ATTACHMENT 13
Exelon Generation Company, LLC Instrument Setpoint Calculations

LIST OF CALCULATIONS INCLUDED

Calculation LE-0107, Rev.1, "GE NUMAC PRNM Setpoint Study"

ATTACHMENT 1
Design Analysis Major Revision Cover Sheet
Page 1 of 5

Design Analysis (Major Revision)		**Last Page No.** [5] Att. 7 Page 5	
Analysis No.: [1]	LE-0107	**Revision:** [2] 001	
Title: [3]	GE NUMAC PRNM Setpoint Study		
EC/ECR No.: [4]	09-00096	**Revision:** [6] 001	
Station(s): [7]	Limerick	**Component(s):** [14]	
Unit No.: [8]	1,2	APRM-1,2,3,4	
Discipline: [9]	LEDE	RBM-A,B	
Descrip. Code/Keyword: [10]	N/A		
Safety/QA Class: [11]	SR		
System Code: [12]	071, 074		
Structure: [13]	N/A		

CONTROLLED DOCUMENT REFERENCES [15]

Document No.:	From/To	Document No.:	From/To
Tech. Spec. Section 2.2.1	To	LEAM-MUR-0041	From
Tech. Spec. Section 3.3.6	To	LEAM-MUR-0046	From
UFSAR Sect. 7.6	To		
Tech. Spec. Section 3.3.1	To		

Is this Design Analysis Safeguards Information? [16] Yes ☐ No ☒ If yes, see SY-AA-101-106

Does this Design Analysis contain Unverified Assumptions? [17] Yes ☐ No ☒ If yes, ATI/AR#:

This Design Analysis SUPERCEDES: [18] **In its entirety.**

Description of Revision (list affected pages for partials): [19] This revision incorporates Minor Revisions 0A, 0B, and 0C, as well as 1) Determines the Allowable Values (AVs) and Nominal Trip Setpoints (NTSPs) for the Average Power Range Monitor (APRM) flow-biased Simulated Thermal Power (STP) Scram (Two Loop Operation (TLO) and Single Loop Operation (SLO)) and APRM flow-biased STP Rod Block (SLO), as well as the AVs for the APRM flow-biased STP Rod Block (TLO) in support of thermal power optimization; 2) Determines As Left Tolerances (ALT) and As Found Tolerances (AFT) for APRM flow-biased trips for use in Instrument performance trending.
(continued on next page)

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	Print Name	Sign Name	Date
Method of Review: [21]	**Detailed Review** ☒	**Alternate Calculations (attached)** ☐	**Testing** ☐
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Review Notes: [23]	Independent review ☒	Peer review ☐	
	Minor comments all resolved.		
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Independent 3rd Party Review Reqd? [26]	Yes ☐	No ☒	
Exelon Approver: [27]	Raymond T. George		1/21/10
	Print Name	Sign Name	Date

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(continued from Description of Changes)

Safety margin is addressed by the difference between the ALs and the Safety Limits (the ALs are established in the GE task reports). Operating margin is addressed by meeting the Spurious Trip Avoidance (STA) criteria in this calculation. The allowances between the NTSPs and AVs are either the same or 0.1% RTP less than in Revision 0. A 0.1% RTP reduction in margin is in the conservative direction. Since the AVs are based on actual estimates of instrument uncertainty, there is reasonable assurance that this slight reduction in margin will not increase the probability of exceeding the Tech Spec AV limit.

The calculation Excel file for the base revision was not available for incorporating the changes for this revision, and values changed with this revision have been calculated manually. As such, only the following affected pages have been replaced/added: 1, 1A, 1B, 2, 3, 5, 6, 6A, 7, 7A, 9, 13, 13A, 14, 15, 17, 21, 22, 23, 24, 26, 27, 28, 29, 34, 37, 39A, 39B, 39C, 40, Att. 2 Page 6, Att. 5, Att. 6, Att. 7.

