ENERGY NORTHWEST

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Proprietary – Withhold under 10 CFR 2.390. Enclosure 1 contains PROPRIETARY information.

January 12, 2017
GO2-17-015

10 CFR 50.90

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Subject: **COLUMBIA GENERATING STATION, DOCKET NO. 50-397 RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION, COLUMBIA MUR LAR: ELECTRICAL INSTRUMENT AND CONTROLS BRANCH (EICB) AND REACTOR SYSTEMS BRANCH (SRXB) (CAC NO. MF8060)**

References:

1. Letter GO2-16-096 from A. L. Javorik (Energy Northwest) to NRC: "License Amendment Request to Revise Operating License and Technical Specifications for Measurement Uncertainty Recapture (MUR) Power Uprate," dated June 28, 2016 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16183A365)
2. Letter GO2-16-124 from A. L. Javorik (Energy Northwest) to NRC: "Response to License Amendment Request - Opportunity to Supplement," dated August 18, 2016 (ADAMS ML16231A511)
3. E-mail from J. Klos (NRC) to R. M. Garcia (Energy Northwest) " EICB RAIs for Columbia MUR," dated November 16, 2016 (CAC No. MF8060)
4. E-mail from J. Klos (NRC) to R. M. Garcia (Energy Northwest) " EICB RAIs for Columbia MUR," dated January 4, 2017 (CAC No. MF8060)
5. E-mail from J. Klos (NRC) to R. M. Garcia (Energy Northwest) "NON Proprietary Request for Additional Information Regarding Columbia MUR Power Uprate" dated November 22, 2016 (CAC No. MF8060)
6. E-mail from J. Klos (NRC) to R. M. Garcia (Energy Northwest) "NON Proprietary Request for Additional Information Regarding Columbia MUR Power Uprate" dated January 4, 2017 (CAC No. MF8060)

When Enclosure 1 is removed from this letter, the letter and remaining enclosure and attachment are NON-PROPRIETARY.

Dear Sir or Madam:

By Reference 1, Energy Northwest submitted a license amendment for Columbia Generating Station (Columbia) to recapture certain measurement uncertainties as a power uprate. By Reference 2, Energy Northwest supplemented the original request. In References 3 and 5, the US Nuclear Regulatory Commission (NRC) requested additional information related to the Columbia submittal. The enclosures to this letter contain the requested information.

Enclosure 1 to this letter contains proprietary information as defined by 10 CFR 2.390. GE-Hitachi Nuclear Energy Americas LLC (GEH), as the owner of the proprietary information, has executed the affidavit attached to this letter, which identifies that the enclosed proprietary information has been handled and classified as proprietary, is customarily held in confidence, and has been withheld from public disclosure. The proprietary information was provided to Energy Northwest in a GEH transmittal that is referenced by the affidavit. The proprietary information has been faithfully reproduced in the enclosed such that the affidavit remains applicable. GEH requests that the enclosed proprietary information be withheld from public disclosure in accordance with the provisions of 10 CFR 2.390 and 9.17. The non-proprietary version of Enclosure 1 is provided as Enclosure 2. The remaining requested information, which is also not considered proprietary, is provided in Enclosure 3.

On November 16, 2016, phone calls between the NRC staff and Energy Northwest staff were held to discuss the details of References 3 and 5. During one call, Energy Northwest provided the following additional clarifications to the NRC Staff.

1. With regards to Columbia's Leading Edge Flow Meter (LEFM), condition reports to address operational issues with the LEFM system since installation have been opened in the Columbia's Correction Action Program (CAP) with the following status:

    - Software;

      The software updates were completed in December 2016. This will allow Columbia to "run" the LEFM system for an extended monitoring period to ensure the corrective actions were adequate. During this monitoring period, Columbia will not take credit for the LEFM system.

    - Hardware;

      The hardware repair/replacement is scheduled for completion in refueling outage 23, scheduled in May of 2017. Following these actions, the vendor will recommission the system to certify functionally.

With regards to the frequency of update of the LEFM data, the LEFM flow calculations are based on a 60 second rolling average that is averaged for a two hour period and compared to a two hour averaged venturi calculated flow. This ratio is produced once a minute and is then applied to the venturi flow to produce an LEFM calibrated venturi feedwater flow.

References 4 and 6 revised the response date from January 5, 2017, to January 13, 2017.

The No Significant Hazards Consideration Determination (NSHCD) provided in the original submittal is not altered by this submittal. This letter contains no regulatory commitments.

If you have any questions or require additional information, please contact Mr. R. M. Garcia at (509) 377-8463.

I declare under penalty of perjury that the foregoing is true and correct.

Executed this 12th day of January, 2017.

Respectfully,

A. L. Javorik
Vice President, Engineering

Attachment: As stated
Enclosures: As stated

cc: NRC RIV Regional Administrator
NRC NRR Project Manager
NRC Senior Resident Inspector/988C
WA Horin – Winston & Strawn w/o Enclosures
RR Cowley -WDOH (email) w/o Enclosures
CD Sonoda – BPA/1399 (email) w/o Enclosures
EFSECutc.wa.gov-- EFSEC (email) w/o Enclosures

GO2-17-015

Attachment

Affadavit for Witholding

GE-Hitachi Nuclear Energy Americas LLC

AFFIDAVIT

I, Lisa K. Schichlein, state as follows:

(1) I am a Senior Project Manager, NPP/Services Licensing, Regulatory Affairs, GE-Hitachi Nuclear Energy Americas LLC (GEH), and have been delegated the function of reviewing the information described in paragraph (2) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in Enclosure 1 of GEH letter, DOC-0001-1115-123, "GEH Responses to CGS MUR RAIs EICB-RAI-1 and RAI-SRXB-4, 6, 8, 10, and 13," dated December 7, 2016. The GEH proprietary information in Enclosure 1, which is entitled "Responses to EICB-RAI-1 and RAI-SRXB-4, 6, 8, 10, and 13 in Support of the CGS MUR LAR," is identified by a dotted underline inside double square brackets. [[This sentence is an example.{3}]] GEH proprietary information in figures and large objects is identified with double square brackets before and after the object. In each case, the superscript notation {3} refers to Paragraph (3) of this affidavit, which provides the basis for the proprietary determination.

(3) In making this application for withholding of proprietary information of which it is the owner or licensee, GEH relies upon the exemption from disclosure set forth in the *Freedom of Information Act* ("FOIA"), 5 U.S.C. Sec. 552(b)(4), and the *Trade Secrets Act*, 18 U.S.C. Sec. 1905, and NRC regulations 10 CFR 9.17(a)(4), and 2.390(a)(4) for trade secrets (Exemption 4). The material for which exemption from disclosure is here sought also qualifies under the narrower definition of trade secret, within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975 F.2d 871 (D.C. Cir. 1992), and Public Citizen Health Research Group v. FDA, 704 F.2d 1280 (D.C. Cir. 1983).

(4) The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs (4)a. and (4)b. Some examples of categories of information that fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by GEH's competitors without license from GEH constitutes a competitive economic advantage over other companies;

b. Information that, if used by a competitor, would reduce their expenditure of resources or improve their competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product;

c. Information that reveals aspects of past, present, or future GEH customer-funded development plans and programs, resulting in potential products to GEH;

d. Information that discloses trade secret or potentially patentable subject matter for which it may be desirable to obtain patent protection.

(5) To address 10 CFR 2.390(b)(4), the information sought to be withheld is being submitted to NRC in confidence. The information is of a sort customarily held in confidence by GEH, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by GEH, not been disclosed publicly, and not been made available in public sources. All disclosures to third parties, including any required transmittals to the NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary or confidentiality agreements that provide for maintaining the information in confidence. The initial designation of this information as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in the following paragraphs (6) and (7).

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, who is the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge, or who is the person most likely to be subject to the terms under which it was licensed to GEH.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist, or other equivalent authority for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GEH are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary or confidentiality agreements.

(8) The information identified in paragraph (2), above, is classified as proprietary because it contains the detailed GEH methodology for thermal power optimization for GEH Boiling Water Reactors (BWRs). Development of these methods, techniques, and information and their application for the design, modification, and analyses methodologies and processes was achieved at a significant cost to GEH.

The development of the evaluation processes along with the interpretation and application of the analytical results is derived from the extensive experience and information databases that constitute a major GEH asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GEH's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GEH's comprehensive BWR safety and technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology and includes development of the expertise to determine and apply the appropriate evaluation process. In addition, the technology base includes the value derived from providing analyses done with NRC-approved methods.

The research, development, engineering, analytical and NRC review costs comprise a substantial investment of time and money by GEH. The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to

quantify, but it clearly is substantial. GEH's competitive advantage will be lost if its competitors are able to use the results of the GEH experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to GEH would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive GEH of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing and obtaining these very valuable analytical tools.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on this 6th day of December 2016.

