.S. Industry Guidance

7. ANSI/ISA-67.04.01-2006, “Setpoints for Nuclear Safety Related Instrumentation.”
8. ISA-RP67.04.02-2000, “Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation.”
9. TSTF-493, Rev. 1, “Clarify Application of Setpoint Methodology for LSSS Functions.”

10. ASME Fluid Meters Sixth Edition, 1971.

11. ASME MFC-3M-1989, “Measurement of Fluid Flow in Pipes Using Orifices, Nozzles, and Venturi.”

12. ISA S51.1-1979 (R1993), “Process Instrumentation Technology, Reaffirmed 26 May 1995.”

13. ISA-S67.04-1994, Part I. "Setpoints for Nuclear Safety-Related Instrumentation Used in Nuclear Power Plants."

AREVA NP Documents

14. EMF-2341(P), Rev. 1, “Generic Strategy for Periodic Surveillance Testing of TELEPERM TM XS Systems in U.S. Nuclear Generating Stations.”

List of Changes for ANP-10275NP-A

Section	Page	Change Description
4.2	4-4	Revised equation for AV to reflect that AV equals the AF tolerance. Revised final two paragraphs to reflect new AV definition.
	4-5	Added continuation paragraph of revised AV definition. Revised Figure 4.2-1 to reflect revised AV definition.