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Revision Summary

Rev. No.	Description of Revision	Names (with Dates)		
		Preparer	Reviewer	Approver
0	This calculation incorporated ECR LG 99-00434, Revs 0 & 1. Modification P-00224 (PRNM System Replacement/Stability) initiated this calculation.	ME Driscoll 03/21/00 GJ Bonanni 04/25/00	DW Reigel 03/21/00 RT George 04/27/00	KM Knaide 05/1/00
1	This major revision incorporated minor revisions 0A, 0B, and 0C as well as 1) determined new NTSPs and AVs for the APRM Flow-Biased STP Scram functions and new AVs for the APRM Flow-Biased STP Rod Block functions, and 2) determined As Left Tolerances (ALT) and As Found Tolerances (AFT) for APRM flow-biased trips for use in instrument performance trending.	T Filipiak D Cujko 01/20/10	A Luthra 01/20/10	WA Barasa 01/20/10

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1. Universal Glossary
2. Bases Document (Ref. 6.5.4)
3. Neutron Noise Data Summary (1 page from pre-existing fax, Ref. 6.3.1.2)
4. Flow Noise Data (Ref. 6.3.1.1)
5. Guidelines for Stability Option III "Enabled Region" (TAC M92882)
6. Minimum Number of Operable OPRM Cells for Option III Stability at Limerick 1 & 2
7. Bases Document (Ref. 6.5.5)

Note: During review and revision of Calculation LE-0107 (GE NUMAC PRNM Setpoint Study) for the MUR project, selected references could not be reproduced for updating and selected documentation could not be reproduced to support legacy assumptions. The specific issues are:

1) Reference 6.3.5 – GE Report NEDC-32193P identified in the calculation as Rev. 2, Oct. '93 and PIMS identifies only a Rev. 0 from Apr. '93.
2) Reference 6.5.1.2 – The calculation lists GE Doc. 24A5221HH0 Rev. 0. Latest revision in PIMS is Rev. 3.
3) Assumptions 5.2.1, 5.2.2, and 5.2.3 identify implementing procedures and provide linkage to these references in the calculation.

IR 1017215 will drive the resolution of these issues.

LGS 1 & 2
NUMAC PRNM Setpoint Study

1.0 PURPOSE / OBJECTIVE

The purpose of this setpoint design calculation is to provide Allowable Values (AV) and Nominal Trip Setpoints (NTSP) for various setpoint functions of NUMAC Power Range Neutron Monitoring (PRNM) System (APRM/RBM with ARTS/MELLLA, RFM, LTS Option III OPRM) for Limerick Generating Station Units 1 & 2. Therefore, this calculation utilizes methodologies of Ref. 6.1 (prevalent essentially for NUMAC PRNM) and 6.2.1 (prevalent essentially through FT). The methodologies used in this calculation comply with the requirements of NRG RG 1.105. The results are validated for adequacy against the appropriate criteria.

Ref. 6.1 includes calculations that may be used to ensure that the probabilities of Spurious Trip Avoidance is equal to or greater than 95% and the probability of Licensee Event Report avoidance is equal to or greater than 90%. This LER avoidance criterion is not required by the PECO procedure, Ref. 6.2.1, and is not considered in establishing the setpoints in this setpoint analyses. Those calculations are, however, included in Section 7.2 for information only.

NUMAC PRNM channels addressed herein are as follows (names of functions are given; names may be slightly different elsewhere; e.g., in specifications):

1) APRM setpoints: Neutron Flux Upscale Trip (Scram), STP Flow-Biased Trip (Scram) TLO and SLO, STP Flow-Biased Alarm (Rod Block) TLO and SLO, STP Clamp Trip (Scram), STP Clamp Alarm (Rod Block), Neutron Flux Upscale Setdown Trip (Scram), STP Upscale Setdown Alarm (Rod Block), Neutron Flux Downscale Alarm and Trip (Rod Block and RRCS), and (Recirculation) Flow Upscale Level Alarm (Rod Block);
2) RBM setpoints: Neutron Flux Downscale, Low, Intermediate, and High Power and Trip, and (Recirculation) Flow Compare Level Alarm.

The objective will be accomplished, as applicable, by the following approaches:

1. Using the Analytical Limit (ANL)/Design Basis (DB) defined by references identified in the tables of Section 2.0 and the error terms (LA, CA, LD, PEA and PMA) generated herein to calculate new AV and NTSP. (The actual value selected may be the same as the calculated value or a more conservative value bounded by the calculated value.)
2. Using pre-selected nominal NTSP values defined by references identified in the tables of Section 2.0 and the error terms (LA, CA, LD, PEA and PMA) generated herein to calculate new AV values. This approach is used where the actual bases is a nominal value for the NTSP, but Tech Spec entries require an "AV". (The actual value selected may be the same as the calculated value or a more conservative value bounded by the calculated value.)
3. Using pre-selected nominal AV and NTSP values defined by assorted references identified in the tables of Section 2.0 and the error terms (LA, CA, LD, PEA and PMA) generated herein to confirm that the AV and NTSP values are mutually consistent and compatible. (The values are considered

to be consistent and compatible if the difference between the AV and NTSP is equal to or greater than the difference that is calculated by the methodologies.)