Lisa K. Schichlein

Lisa K. Schichlein
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RAI-EICB-1

In TS 3.3.6.1, "Primary Containment Isolation Instrumentation," Table 3.3.6.1-1, "Primary Containment Isolation Instrumentation Function," Function 1.c "Main Steam Line Flow – High" is being revised from an Allowable Value of ≤ 124.4 pounds per square inch – differential (psid) to ≤ 137.9 psid. This change is being made due to the increased steam flow at the MUR power level.

In Section 5.3.5, "Main Steam Line High Flow Isolation," of Enclosure 7 to the application, General Electric-Hitachi (GEH) Report NEDC-33853P, "Safety Analysis Report for Columbia Generating Station Thermal Power Optimization," Revision 0 (proprietary), the licensee states that the Analytical Limit of 140% was not changed but the Allowable Value (AV) for this function was recalculated using the GEH methodology and a TS AV change is required to change the differential pressure at the allowable steam flow.

In Section 2.5 of the application, the licensee proposes to revise the AV for Main Steam Line Flow-High from a current value of ≤ 124.4 psid to ≤ 137.9 psid.

In order to meet the requirements of Title 10 of the Code of Federal Regulations 50.36, "Technical specifications," and Regulatory Guide 1.105, "Setpoints for Safety-related Instrumentation," Revision 3, dated December 1999, please provide a summary of the calculation used to calculate the revised AV on the docket.

Energy Northwest Response to RAI-EICB-1

Increase in Differential Pressure -- General:

For the Columbia Thermal Power Optimization (TPO; also known as Measurement Uncertainty Recapture (MUR)) power uprate project, there will be an uprate of 1.66% thermal power and an increase in main steam flow. The Analytical Limit (AL) for the Main Steam Line (MSL) high flow isolation of 140% of rated steam flow is not changed in terms of percent rated MSL flow, per Reference 1-1 Section F.4.2.5. However, it results in an increase in absolute MSL flow, as measured and indicated in differential pressure (psid).

The AL in units of differential pressure in the MSL flow venturi has been re-calculated using the method defined in Reference 1-2 (compressible fluids) and Reference 1-3 (Services Information Letter (SIL) 438, Revision 2). Note that Reference 1-3 was later revised, but there were no changes in the methodology. A copy of SIL 438 Revision 3 follows this RAI response. The AV and Nominal Trip Setpoint (NTSP) have been re-calculated in terms of differential pressure, and are the result of a complete setpoint calculation using standard GEH methodology (Reference 1-4) and revised inputs for increased instrument uncertainties.

Increase in Differential Pressure for AL:

The Current Licensed Thermal Power (CLTP) AV is based on the CLTP calculated AL differential pressure (psid) which was determined by GEH methodology in place at that time.

The current methodology is a revised model (Reference 1-3) that includes a better representation of the thermodynamic principles involved in the process for calculating this AL differential pressure for any given MSL flow. This includes an adjustment to the isentropic coefficient (ratio of specific heats at constant pressure and constant volume) of steam from 1.255 for dry steam assumed in earlier calculations to 1.080, which more realistically approximates the moist steam flowing through the MSLs and the venturi in each MSL. This methodology also includes consideration of the pressure drop between the reactor pressure vessel steam dome and the entrance of the venturi, which was not accounted for in the previous calculation. Taken together, these improvements result in a higher differential pressure for any given MSL flow with respect to the previous calculation. The methodology, including equations, are included in Reference 1-3.

Using the current methodology for calculating the differential pressures (Reference 1-3) for TPO (MUR) conditions results in an AL of 145.37 psid, compared against the AL of 127.5 psid for CLTP conditions with the previous methodology.

Therefore, the resulting increase in the newly calculated AL differential pressure is due to the combination of:

1) a slight increase in AL differential pressure due to the absolute MSL flow increase at 140% of rated TPO steam flow, and
2) a larger increase in AL differential pressure for the same MSL flow due to the methodology improvement noted above.

Ultimately for TPO, this combination results in an increase for the newly calculated AV differential pressure (psid) for MSL flow - high from a current value of ≤ 124.4 psid to ≤ 137.9 psid

<u>GEH Instrument Setpoint Methodology -- General:</u>

GEH setpoint calculations are based on the GEH instrument setpoint methodology contained in NEDC-31336P-A (Reference 1-4) that has been approved by the Nuclear Regulatory Commission (NRC). Conceptually, the GEH method is based on Instrument Society of America (ISA) Method 2, but leads to more conservative setpoints and is sometimes referred to as "Method 2 plus." According to this NRC-approved methodology, the setpoints are calculated from the AL, or from the AV if there is no AL, using a top down approach, and margin is calculated by methodology:

- between the AL and the AV,
- between the AL and the NTSP, and
- between the AV and the NTSP.

The margin between the AL and the final NTSP is at least equal to, and generally greater than that needed, to meet the 95% probability requirement of NRC Regulatory Guide (RG) 1.105 Revision 3 (Reference 1-5).

GEH's setpoint methodology for operating plants uses single-sided statistics in the development of AVs and NTSPs for instrument channels that provide trips when the process variable being measured approaches the setpoint in one direction, as described

in Reference 1-4. The MSL high flow Group 1 isolation setpoint function provides a trip (i.e., isolation) where the setpoint is approached in only one direction. Per the Safety Evaluation (SE) from the NRC (dated November 6, 1995) for Reference 1-4:

> "The GE methodology utilizes single-sided distributions in the development of trip setpoints and allowable values. ... The staff has stated that this methodology is acceptable provided that a channel approaches a trip in only one direction."

GEH's setpoint methodology for operating plants uses vendor instrument error (uncertainty) specifications conservatively to provide setpoints that meet margin requirements to a high degree of confidence. This was demonstrated by actual data analysis during licensing of the GEH methodology (Reference 1-4). GEH's instrument setpoint methodology was approved by the NRC in November 1995 while RG 1.105, Revision 2 (Reference 1-6) was in use. RG 1.105 Revision 3 (Reference 1-5) was introduced in December 1999, but the revised content, that quantified the confidence level to be 95%, did not invalidate or affect the approved GEH setpoint methodology. Per the SE from the NRC for Reference 1-4 for the Boiling Water Reactor Owners' Group (BWROG):

> "... the BWROG presented data to show that although the GE setpoint methodology does not produce results with a defined confidence level, it was shown that the data analysis can produce results that have a high degree of confidence (95 percent confidence limits). ... By establishing that the 95 percent confidence intervals are bounded by the design allowances developed per NEDC-31336, GE has shown that the results produced by the GE setpoint methodology can be established with high confidence."

The AL is a process parameter value used in the safety analysis (or transient analysis, as applicable) and represents a limiting value for the automatic initiation of protective actions. From the AL, an AV is first calculated which has margin from the AL based on all measurement errors (uncertainties) except drift. [[

]]

All random errors (uncertainties) are combined using the Square Root of the Sum of the Squares (SRSS) method, and non-conservative bias errors (uncertainties) are added algebraically. The AV represents the limiting value to which a setpoint can drift (as determined from surveillance) and still ensure that the AL is protected. [[

]] The AV is the value specified in the Technical Specifications (TS), and is an AL surrogate that assures the AL is protected if the setpoint (i.e., instrument setting) does not exceed it.

A pictorial representation of the methodology is shown in Figure 1-1.

[[

]]

NTSP	= Nominal Trip Setpoint
NTSP1	= LTSP = Initial NTSP with Minimum Required Margin from AL
LTSP	= Limiting Trip Setpoint
NTSP(Adj)	= $NTSP_F$ = Final NTSP with Required Margin to AV
PMA	= Process Measurement Accuracy (Error)
PEA	= Primary Element Accuracy (Error)

[[

]]

D	= Drift between Calibrations
C	= Calibration Error (including ALT)
LER	= Licensee Event Report
ALT	= As-Left Tolerance
LAT	= Leave Alone Tolerance (= ALT)
OSP	= Operating Setpoint (= NTSP(Adj) = $NTSP_F$)
STA	= Spurious Trip Avoidance

Figure 1-1

MSL High Flow Group 1 Isolation Setpoints – Columbia:

AV and NTSP setpoint calculations were performed to support the TPO (MUR) uprate Columbia, based on the new TPO AL in terms of differential pressure. The calculations were based on the implementation of TPO at 3,544 MWt. The MSL high flow Group 1 isolation calculations were based on the error (uncertainty) terms associated with the existing MSL high flow instruments. The As-Left Tolerances (ALTs) (i.e., the tolerance within which the device calibration reading is left after calibration) were considered in the calculations; these tolerances will be based on the existing Differential Pressure Indicating Switches (DPISs). The instrument errors (uncertainties) are related to the flow instruments used to measure MSL flows, and are documented in the summary inputs/outputs document (Reference 1-7), and were all combined using the same unit of differential pressure (psid). [[
]]

A copy of Reference 1-7 is enclosed, following this RAI response, for the NRC's review of the instrument uncertainty inputs used in the setpoint calculation. The associated setpoint calculation spreadsheets for Reference 1-7 may be viewed by the NRC at a GEH office, upon request.

The following Table 1-1 provides a comparison of the calculated results in units of differential pressure (psid) for the Columbia setpoint calculation for TPO conditions, per GEH instrument setpoint methodology. Note, as stated earlier, the final adjusted $NTSP_F$ is further away from the AL than NTSP1, the Limiting Trip Setpoint (LTSP). Also, note that the intermediate NTSP(s) are not included.

For the AL increase of 17.87 psid, the AV increased by 13.5 psid.

Table 1-1

Parameter	TPO psid [1]
AL	145.37
AV	137.9
NTSP1 (LTSP)	137.6
$NTSP_F$	134.6

Note:

1. The AV and NTSPs exclude head correction (Reference 1-7).

References:

1-1 GE Nuclear Energy, "Licensing Topical Report Generic Guidelines and Evaluations for General Electric Boiling Water Reactor Thermal Power Optimization," NEDC-32938P-A, Revision 2, May 2003.

1-2 American Society of Mechanical Engineers Research Committee, Fluid Meters, 6th Edition, 1971.

1-3 GE Hitachi Nuclear Energy SIL 438, "Main Steam Line High Flow Trip Setting," Revision 2, May 10, 2013 (and later updated without methodology change to Revision 3, July 28, 2016). [Attached to enclosure]

1-4 GE Nuclear Energy, "General Electric Instrument Setpoint Methodology," NEDC-31336P-A, September 1996.

1-5 NRC RG 1.105, "Setpoints for Safety-related Instrumentation," Revision 3, December 1999.

1-6 NRC RG 1.105, "Instrument Setpoints for Safety-related Systems," Revision 2, February 1986.

1-7 GE Hitachi Nuclear Energy, "Instrument Limits Calculation Energy Northwest Columbia Generating Station Main Steam Line High Flow Group 1 Isolation," 000N7333-R2-Col-TPO-MslHiFlo-Calc, Revision 1, March 2016. [Attached to enclosure]

RAI-SRXB-4: Fuel Thermal Margin Monitoring

In Section 2.2, "Thermal Limits Assessment," of the TSAR [General Electric-Hitachi (GEH) Report NEDC-33853P, "Safety Analysis Report for Columbia Generating Station Thermal Power Optimization" (TSAR)], it states that [[

]]. To meet the requirements of 10 CFR 50, Appendix A, GDC [General Design Criteria]10 and 15 for assuring the design conditions with respect to the integrity of physical barriers, please justify the applicability of the TSAR for use of the 4.8 MWt/bundle basis or provide a plant specific analysis.

Energy Northwest Response to RAI-SRXB-4

The TSAR and TLTR both describe the same, generic analysis. The generic basis for [[ ]] at 100% original RTP. At 25% of [[ ]], average bundle power is [[ ]]. Columbia's average bundle power at 25% of MUR uprated power is 1.16 MWt/bundle.

According to Section 5.8 of the TLTR, "[[

]]" Columbia does not exceed [[ ]] at 25% of MUR uprated thermal power. Therefore, the threshold for fuel thermal margin monitoring is 25% MUR uprated thermal power.

RAI-SRXB-6: Emergency Core Cooling System-Loss-Of-Coolant Accident Performance Analyses

Table 4.1 of TSAR shows the Emergency Core Cooling System (ECCS) Loss-Of-Coolant Accident (LOCA) analysis results for GNF2 fuel. It is not clear whether the GNF2 fuel is the only fuel type for the upcoming cycle with MUR uprated power. It is noted from the COLR for Cycle 23 that the current cycle reactor core contains GE14 in addition to the GNF2 fuel. To meet the requirements of 10 CFR 50, Appendix A, GDC 10, GDC 15 and 10 CFR 50.46 for assuring the design and LOCA conditions with respect to the integrity of physical barriers and the completeness and accuracy requirements of 10 CFR 50.9, please provide the analysis result similar to Table 4.1 of TSAR for GE14 if GE14 is applicable and used in the next cycle. In addition, please provide a justification meeting the [[ ]] Peak Cladding Temperature (PCT) margin criteria if GE14 is applicable and used in the next cycle.

Energy Northwest Response to RAI-SRXB-6

Table 6-1, below, provides the ECCS-LOCA analysis results for GE14 fuel based on NEDC-33507P (Reference 6-1).

The current GE14 and GNF2 ECCS-LOCA analyses were performed at ≥ 102% of Current Licensed Thermal Power (CLTP), which bounds the Thermal Power Optimization (TPO) uprate, and the ECCS-LOCA results for Columbia are in conformance with the licensing requirements of 10 CFR 50.46. Therefore, the pre-TPO LOCA analyses for GE14 and GNF2 fuel bound the 1.66% TPO uprate for Columbia.

Table 6-1 COLUMBIA ECCS-LOCA Analysis Results

Parameter	GE14 Fuel	Analysis Limit
Nominal PCT	1,365°F	N/A
Appendix K PCT	1,647°F	≤ 2,200°F (1)
Licensing Basis PCT	1,710°F	≤ 2,200°F (1)
Maximum Local Oxidation	< 1.0%	≤ 17% (1)
Core-Wide Metal-Water Reaction	< 0.1%	≤ 1.0% (1)

Note:

1. 10 CFR 50.46 ECCS-LOCA analysis acceptance criteria

The assessment of the upper bound PCT and the demonstration of margin and compliance as discussed in Section 4.3 of NEDC-33853P (TSAR) for the GNF2 fuel basis is implicit to the approved GEH methodology as described there and would be equally applicable to the GE14 fuel bundles in the core.

Reference

6-1 GE Hitachi Nuclear Energy, "APRM/RBM/Technical Specifications /Maximum Extended Load Line Limit Analysis," NEDC-33507P, Revision 1, January 2012.

RAI-SRXB-8: Anticipated Transient Without Scram (ATWS)

To meet the requirements of 10 CFR 50, Appendix A, GDC 10 and 15 for assuring the design conditions with respect to the integrity of physical barriers, the completeness and accuracy requirements of 10 CFR 50.9, and the requirements for ATWS as specified in 10 CFR 50.62, "Requirements for reduction of risk from anticipated transients without scram (ATWS) events for light-water-cooled nuclear power plants," please provide information for the following:

For TSAR, Section 9.3.1, "Anticipated Transient Without Scram," please provide the CGS [Columbia]-specific ATWS analysis results at 100% Current Licensed Thermal Power (CLTP) and the margin of the ATWS acceptance criteria for the following:

(a) PCT,

(b) Peak clad oxidation and,

(c) Peak containment pressure.

Energy Northwest Response to RAI-SRXB-8

The current COLUMBIA-specific ATWS analysis results are below.

(a) The limiting peak cladding temperature (PCT) is determined to be 1,572°F; the limit is 2,200°F.

(b) The peak local cladding oxidation is not explicitly calculated because the calculated ATWS PCT is below 1,600°F. Cladding oxidation is insignificant if the PCT remains below 1,600°F.

(c) The peak containment pressure was determined to be less than 12 psig, which is below the 45 psig limit.

RAI-SRXB-10: Station Blackout (SBO)

Provide a confirmation of meeting the requirements in 10 CFR 50.63, "Loss of alternating current power," for the MUR power uprate. Specifically, please provide a description on if the plant has sufficient condensate inventory for MUR power uprate operation and whether the reactor core isolation cooling (RCIC) or high pressure coolant injection (HPCI) systems can provide core cooling and coverage during the SBO coping period.

Energy Northwest Response to RAI-SRXB-10

The current SBO analysis of record is based on a power level of 3,629 MWt, which bounds the measurement uncertainty recapture (MUR) power level. The evaluation concluded that there is sufficient condensate storage inventory such that, with the continued availability of the RCIC or high pressure core spray (HPCS) systems, it will continue to provide the same support for core cooling and coverage during the SBO coping period.

RAI-SRXB-12: Reactor Vessel Fracture Toughness

To meet the requirements of 10 CFR 50, Appendix A, GDC 10 and 15 for assuring the design conditions with respect to the integrity of physical barriers and the completeness and accuracy requirements of 10 CFR 50.9, please provide information for the following questions.

(a) Please confirm that MUR power is used to define the 51.56 effective full power years (EFPY) in Table 3-1, "CGS Upper Shelf Energy 60-Year License (51.56 EFPY)."

(b) In the TSAR, Section 3.2.1, "Fracture Toughness," it appears the same information has been provided in paragraphs (f) and (g) on Page 3-2 of the TSAR. Please confirm if any additional information was supposed to be presented in either paragraph.

Energy Northwest Response to RAI-SRXB-12

(a) Flux/Fluence values applicable to power level of 3,545 MWt were used in calculating the values presented in Table 3-1, "CGS Upper Shelf Energy 60-Year License (51.56 EFPY)" of the TSAR. This bounds the power level (3,544 MWt) discussed in the TSAR for the measurement uncertainty recapture (MUR).