This setpoint analysis does not address assorted NUMAC PRNM channel "setup" or "tuning" parameter not directly related to system functions or outputs (e.g., OPRM tuning values, bypass settings, time constants, power supply settings). These values or settings are established based on various specifications of Ref. 6.5.1, operational requirements and procedures or maintenance/calibration procedures and are outside the scope of this setpoint analysis.

This setpoint analysis does not include the OPRM trip setpoints, since these setpoints will not have any allowable values. The OPRM trip setpoints will be determined based on Option III licensing methodology developed by the Boiling Water Reactor Owner's Group (BWROG) as described in NEDO-32465-A (G-080-VC-00041) and approved by the NRC. The period based detection algorithm (PBDA) setpoints will be documented in the Core Operating Limits Report (COLR) and be controlled by the reload licensing process. Other OPRM settings/parameters are documented on the APRM SPID documents. Attachments 5 and 6 of this calculation include supporting documentation for OPRM Technical Specification values.

Additionally, As Found (AF) and As Left (AL) tolerances are computed for the APRM STP Flow-Biased Scram and Rod Block trip loops using the error terms (loop reference accuracy, loop calibration equipment errors, loop calibration equipment reading errors, and loop instrument drift) generated herein. These tolerances are determined for use in trending instrument performance. The methodology utilized is in accordance with Reference 6.9.2 and is described in detail in Section 7.1.23. (Reference 6.9.2 is currently pending NRC approval.)

2.0 SUMMARY OF RESULTS

The following AV and NTSP/IS are established in Section 7 by calculation or methods as described in Section 1.0.

1. ***APRM Channel***

	TRIP	ANL or DB (See Note (a))	AV (See Note (a))	NTSP or IS (See Note (a))
a-1.	STP Flow Biased Scram (TLO)	0.65W + 65.1 (Ref. 6.5.6)	0.65W + 62.2	0.65W + 61.7
a-2.	STP Flow Biased Scram (SLO)	0.65W + 60.1 (Ref. 6.5.6)	0.65W + 57.2 (Ref. 6.5.6)	0.65W + 56.7 (Ref. 6.5.6)
b-1.	STP Flow Biased Rod Block (TLO)	N/A	0.65W + 54.7 (approach 2)	0.65W + 54.3 (Ref. 6.5.7)
b-2.	STP Flow Biased Rod Block (SLO)	N/A	0.65W + 49.7 (Ref. 6.5.6)	0.65W + 49.3 (Ref. 6.5.6)
c.	STP Flow Biased Clamp Scram	119.0 (Ref. 6.5.4)	117.0	116.6
d.	STP Flow Biased Clamp Rod Block	N/A	108.4 (approach 2)	108.0 (Ref. 6.5.4)
e.	Neutron Flux Upscale Trip - Setdown	N/A	20.0 (Ref. 6.5.4)	15.0 (Ref. 6.5.4)
f.	STP Upscale Rod Block - Setdown	N/A	13.0 (Ref. 6.5.4)	12.0 (Ref. 6.5.4)
g-1.	Neutron Flux Downscale Alarm Rod Block (decreasing)	0.5 (Ref. 6.5.4)	2.8	3.2
g-2.	Neutron Flux Downscale Trip RRCS (increasing)	N/A	5.0 (Ref. 6.5.4)	4.3 (Ref. 6.5.4 & note (b))
h.	Fixed High Neutron Flux Scram	121.0 (Ref. 6.5.4)	118.7	118.3
i.	Flow Upscale	N/A	115.6 (Ref. 6.5.4)	113.4 (Ref. 6.5.4)

W= percent of rated recirculation drive flow

Notes: (a) All ANL/DB, AV or NTSP/IS values are % P except item i which is % W.
(b) NTSP for g-2 is equal to NTSP for g-1 plus 1.1% per 5.1.6.

The AVs and NTSPs for the STP Flow Biased Scram and Rod Block functions determined in Section 7 of this calculation are compared with the values provided in the GE Thermal Power Optimization Project Task Reports (References 6.5.6 and 6.5.7) in the following table. For the STP Flow Biased Scram NTSPs (TLO and SLO), STP Flow Biased Scram AVs (TLO and SLO), and the STP Flow Biased Rod Block SLO NTSP, the calculated values are equal to the Task Report Values. For the STP Flow Biased Rod Block AVs (TLO and SLO), the calculated values are more conservative than the Task Report values and should therefore be used as the Tech Spec values. The STP Flow Biased Rod Block TLO NTSP value in the calculation was taken directly from Ref. 6.5.7, consistent with Approach 2 of this calculation and therefore no comparison is warranted.