(b) Paragraph (g) should be deleted as it duplicates text contained in paragraph (f). Inclusion of paragraph (g) is an editorial error. The text in paragraph (f) includes what was intended to be presented and no additional information was intended.

Attached References for ECIB-RAI-1
1-3 GE Hitachi Nuclear Energy SIL 438, "Main Steam Line High Flow Trip Setting," Revision 2, May 10, 2013 (and later updated without methodology change to Revision 3, July 28, 2016).
Reference 1-7 Non-Propietary Version
1-7 GE Hitachi Nuclear Energy, "Instrument Limits Calculation Energy Northwest Columbia Generating Station Main Steam Line High Flow Group 1 Isolation," 000N7333-R2-Col-TPO-MslHiFlo-Calc, Revision 1, March 2016.

Main Steam Line High Flow Trip Setting

SIL No. 438
Revision 3

July 28, 2016

Introduction

The original SIL 438 was written because a review of the Main Steam Line (MSL) high flow trip setpoint for an operating BWR disclosed an inconsistency between the actual setting and that specified in the plant technical specifications. The difference was attributed to the use of design steam flow conditions rather than rated conditions in the original setpoint calculation. The original SIL 438 informed BWR owners of this potential inconsistency and provided a method for determining the proper setpoint for the MSL high flow trip.

SIL 438 Revision 1 corrects an error in the equation for calculating the MSL high flow trip setpoint. Using the uncorrected equation found in the original SIL 438 could result in a nonconservatism of approximately 3% in steam flow when calculating the Analytic Limit (AL) or trip setpoint.

SIL 438 Revision 2 incorporates changes to Attachment 1. These changes are due to a revision of the model that prevents non-conservative setpoints for specific conditions which were communicated to utilities in a GEH 10 CFR Part 21 Communication (SC 12-18 R2). This revised model relates steam flow (% rated) and venturi flow limiter pressure drop (ΔP psid) to better represent the thermodynamic principles involved in this process. The revised model for calculating ΔP for any given MSL flow includes an adjustment to the isentropic coefficient (ratio of specific heats at constant pressure and constant volume) of steam from 1.255 for dry steam assumed in the earlier analyses to 1.080 which more realistically approximates the moist steam flowing through the MSL and venturi, and also includes the pressure drop between the dome and the entrance of the flow limiter. A clarification is added to the upstream density term ρ to reflect an actual steam/water mixture at the venturi throat entrance. Other minor edits to Attachment 1 are also included.

SIL 438 Revision 3 clarifies wording contained in SIL 438 Rev 2 Recommendations Item 2. This recommendation discusses how to determine if the current (existing) setpoint AL (in ΔP units) is conservative with respect to the value of flow-instrument ΔP associated with the AL flow rate as calculated using the equation in Attachment 1. If the existing calculations have been performed according to the methodology found in SIL 438 Rev 2, there is no need to revise those calculations.

Discussion

The MSL high flow sensors detect and isolate breaks in the main steam lines outside the reactor containment. The high flow trip initiates reactor isolation by closing the Main Steam Isolation Valves (MSIVs) to minimize potential release of radioactive materials to the environment and to minimize coolant inventory loss.

The trip signal for the MSL high flow isolation is taken from differential pressure measuring instruments connected to the flow limiters (venturis) in each steam line. The venturis also limit the maximum flow from a steam line break to approximately 200% of the original rated steam flow for each steam line. The maximum setpoint (in % flow and

corresponding ΔP psid) for the MSL high flow trip must be less than the maximum flow (choked flow and corresponding ΔP psid) calculated for each steam line, and the minimum setpoint should be sufficiently above 100% of rated steam flow (and corresponding ΔP psid) for each steam line to prevent spurious trips. A typical setpoint AL is 140% Nuclear Boiler Rated (NBR) steam flow. This setpoint permits on-line testing of the MSIVs at power.

Many plant technical specifications specify a setpoint for the MSL high flow trip based on an upper AL equivalent to 140% NBR steam flow. The actual setpoint is then calculated as a corresponding pressure drop across the differential pressure sensing device.

The MSL high-flow setpoint isolates the MSIVs and minimizes the potential release of radioactive materials and reactor coolant to the environment in the event of a MSL break accident. The MSL high-flow setpoint AL corresponds to the maximum licensed flow rate and ΔP at which this protective function occurs. Therefore, conservative establishment of the MSL high-flow AL is important for ensuring the MSL high-flow trip function.

The setpoint calculations assure that MSL high-flow trip actuation occurs before the MSL flow reaches the AL. Thus, the AL must be established as a value acceptably below the choked flow rate to ensure that flow does not choke at some rate less than needed for actuation of the MSL high-flow trip.

Margin between the choked flow rate and the MSL high-flow AL (termed "MSL flow margin" here) at or near the Original Licensed Thermal Power (OLTP) is relatively large, greater than 30% of rated flow for many plants, so that the choked flow rates are much greater than the AL values typically used. Increases in the MSL flow at power uprated from OLTP have often included raising the AL to keep the AL at the same percent of rated flow, which decreases the MSL flow margin. As an example, for a constant pressure power uprate for which the choked flow rate remains the same in terms of absolute flow (lbm/sec) but decreases as a percent of flow at the uprated condition, an AL set at 140% of uprated flow is closer to the choked flow than an AL set at 140% of original flow, and the margin between choked flow conditions and the AL is thereby reduced. This trend of decreasing margin requires an evaluation to ensure that MSL flow margins for extended power uprate remain sufficient to ensure reliable high-flow trip functionality. In these evaluations, a potential safety concern arises if the ΔP corresponding to choked flow is less than the ΔP corresponding to the AL; under that condition it is possible the trip would not activate and isolation would not occur.

Recommendations

GE Hitachi Nuclear Energy (GEH) recommends that owners of GE BWRs verify that the proper instrument trip setpoint has been established. The following procedure is recommended to determine whether there is an inconsistency between plant technical specifications and actual trip setpoints:

1) Perform an evaluation (or calculation) to assure that the AL (flow units) is less than the choked flow rate as determined with the GEH methodology revised in 2013 (or later). Plant staff can contact their GEH services representative for assistance. For choked flows <145% NBR steam flow, GEH recommends contacting GEH to determine the

establishment of an appropriate MSL high-flow AL which may be below 140% NBR steam flow. In some cases, additional setpoints evaluation may be necessary to establish an AL that ensures sufficient spurious trip margin.

2) Determine whether the current (existing) setpoint AL (in ΔP units) is conservative with respect to the value of flow-instrument ΔP associated with the AL flow rate [as calculated using the equation in Attachment 1]. In other words, the newly calculated ΔP number at the flow rate corresponding to the MSL high flow AL may be checked against the ΔP AL number used in the current setpoint calculation. If the newly calculated ΔP number at the flow rate corresponding to the MSL high flow AL value is <u>higher</u> than the ΔP AL number used in the current (existing) setpoint calculation, then the current (existing) setpoint AL number is conservative.

To receive additional information on this subject, or for assistance in implementing a recommendation, please contact your local GEH Representative.

This SIL pertains only to GEH BWRs. The conditions under which GEH issues SILs is stated in SIL No. 001 Revision 6, the provisions of which are incorporated into this SIL by reference.

Product Reference

B21 – Nuclear Boiler

Technical Source

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Approved for Release

J. Burke, Manager, Services Engineering

Issued by:
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Attachment 1

Calculation of Main Steam Line High Flow Trip Setpoint

The equation[1] for calculating the main steam line high flow trip setpoint is:

$W = 1890.07 \frac{CYd^2 F_{aSST}}{(1-B^4)^{1/2}} (\rho \Delta P)^{1/2}$ or $\Delta P = \frac{W^2(1-B^4)}{3.57236\times10^6} \frac{1}{C^2Y^2d^4 F_{aSST}{}^2 \rho}$ (note: not closed form)

where:

Y = expansion factor for a gas (ratio):

$$Y = \left[r^{2/k} \times \frac{k}{k-1} \times \frac{1-r^{\frac{k-1}{k}}}{1-r} \times \frac{1-B^4}{1-(B^4 r^{2/k})} \right]^{1/2}$$

P_1 = static pressure at entrance to flow limiter (i.e., dome pressure minus outlet nozzle and line losses; in units of absolute pressure)

P_2 = static pressure at flow limiter throat (absolute pressure)

ΔP = differential pressure across flow limiter $P_1 - P_2$ (psid)

W = steam flow rate at desired analytic limit or trip setpoint (lbm/hr)

C = coefficient of discharge (0.995 for a venturi tube with a machined entrance cone) (ratio)

d = throat inside diameter, (in)

D = pipe inside diameter, (in)

B = ratio of throat to pipe inside diameter at temperature = $(d\sqrt{Fa_{SST}})/(D\sqrt{Fa_{CS}})$

F_{aSST} = area thermal expansion factor (ratio) for stainless steel flow limiter (approximately 1.009 for 300 series stainless steel primary element thermal expansion from 68°F to temperature of 525 to 550°F)

F_{aCS} = area thermal expansion factor (ratio) for carbon steel MSL pipe (approximately 1.0068 for carbon steel pipe thermal expansion from 68°F to 525 - 550°F)

ρ = upstream fluid density at pressure P_1 (lbm/ft^3) for a steam/water mixture at the flow limiter entrance. Note: an initial moisture content in the dome is typically 0.1%. The calculated ΔP is insignificantly affected by moisture content. A value of 0.5% can be conservatively used for plants that have a history of periodic moisture in excess of 0.1%.

r = ratio of throat static pressure to entrance static pressure P_2/P_1; also equal to $\frac{P_1-\Delta P}{P_1}$ (use absolute pressures)

k = ratio of specific heats of fluid $\frac{C_p}{C_v}$ (representative isentropic exponent for a steam/water mixture in the range of 900 psia to 1100 psia dome pressure, k = 1.080)

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[1]American Society of Mechanical Engineers, "Report of ASME Research Committee on Fluid Meters", Sixth Edition, 1971, P. 233, and May 1974 Errata.

HITACHI

GE Hitachi Nuclear Energy

Non-Proprietary Information – Class I (Public)

GEH Number: 000N7333-R2-Col-TPO-MslHiFlo-Calc-NP
Revision Number: 1
March 2016

Instrument Limits Calculation
Energy Northwest
Columbia Generating Station

Main Steam Line High Flow
Group 1 Isolation

[Signed electronically as part of the Independent Verification process.]
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IMPORTANT NOTICE REGARDING CONTENTS OF THIS REPORT

Please Read Carefully

A. Disclaimer

The only undertakings of the GE Hitachi Nuclear Energy (GEH) respecting information in this document are contained in the contract between Energy Northwest and GEH, Columbia Generating Station (CGS) Thermal Power Optimization (TPO) project, Purchase Order #340140, as further amended to the date of transmittal of this document, and nothing contained in this document shall be construed as changing the contract. The use of this information by anyone other than CGS, or for any purpose other than that for which it is intended is not authorized; and with respect to any unauthorized use, GEH makes no representation or warranty, express or implied, and assumes no liability as to the completeness, accuracy or usefulness of the information contained in this document, or that its use may not infringe privately owned rights.

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This is a non-proprietary version of the document 000N7333-R2-Col-TPO-MslHiFlo-Calc, which has the proprietary information removed. Portions of the document that have been removed are indicated by an open and closed bracket as shown here [[ ]].

GE-Hitachi Nuclear Energy Americas LLC

REVISION SUMMARY:

Rev	Required Changes to Achieve Revision
0	Initial issue
1	Revised for new target thermal power level for TPO and rated MS flow rate, and for the resulting changes in the Analytical Limit, Operational Limit, and other related changes in differential pressure.

Contents:

This document is a supplemental analysis data sheet to Reference 1. Included in this document in sequential order are:

- The setpoint function for the system,
- The setpoint function analyses inputs and the source reference of the inputs,
- The device in the setpoint function instrument loop,
- The component analysis inputs and input sources,
- The calculated results,
- Input comments and result recommendations,
- References.

1. Function: Main Steam Line High Flow Group 1 Isolation

Setpoint Characteristics:	Definition				Reference(s)
Event Protection:	Limiting event for the setpoint: Detect and mitigate the consequences of a Main Steam Line (MSL) break by sending a signal to the Nuclear Steam Supply Shutoff System (NSSSS) for Group 1 isolation (closure of the Main Steam Isolation Valves (MSIVs) and MSL Drains (MSLDs).				Ref. 2 Sect. 3.13; Ref.3.2 Appendix C
Function After Earthquake	☒	Required	☐	Not Required	Ref. 3.2 Sect. 6.3
Setpoint Direction	☒	Increasing	☐	Decreasing	Ref. 3.1; Ref. 3.2
Single or Multiple Channel	☐	Single	☒	Multiple	Ref. 3.1; Ref. 3.2
LER Calculation Basis if Multiple Channel	Standard (Conservative) LER Calculation ☒, or Configuration Specific LER Calculation ☐				Ref. 1 Sect. 5.3; Ref. 2 Sect. 3.13
Trip Logic for Configuration Specific LER Calculation	n/a				

Current Function Limits:	Value/Equation		Reference(s)	
	Present Calculation (CLTP Conditions)	TPO Conditions		
Analytical Limit	127.5 psid 140% flow	145.37 psid 140% flow	Ref. 3.1; Ref. 3.2	Ref. 6.1; Comment 8; Comment 9
Tech Spec Allowable Value	124.4 psid		Ref. 3.1; Ref. 3.2	
Setpoint	115.6 psid 111.0 psid (IMDS)		Ref. 3.1; Ref. 3.2	
Operational Limit	72 psid 105% flow	112.12 psid 127% flow	Ref. 3.2 Appendix C	Ref. 6.1; Ref. 2 Sect. 3.13

Plant Data:	Value Present Calculation	Value Power Uprate Condition	Sigma if not 2	Reference(s)	
Primary Element					
• Accuracy (APEA)	± 2% of rated flow	± 0.75% of point = ± 3.02 psid		Ref. 3.2 Sect. 6.2	Ref. 1 Sect. 3.5; Ref. 6.1; Comment 8
• Drift (DPEA)	negligible	negligible			Comment 7
Process Measurement Accuracy (PMA)	± 1% of Calibrated Span (SP)	4.23 psid [[ ]]		Ref. 3.2 Sect. 6.2	Ref. 1 Sect. 3.4; Ref. 6.1 Comment 8

Components (or Devices) in Setpoint Function Instrument Loop:

- Venturi Flow Nozzle
- Differential Pressure Indicating Switch (DPIS)

2. Components:

2.1 Differential Pressure Indicating Switch (DPIS)

Component Information:	Value/Equation	Reference(s)
Plant Instrument ID No.	MS-DPIS-8A-D, MS-DPIS-9A-D, MS-DPIS-11A-D, MS-DPIS-810A-D	Ref. 3.2 Sect. 6.3
Instrument vendor	Barton®	Ref. 3.2 Sect. 6.3
Model ID No. (including Range Code, as applicable)	288A	Ref. 3.2 Sect. 6.3
Plant Location(s)	(not provided)	Ref. 3.2; Comment 2
Process Element	Venturi (MS-FE-5A)	Ref. 3.2 Sect. 6.2

Inputs:

Vendor Specifications:	Value / Equation	Sigma if not 2	Reference(s)
Top of Scale	+150 psid		Ref. 3.2 Sect. 6.2 & Sect. 6.3; Comment 9
Bottom of Scale	-15 psid		Ref. 3.2 Sect. 6.2 & Sect. 6.3; Comment 9
Upper Range Limit	+150 psid		Ref. 3.2 Sect. 6.2 & Sect. 6.3; Comment 9
Accuracy (Acc.)	Repeatability: ± 0.2% Full Scale (FS) (not used) ± 0.25% Full Scale (FS) (used)		Ref. 3.2 Sect. 6.3 & Att. 3 Ref. 5.1 Sect. 1-4; Ref. 3.1
Temperature Effect	No additional error when operated from -40 – +180 degF		Ref. 3.2 Sect. 6.3 & Att. 3
Seismic Effect	Zero		Ref. 3.2 Sect. 6.3; Comment 10
Radiation Effect	Zero		Ref. 3.2 Sect. 6.3; Comment 10
Humidity Effect	Included in accuracy		Ref. 3.2 Sect. 6.3; Comment 4
Power Supply Effect	n/a		Ref. 3.2 Sect. 6.3; Comment 4
RFI/EMI Effect	Included in accuracy / n/a		Ref. 3.2 Sect. 6.3; Comment 4
Insulation Resistance Effect	n/a		Ref. 3.2 Sect. 6.3; Comment 4
Over-pressure Effect	Zero		Comment 11
Static Pressure Effect	± 0.25 %FS / 1000 psi over range pressure = approx. ± 0.258 %FS		Ref. 3.2 Sect. 6.3; Comment 12

2.1 Differential Pressure Indicating Switch (cont'd)

Plant Data:	Value	Reference(s)
Calib Temperature Range	70 °F	Ref. 3.2 Sect. 6.3
Normal Temperature Range	40 – 104 °F	Ref. 3.2 Sect. 6.3
Trip Temperature range	40 – 104 °F	Ref. 3.2 Sect. 6.3; Comment 13
Plant seismic value	4.5 g	Ref. 3.2 Sect. 6.3
Plant Radiation value	2.8 x10^4 RAD TID	Ref. 3.2 Sect. 6.3
Plant Humidity value	20% - 90% RH (normal) 40% (calibration)	Ref. 3.2 Sect. 6.3
Power Supply Variation value	± 12 Vdc	Ref. 3.2 Sect. 6.3
RFI/EMI value	Not provided	Comment 4
Over-pressure value	Not used	Comment 11
Static Pressure value	1035 psig	Ref. 3.2 Sect. 6.3; Comment 12