APRM Function	Allowable Value			NTSP		
	GE Task Report Value	LE-0107 Value	Comparison	GE Task Report Value	LE-0107 Value	Comparison
STP F-B Scram (TLO)	0.65W+62.2 Ref. 6.5.7	0.65W+62.2	Same	0.65W+61.7 Ref. 6.5.7	0.65W+61.7	Same
STP F-B Scram (SLO)	0.65W+57.2 Ref. 6.5.7	0.65W+57.2	Same	0.65W+56.7 Ref. 6.5.7	0.65W+56.7	Same
STP F-B Rod Block (TLO)	0.65W+54.8 Ref. 6.5.6	0.65W+54.7	Calc. value conservative	N/A	N/A	N/A
STP F-B Rod Block (SLO)	0.65W+49.8 Ref. 6.5.6	0.65W+49.7	Calc. value conservative	0.65W+49.3 Ref. 6.5.7	0.65W+49.3	Same

2.	***RBM Channel***				
	TRIP	MCPR	ANL or DB (See Notes (a) &(b))	AV (See Notes (a) &(b))	NTSP/IS (See Notes (a) &(b))
a	Low Power Setpoint (LPSP)		30.0 (Ref. 6.3.5)	28.4	28.1 (See 5.1.5)
b.	Intermediate Power Setpoint (IPSP)		65.0 (Ref. 6.3.5)	63.4	63.1
c.	High Power Setpoint (HPSP)		85.0 (Ref. 6.3.5)	83.4	83.1
d.	Low Trip Setpoint (LTSP) (Ref. 6.3.5)	1.20 1.25 1.30 1.35	118.0 / 117.0 121.0 / 120.0 124.0 / 123.0 127.0 / 125.8	116.5 / 115.5 119.5 / 118.5 122.5 / 121.5 125.5 / 124.3	116.5 / 115.5 119.5 / 118.5 122.5 / 121.5 123.0 / 123.0 (Assumption 5.1.4)
e.	Intermediate Trip Setpoint (ITSP) (Ref. 6.3.5)	1.20 1.25 1.30 1.35	112.0 / 111.2 116.0 / 115.2 119.0 / 118.0 122.0 / 121.0	110.5 / 109.7 114.5 / 113.7 117.5 / 116.5 120.5 / 119.5	110.5 / 109.7 114.5 / 113.7 117.0 / 116.5 117.0 / 117.0 (Assumption 5.1.4)
f.	High Trip Setpoint (HTSP) (Ref. 6.3.5)	1.20 1.25 1.30 1.35	108.0 / 107.4 110.0 / 110.2 114.0 / 113.2 117.0 / 116.0	106.5 / 105.9 109.5 / 108.7 112.5 / 111.7 115.5 / 114.5	106.5 / 105.9 109.5 / 108.7 111.0 / 111.0 111.0 / 111.0 (Assumption 5.1.4)
g.	Downscale Trip Setpoint (DTSP)		N/L (Ref. 6.3.5)	2.0 (Ref. 6.5.5)	5.0 (Ref. 6.5.5)
h.	Flow Compare		N/A	N/A	10.0 (Ref. 6.5.4)

Notes: (a) All ANL/DB, AV or NTSP/IS values are % P except item h which is % W.

(b) For the LTSP, ITSP, and HTSP AV and NTSP values, the first entry (larger value "w/o filter") applies for filter time constant (τ_{c1}) settings of $\tau_{c1} \leq 0.1$ second while the second entry (smaller value "w/filter") applies for settings of $0.1 < \tau_{c1} < 0.55$ seconds.

The following ALT/AFT and LAZ Tolerances are established in Section 7 by calculation and by methods as described in Section 1.0.

ALT/AFT and LAZ Tolerances Associated with STP APRM Flow-Biased Scram and Rod Block Calibration Checks:

- ALT/AFT and LAZ tolerances do not apply for STP APRM flow-biased actuations per justification provided in section 7.1.23.

- Calculated ALT/AFT and LAZ tolerances associate with the combined FT/RFM calibration check as defined in References 6.2.3.2.1 through 6.2.3.2.8 are as follows (per section 7.3.5):

  RFM LALT = LAZ = ±1.3 % rated Q
  RFM LAFT = ±1.9 % rated Q

This analysis does not provide an acceptance criteria for the calculated RFM LALT (LAZ) and RFM LAFT. Results are merely summarized as determined in Section 7.3.5.