Drift:	Value		Sigma if not 2	Reference(s)
Current Calib. Interval	18 Mo. ☐ Includes extra 25%			Ref. 3.2 Sect. 6.3
Desired Calib. Interval	22.5 Mo. ☒ Includes extra 25%			Ref. 3.2 Sect. 6.3
Drift Source	☒ Calculated ☐ Vendor			Ref. 1 Sect. 3.3
Drift Value	= ± 1.0 % SP / 18 months	± 1.118034 % SP / 22.5 months		Ref. 1 Sect. 4.3.1; Ref. 3.2 Sect. 6.3 & Att. 3; Comment 10

2.1 Differential Pressure Indicating Switch (cont'd)

Calibration:	Value / equation	Sigma if not 3	Reference(s)
As Left Tolerance	± 2 %FS DPIS		Ref. 5.1 Sect. 3.8. A.; Comment 14
Leave Alone Tolerance	= ALT		Comment 15
Input Calibration Tool:	Heise® Pressure Gauge Model CMM 750		Ref. 3.2 Sect. 6.3
Accuracy	Total: ± 0.1 %FS		Ref. 3.2 Sect. 6.3 & Att. 2; Ref. 5.2
Resolution / Readability			
Minor Division	1 psid		Ref. 3.2 Sect. 6.3 & Att. 2
Upper Range	750 psid		Ref. 3.2 Sect. 6.3
Temperature Effect			
Input Calibration Standard:	Not provided		Ref. 3.2
Accuracy	Assumed equal to $^1/_4$ Calibration Tool Accuracy		Ref. 3.2 Sect 6.3; Comment 3; Comment 6
Resolution / Readability			
Minor Division	n/a		
Upper Range	n/a		
Temperature Effect			
Output Calibration Tool:	n/a		Ref. 3.2
Accuracy			
Resolution / Readability			
Minor Division			
Upper Range			
Temperature Effect			
Output Calibration Standard:	n/a		Ref. 3.2
Accuracy			
Resolution / Readability			
Minor Division			
Upper Range			
Temperature Effect			

Application Specific Input:	Value	Sigma if not 2	Reference(s)

3. Summary Results:

Calculated Values:

Setpoint Function	Analytic Limit (from Section 1)	Allowable Value † †††	Setpoint (NTSP) † †††	Meets LER Avoidance Criteria	Meets Spurious Trip Avoidance Criteria ††
MSL High Flow Group 1 Isolation	140% flow 145.37 psid	137.9 psid	134.6 psid	Y	Y

† Excludes head correction.

†† See Comment 16 regarding the STA evaluation.

††† Comment 17.

Application Specific Setpoint Adjustments:

Setpoint Function	AL to AV (psid)	AL to NTSP1 (psid)	(psid)
Minimum Required Margins (psid) from AL (Ref. 1; Ref. 2)	7.382295 †	7.728457 †	
Limiting Trip Setpoint (LTSP) = NTSP1 (Ref. 1; Ref. 2; Ref. 8)			137.6 ††††

† Exclusive of head correction.

†††† Note that the calculated AV and NTSP are rounded down away from the AL. Note also that in reality, the LTSP would not work as the instrument setting, because it is too close to the calculated AV, considering the value of the LAT.

4. Comments and Recommendations:

1. Unless specifically identified as "bias" errors in this document, all instrument uncertainty errors will be considered to be random in nature, even when the "±" symbol is not shown.
2. Some plant specific information has not been provided in the current CGS setpoint calculation(s) or documents and is considered unnecessary because the impact of this information is included within the instrument accuracy values within the current CGS setpoint calculation(s) or documents, or otherwise does not affect the setpoint calculations.
3. Unless specified otherwise, all calibration tool errors are considered to include resolution / readability errors and temperature effect errors. For the errors of assumed calibration standards, the temperature effect term is considered to be included in the accuracy of the assumed standard. The resolution/readability error for assumed calibration standards does not apply, because it is not actually read.
4. Temperature effect, radiation effect, seismic effect, humidity effect, power supply effect, Radio Frequency Interference/ Electromagnetic Interference (RFI/EMI) effect, and Insulation Resistance Effect (IRE) errors are marked "n/a," "negligible," "not provided," or "included in accuracy," and are considered to have negligible or no impact on the manufacturer's accuracy terms when they are not identified separately.
5. Per References 1 and 2, overpressure effects are only applicable to certain pressure measurement devices (e.g., differential pressure transmitters), and static pressure effects are only applicable to certain differential pressure measurement devices. These effects are marked "n/a" for other devices.
6. Where a specific input was not provided on the Calibration Standards, an assumed inaccuracy ratio of one-quarter (i.e., $^1/_4$) that of the Device inaccuracy is used. Per Ref. 3.2 (Attachment 1): "The instruments traceable to the National Bureau of Standards used to calibrate the tool crib instruments are at least four (4) times as accurate as the tool crib instrument being calibrated."
7. The PEA is assumed to be independent of time because it is assumed that the flow primary elements do not degrade with time (Ref. 1). Therefore, the drift component of the PEA is considered to be negligible. (Ref. 3.2 Section 6.3)
8. The methodology of Ref. 5.1 was used to determine the AL for TPO conditions (Ref. 6.1). Also, the APEA and PMA were determined for TPO steam flow conditions (Ref. 6.1 and Ref. 2).
9. The calibrated span for the Differential Pressure Indicating Switch (DPIS) in the current setpoint calculation of record (Ref. 3.2) is from -15 psid to +150 psid, resulting in a Calibrated Span (SP) equal to 165 psid. The vendor states that all switches are adjustable from 5% to 95% of factory calibrated scale (Ref. 5.1). This SP encompasses the Analytical Limit (AL) for TPO conditions, and is within 156.75 psid, 95% of the calibrated scale. Therefore, the Allowable Value (AV) and the Nominal Trip Setpoint (NTSP) will be within the instrument scale.

   However, note that the AL for TPO conditions is 96.9% of the Upper Range Limit of 150 psid.
10. The current approach in GEH setpoint calculation methodology treats the Drift Effect, Radiation Effect, and the Seismic Effect for this instrument to be a 2 sigma values.
11. These devices use a sealed bellows unit, and therefore are not subject to Over Pressure Effect (OPE).

4. Comments and Recommendations (cont'd):

12. The DPIS Static Pressure Effect (SPE) is 0.25% Full Scale (FS) per 1000 psi over range pressure. Per Ref. 3.2 Section 6.3, the MS head has a pressure of 1000 psi and the high range of the switch is 72.28 Inches Water Gauge (InWG), and this converts to approx. 2.61 psi. The RPV Steam Dome pressure is 1035 psi. Thus the SPE = 0.25% FS * [(1035 – 2.61)/1000] = 0.258098 % FS.
13. These instruments function very early in the event of a steam line break and have no function after the Main Steam Isolation Valves close. Therefore, the environmental conditions several minutes after the Loss of Coolant Accident (LOCA) would not affect the accuracy of the instruments.
14. Whereas the current setpoint calculation of record (Ref. 3.2 Section 6.3) does not use an As-Left Tolerance for the DPIS, the DPIS Vendor document (Ref. 5.1 Section 3.8. A.) states that when changing the Switch setpoint, the setting will be placed within ±2 % FS. For conservatism, this setpoint calculation uses that error as the As-Left Tolerance.
15. Because the calibration tolerance terminology at CGS differs slightly from GEH Instrument Setpoint Methodology, the definitions for the terms used in this document are provided here.
    a. As-Left Tolerance (ALT): This is the tolerance within which the device calibration reading is left after calibration (Ref. 1). The instrument must be reset to the final NTSP ± ALT at each calibration. (Ref. 8)
    b. Leave Alone Tolerance (LAT): This is the tolerance within which a calibration adjustment need not be performed, and is intended to allow for normal variations in instrument readings due to accuracy and drift (Ref. 1). Because of the guidance in Ref. 8 to reset the instruments during every calibration to the final NTSP ± ALT, the LAT is set equal to the ALT.
16. Per GEH Setpoint methodology (Ref. 1 and Ref. 2), the criteria for Spurious Trip Avoidance [[ ]].
17. This report shows the changes in the AV and the NTSP for TPO conditions. CGS may choose to select other numbers for the AV and NTSP that are more conservative, that is, further away from the AL, while maintaining enough margin between the selected NTSP and the Operational Limit for Spurious Trip Avoidance considerations.
18. Transfer functions used in this calculation:
    Differential Pressure Indicating Switch (DPIS) Output causes a contact closure (switch).

5. References:

1. NEDC-32889P, "General Electric Methodology for Instrumentation Technical Specification and Setpoint Analysis," Class III (Proprietary), Rev. 3, November 2002.