Comparison of Calculated RFM LAFT and LALT (LAZ) with existing Surveillance Test Procedure Requirements:

Per the current surveillance test procedures (References 6.2.3.2.1 through 6.2.3.2.8), the RFM loop calibration checks are performed by applying differential pressures at each of the two recirculation flow transmitters (recirc loop A & B) while monitoring the RFM output for proper indication of total flow. The procedures merely specify acceptable lower and upper limits of indicated flow; they do not specify a desired or nominal flow value. As such, the algebraic difference between the specified acceptable lower and upper limits corresponds to acceptance spans equal to 3.9 and 4.0% rated Q (depending on the applied test pressures). The calculated loop as-left tolerance (LALT) determined in this analysis (+/-1.3% rated Q around a nominal value) corresponds to an acceptance span equal to 2.6% rated Q (or 2 times 1.3%), which is smaller than the current 3.9% and 4.0% acceptance spans. Therefore, the LALT (or LAZ) determined in this analysis is tighter than the as-left requirements (or acceptable limit requirements) specified in the surveillance test procedures. Additionally, the calculated loop as-found tolerance (LAFT) determined in this analysis (+/- 1.9% rated Q around a nominal value) corresponds to an acceptance span equal to 3.8% rated Q (or 2 times 1.9%) which is also smaller than the current 3.9% and 4.0% acceptance spans. Therefore, the LAFT determined in this analysis is also tighter than the as-left requirements (or acceptable limit requirements) specified in the surveillance test procedures.

3.0 DESIGN INPUT / CRITERIA

3.1 The purposes of the instruments in the PRNM Channels of this Design Calculation are to:

1. provide a warning to the reactor operators via annunciation in the Control Room, and
2. provide scram trip signals to the Reactor Protection System, and
3. provide trip signals to the Rod Withdrawal Block Circuitry indicating that the reactor power or recirculation flow is exceeding its operational limits, and
4. provide an APRM downscale signal to RRCS indicating that the reactor is shutdown and SLC injection is not required or can be terminated.

The calculations in this report are consistent with the following figure, which is based on Ref. 6.5.1:

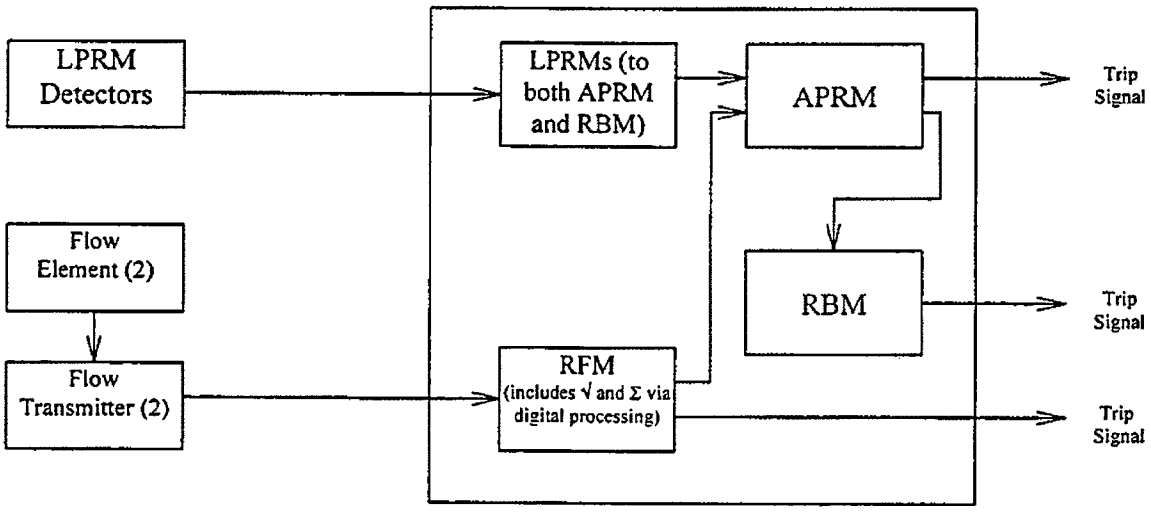

Figure 1. PRNM Functionality Sketch

3.2 APRM Channel

3.2.1 Process Design Parameters – All Channels Except STP Flow-Biased Scram and Rod Block (See 3.2.2 for STP Flow-Biased Scram and Rod Block Input)