2. NEDC-31336P-A, "General Electric Instrument Setpoint Methodology," Class 3 (Proprietary), September 1996.

3. Current applicable Columbia Generating Station (CGS) setpoint documents/inputs:

   3.1. CGS letter, "Columbia Generating Station Transmittal of TPO T0506 Design Input Request Rev 0," Steve Sheahan (CGS) to Larry King (GEH), CGS-MUR-14-015, December 12, 2014,
   with attached DIR response, Rev. 0, November 18, 2014.

   Energy Northwest eMail message, "FW: Transmittal of MUR DIR T0506 R0 (CGS-MUR-14-015)," Steve Sheahan (Energy Northwest CGS) to Larry W. King (GEH), January 21, 2015 4:52 PM,
   with eight (8) attached files (including Ref. 3.2).

   CGS letter, "Columbia Generating Station Transmittal of TPO T0506 R1 Design Input Request, Steven Sheahan (CGS) to Larry King (GEH), CGS-MUR-14-025, September 30, 2015,
   with attached DIR response, Rev. 1, September 23, 2015 (pages 1, 2, and 11)

   3.2. Washington Public Power Supply System, Calculation E/I-02-92-1063, "Setting range determination for instrument loop MS-DPIS-8A," Rev. 0, December 29, 1993.

4. GEH letters / reports

   4.1. GEH Services Information Letter (SIL) 438, "Main Steam Line High Flow Trip Setting," Rev. 2, May 10, 2013.

5. Vendor Specifications:

   5.1. Cameron "Models 288A/288C/290D Differential Pressure Indicating-Switches (M288 for Industrial Service and Barton® brand 288A (non-C) for Nuclear Service," Installation Manual, Part No. 10300, Rev. 01, July 2007.

   5.2. Heise® "Model CMM Precision Pressure Gauge," Bulletin HE-3, Ashcroft Inc., Rev. October 2008.

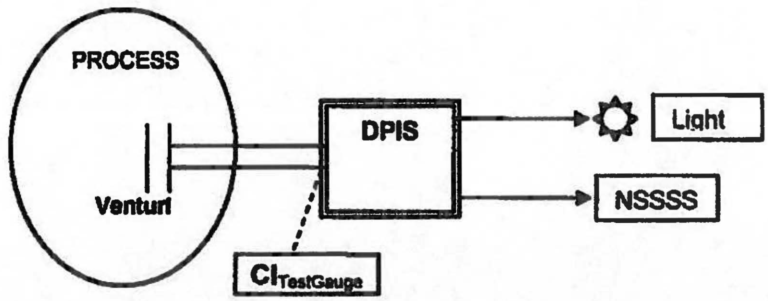
6. GEH TPO Reports for CGS:

   6.1. DBR-0009562 R1, "Columbia TPO Simplified Methodology ΔP vs. Flow Calculations for Nominal, PMA, and PEA Cases – Rev 1," Rev 1, Class II (Proprietary), February 29, 2016 [GEH internal document; not releasable].

7. American Society of Mechanical Engineers (ASME) Research Committee, Fluid Meters, 6th Edition, 1971.

8. NRC Regulatory Issue Summary 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," 24 August 2006 [ML051810077].

6. Loop Diagram:



Note: Calibration tools are shown with dotted lines since these instruments are connected only during calibration. Only tools used for the calculating the system setpoints are shown. Calibration standards are not shown. The Light has no error.

7. Acronyms and Abbreviations:

Short Form	Description
AL	Analytical Limit
ALT	As-Left Tolerance
APEA	Accuracy – Primary Element Accuracy
approx.	approximately
ASME	American Society of Mechanical Engineers
Att.	Attachment
AV	Allowable Value
Calc	Calculation
Calib.	Calibration
CFR	Code of Federal Regulations
CGS; Col	Columbia Generating Station
CI	Input Calibration Tool
CLTP	Current Licensed Thermal Power
Cont'd	Continued
DBR	Design Basis Specification
dc	Direct current
deg	Degrees
DIR	Design Input Request
DPEA	Drift – Primary Element Accuracy
DPIS	Differential Pressure Indicating Switch
e.g.	for example
EMI	Electro Magnetic Interference
F	Fahrenheit
FE	Flow Element
Flo	Flow
FS	Full Scale
FW	Forward
g	Acceleration due to gravity
GE	General Electric Company
GEH	GE Hitachi Nuclear Energy
Hi	High
ID	Identification
i.e.	that is
IMDS	Instrument Master Data Sheet
Inc.	Incorporated
InWG	Inches Water Gauge
IRE	Insulation Resistance Effect
LAT	Leave Alone Tolerance
LER	Licensee Event Report
LLC	Limited Liability Company

Short Form	Description
LOCA	Loss of Coolant Accident
LTSP	Limiting Trip Setpoint
Mo.	Month
MS	Main Steam
MSIV	Main Steam Isolation Valve
MSL; Msl	Main Steam Line
MSLD	MSL Drains
MUR	Measurement Uncertainty Recovery
N	No
n/a	not applicable
No.	number
NRC	Nuclear Regulatory Commission
NSSSS	Nuclear Steam Supply Shutoff System
NTSP	Nominal Trip Setpoint
OPE	Over-Pressure Effect
PEA	Primary Element Accuracy
PMA	Process Measurement Accuracy
PM	Post Meridiem (i.e., between noon and midnight)
psi	Pounds per square inch
psid	psi differential
psig	psi gauge
®	Registered trademark
RAD	Radiation Absorbed Dose
Ref.	Reference
Rev.; Rev; R	Revision
RFI	Radio Frequency Interference
RH	Relative Humidity
Sect.	Section
SIL	Services Information Letter
SP	Calibrated Span
SPE	Static Pressure Effect
STA	Spurious Trip Avoidance
Tech Spec	Technical Specifications
TID	Total Integrated Dose
TPO; Tpo	Thermal Power Optimization
V	Volt
VA	Vendor Accuracy
VD	Vendor Drift
Y	Yes
ΔP	Differential Pressure

<u>RAI-SRXB-1: Reactor Performance Improvement Features</u>

The proprietary General Electric-Hitachi (GEH) Report NEDC-33853P, "Safety Analysis Report for Columbia Generating Station Thermal Power Optimization" (TSAR), Revision 0, Section 1.3.2, "Reactor Performance Improvement Features," lists Feedwater Temperature Reduction (FWTR), Feedwater Heater Out-Of-Service (FWHOOS) and Safety Relief Valve (SRV)/Automatic Depressurization System 2 Valves Out-Of-Service (SRVOOS) as the performance improvement and equipment out-of-service features currently licensed at Columbia. However, the Core Operating Limit Report (COLR) for Cycle 23 does not have these features and instead, has Pressure Regulator Out-of-Service (PROOS). To meet the requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) 50.9 "Completeness and accuracy of information," please provide justification or confirmation for including FWTR, FWHOOS, and SRVOOS in the next cycle's COLR with the MUR power uprate.

<u>Energy Northwest Response to RAI-SRXB-1:</u>

Section 1.0 of the COLR states that the core operating limits for both two loop operation (TLO) and single loop operation (SLO) are applicable for normal feedwater temperature, feedwater heaters out of service, final feedwater temperature reduction and coastdown. As such, the limits presented in COLR Sections 3.0 and 4.0 for Application Groups 1-5 were analyzed assuming a feedwater temperature reduction during the cycle and final feedwater temperature reduction. This coincides with the Reactor Performance Improvement Features FWTR and FWHOOS from NEDC-33853P. Additionally, Application Groups 1-5 were analyzed crediting 12 of the 18 safety relief valves (SRVs) and 6 of the 7 automatic depressurization system SRVs, which coincide with the Reactor Performance Improvement Feature of SRVOOS from NEDC-33853P. The assumptions for valve performance are consistent with the requirements of the Limiting Conditions for Operation in Technical Specifications 3.4.3, 3.4.4, and 3.5.1. Since the COLR contains these assumptions for the current cycle, they will be included in next cycle's COLR with the MUR power uprate.

<u>RAI-SRXB-2: PROOS versus MUR Power Uprate</u>

The MUR power uprate is based on a design and safety analysis assumption that the reactor dome pressure at the new uprated power level will be maintained at the currently licensed rated condition. To meet the requirements of 10 CFR 50 Appendix A, "General Design Criteria for Nuclear Power Plants," General Design Criterion (GDC) 10 and 15 for assuring the design conditions with respect to the integrity of physical barriers, please justify the impact of PROOS on the MUR power uprate in terms of maintaining the reactor dome pressure.

<u>Energy Northwest Response to RAI-SRXB-2:</u>

PROOS is not approved for operational convenience and may only be used for maintenance activities in accordance with 10 CFR 50.65. Technical Specification 3.4.12 ensures compliance with 10 CFR 50 Appendix A, "General Design Criteria for Nuclear Power Plants," General Design Criteria (GDC) 10 and 15 for assuring the

design conditions with respect to the integrity of physical barriers. Technical Specification 3.4.12 requires that the reactor steam dome pressure shall be less than or equal to 1035 psig. Continued operation with the PROOS is limited by the Required Actions and Completion Times of TS 3.4.12. GE Nuclear Services Information Letters, SIL No. 614, Revision 2, "Backup Pressure Regulator," May 18, 2015, recommended a determination whether adequate margin exists for operation at partial power to accommodate a pressure regulator failure downscale (PRFDS) without backup. GE Hitachi performed the PRFDS analysis and determined offrated MCPR and LHGR limits that would ensure adequate margin for integrity of the fuel barrier in the event of a PRFDS without backup. Primary containment, Anticipated Transients Without Scram, reactor stability, reactor internal pressure difference and safety-relief valve cycles were determined not to be impacted. The pressure regulator out of service (PROOS) MCPR and LHGR limits are specified in the COLR in support of GDC 10.

RAI-SRXB-3: FWTR and/or FWHOOS versus MUR Power Uprate

The MUR power uprate is based on a design and safety analysis assumption that the full, standard configuration of feedwater heaters should be in service at the new uprated power level. To meet the requirements of 10 CFR 50, Appendix A, GDC 10 and 15 for assuring the design conditions with respect to the integrity of physical barriers, please justify the appropriateness of FWTR and/or FWHOOS for the MUR power uprate in terms of maintaining the full and standard service of feedwater heaters.

Energy Northwest Response to RAI-SRXB-3:

Final feedwater temperature reduction (FWTR) is only permitted to be used at the end of rated (EOR) cycle power operations when 100% reactor power can no longer be maintained by adjusting recirculation flow or control rods. The FWHOOS is governed by plant procedures and is limited by the current Licensee Controlled Specification 1.1.6, Feedwater Temperature states that in MODE 1, after the EOR cycle exposure has been achieved with steady state THERMAL POWER ≥ 47% of rated thermal power (RTP) the feedwater temperature entering the vessel shall not be < 355°F. If temperature cannot be returned to above this value in 4 hours, power is reduced to <25% RTP. Operation with partial feedwater heating for the purpose of extending the normal fuel cycle was approved by Amendment No. 77 to the Columbia Operating License.

The analysis performed for Amendment 77 is applicable to core flow values up to the maximum attainable (106 percent of rated core flow) and to feedwater temperature reductions as low as 355°F. Therefore, the MUR increase in rated core flow is bounded by this analysis. See the table below.

Thermal-Hydraulic Parameters at TPO Uprate Conditions

Parameter	CLIP	TPO RTP (101.66% of CLIP)
Thermal Power (Percent of Current Licensed Power)	3486 100.0	3544 101.66
Steam Flow (Mlb/hr) (Percent of Current Rated)	15.016 100.0	15.284 101.8
FW Flow (Mlb/hr) (Percent of Current Rated)	14.985 100.0	15.253 101.8
FW Temperature	421.2	422.1
Full Power Core Flow Range (Mlb/hr) (Percent of Current Rated)	87.6 to 115.0 80.7 to 106.0	89.7 to 115.0 82.7 to 106.0

RAI-SRXB-5: Evaluation of Design Changes and Safety Evaluations

To meet the requirements of 10 CFR 50, Appendix A, GDC 10 and 15 for assuring the design conditions with respect to the integrity of physical barriers and the completeness requirement of 10 CFR 50.9, please provide a summary of the evaluation results for the impact of the MUR power uprate on any design changes/safety evaluations that have not yet been implemented in the latest Updated Final Safety Analysis Report if such design/safety evaluations exist.

Energy Northwest Response to RAI-SRXB-5:

MUR power uprate effect on design changes/safety evaluations that have not yet been implemented in the latest Final Safety Analysis Report (FSAR) have been evaluated. None of the design changes or modifications currently under development for future FSAR revisions are reactor thermal power dependent and are, therefore, not affected by operation at the MUR uprate power level.

RAI-SRXB-7: Anticipated Operational Occurrences (AOOs)

To meet the requirements of 10 CFR 50, Appendix A, GDC 10 and 15 for assuring the design conditions with respect to the integrity of physical barriers and the completeness and accuracy requirements of 10 CFR 50.9, please provide information for the following questions relating to Section 9.1, "Anticipated Operational Occurrences," of the TSAR:

(a) Per the footnotes of Table E-1 of the TLTR, please provide the plant-specific disposition. In other words, is ODYN, READY, or TRACG used to perform the analysis? In addition, is a 2% power uncertainty continuously applied?

(b) As compared with current reload analysis for Columbia (Cycle 23 COLR), is the list of AOOs in Table E-1 complete? Please provide a confirmation statement if Table E-1 list is complete.

Energy Northwest Response to RAI-SRXB-7:

(a) The table below provides the plant specific analysis model used for those analysis identified in Table E-1.

	Event Type	Primary Model for Analysis	Power Level (% Uprated)
A.	Fuel Thermal Margin Events		TRACG Method
1.	Generator Load Rejection with Bypass Failure	TRACG	100%*
2.	Turbine Trip with Bypass Failure	TRACG	100%*
3.	FW Controller Failure-Max. Demand	TRACG	100%*
4.	Pressure Regulator Downscale Failure	TRACG	100%*
5.	Loss of FW Heater	3D-Simulator	100%*
6.	Inadvertent HPCI Start (If not bounded by Loss of FW heater)	Not applicable to BWR/5	
7.	Rod Withdrawal Error	3D-Simulator	Local limits
8.	Slow Recirculation Increase (K_f, $MCPR_f$)	3D-Simulator (equiv.)	Max rod line
B.	Limiting Transient Overpressure Events		
9.	Main Steam Isolation Valve Closure with Scram on High Flux (Failure of Direct Scram)	TRACG	100%*

*The power uncertainty allowance applied is 2%.

(b) The list of anticipated operational occurrences for Cycle 23 used the AOO's listed in Table E-1 except for Inadvertent HPCI Start. Columbia is a BWR/5 and has HPCS instead of HPCI. Therefore, Table E-1 is a complete listing of AOO's for Cycle 23.

RAI-SRXB-9: Fuel Pool Cooling (FPC) System Parameters

In the TSAR, Table 6.6, "FPC System Parameters," shows the comparison of FPC system data between CLTP and Thermal Power Optimization (TPO). To meet the requirements of 10 CFR 50.9, please provide responses to the following questions:

(a) Please confirm the MWt values for CLTP and TPO.

(b) Confirm that the data for all FPC system parameters for both CLTP and TPO are the same.

Energy Northwest Response to RAI-SRXB-9:

(a) As stated in Columbia's technical specification, the CLTP is 3486 MWt. The TPO [MUR] power level will be 3544 MWt. The design parameters of FPC have been confirmed to bound the requested 3544 MWt.

(b) As stated, the data for all FPC system parameters for both CLTP and TPO are the same.

RAI-SRXB-11: Reactor Water Cleanup (RWCU) Line Break

In the TSAR, Section 10.1.2.4, "RWCU System Line Breaks," clarify why and how the RWCU process temperature and enthalpy are decreased due to the MUR power uprate to meet the completeness and accuracy requirements of 10 CFR 50.9. Also, please provide the reference reactor power used for this comparison.

Energy Northwest Response to RAI-SRXB-11:

TSAR Section 10.1.2.4 RWCU System Line Breaks states that as a result of the small decreases in RWCU process temperatures and enthalpies, the blowdown rate and energy released decrease slightly; therefore, the original HELB analyses bound the TPO uprate conditions.

The core inlet enthalpy is the result of the mixture of the Feedwater mass flow and associated enthalpy and the return liquid mass flow and associated enthalpy from the separator. The separator liquid mass flow is very close to saturation (high enthalpy / temp) the liquid flow from the separator is the total core flow – vessel steam flow). Because the steam flow increases for TPO and the total core flow is the same (at 100%). The mass flow rate returning from the separator is reduced. Also the feedwater flow increased for TPO. This increases the ratio: feedwater flow / separator return flow. Because feedwater flow is relatively cooler the resulting core inlet enthalpy is reduced. There is a competing effect in that the Feedwater enthalpy is increased because of the increase in FW temperature from 421.2 °F to 422.1 °F. However, that increase is small and the feedwater flow is much less than that the separator return flow. Therefore change in the ratio of the feedwater flow / separator return flow dominates and "offsets" the effect of the feedwater temperature increase.

For CLTP (3486 MWt) conditions the separator return (SR) flow is (108.5 – 15.016) = 93.484 MLbm/hr, and the FW flow is 14.985 MLbm/hr

The ratio of FW flow / SR flow is 0.1603

For TPO (3544 MWt) conditions the separator return (SR) flow is (108.5 – 15.284) = 93.216 MLbm/hr, and the FW flow is 15.253 MLbm/hr

The ratio of FW flow / SR flow is 0.1636

For TPO there is relatively more cool FW flow, even though the FW enthalpy is higher, the net result is a reduction in core inlet enthalpy and therefore a reduction in the recirculation loop and RWCU enthalpies.