		Ref.
Process Variable	Neutron Flux	6.8.2
Normal Operating Value	0 – 100% Power	6.8.2, 6.3.6
Analytical Limit (ANL)/Design Basis (DB)	Section 2.0	6.3.5, 6.5.4
Allowable Value (AV)	Section 2.0	6.5.4, Section 7
Nominal Trip Setpoint (NTSP)	Section 2.0	6.5.4, Section 7

3.2.2 Process Design Parameters –STP Flow-Biased Scram and Rod Block

The STP Flow Biased Scram (TLO) AL is taken from Ref. 6.5.6. The STP Flow Biased Rod Block (TLO) NTSP is taken from Ref. 6.5.7. The SLO AVs and NTSPs for both the STP Flow Biased Scram and Rod Block functions are 5% RTP lower than the respective TLO values as originally specified in Ref. 6.5.4 and confirmed for Thermal Power Optimization by Refs. 6.5.6 and 6.5.7.

3.3 RBM Channel

3.3.1 Process Design Parameters

		Ref.
Process Variable	Neutron Flux	6.8.2
Normal Operating Value	0 – 100% Power	6.8.2, 6.3.5
Analytical Limit (ANL)/Design Basis (DB)	Section 2.0	6.3.5
Allowable Value (AV)	Section 2.0	6.5.4, Section 7, 6.5.5
Nominal Trip Setpoint (NTSP)	Section 2.0	6.5.4, Section 7, 6.5.5

3.4 RFM Channel

3.4.1 Process Design Parameters

		Ref.
Process Variable	Recirculation Flow	6.8.2
Normal Operating Value	0 – 110% Flow	6.8.2, 6.3.4
Analytical Limit (ANL)/Design Basis (DB)	N/A	6.5.4
Allowable Value (AV)	Section 2.0	6.5.4, Section 7
Nominal Trip Setpoint (NTSP)	Section 2.0	6.5.4, Section 7

LGS 1 & 2
NUMAC PRNM Setpoint Study

3.5 Instrument Data

3.5.1 NUMAC

		Ref.
Manufacturer	GE-NUMAC	6.5.1
Model No.	PRNM	6.5.1
Location	Aux. Equipment Room	6.8.1
Location Temp. Range	60-82 F)	6.8.1
Instrument Range	*	6.5.1
Calibration Span (SP)	0-125 %	6.5.1
Electrical Output	0-1.0 Vdc **	6.5.1
Electrical Output	0-1.0 mAdc ***	6.5.1

* It may vary from 0 to greater than 125% depending on the signal; applies to both flux (power) and flow.
** For use by remote recorders.
*** For use by remote meters.

3.5.2 Recirculation Flow Transmitter

		Ref.
Manufacturer	Rosemount	
Model No.	1153DB5RJN0039	6.6.1
Location	Reactor Building	6.8.1
Calibration Temp.	65-90° F	6.1
Normal Temperature	65-106° F	6.8.1
Instrument Range	0-750 in WC	6.6.1
Calibration Span (SP)	0-225.0 in WC	6.2.3
Calibration Span (SP)	0-55,000 gpm	6.2.3
Electrical Output	4-20 mAdc	6.6.1

3.6 Description of Instrument Channel

A functionality sketch of the NUMAC based PRNM system is shown in Figure 1. The sensor inputs and the functions performed by the signal processing electronics remain the same as in the previous analog system, but the hardware configuration is changed.

a) The LPRM detectors feed into the APRM chassis (and LPRM Slave Chassis) which does all the LPRM and APRM signal processing and converts the LPRM signals to digital values.

b) The APRM chassis performs all of the comparison and trip calculations digitally, and issues the Neutron Flux and Simulated Thermal Power trip and rod block signals. There are no separate APRM Trip Units whose accuracy, calibration and drift errors need to be considered.

c) The current signal from the Flow (ΔP) sensors from loops A & B feed directly into the APRM chassis (via a sub-function sometimes referred to as the RFM) which performs all of the signal processing, and converts the flow input signals to digital values. The APRM chassis calculates the loop A and loop B flow from the input current signals, computes the total recirculation flow and generates the flow bias trip setpoints for the APRM trip and rod block functions. The APRM chassis also generates the high flow rod block signal. All calculations are performed digitally. There is no separate Flow Unit (square rooter and summer for generating the flow signal are considered as a calculation functional model only) and no separate Flow Trip Unit whose accuracy, calibration and drift errors need to be considered.

d) The RBM receives digitally processed LPRM detector input from the APRM (and LPRM Slave) Chassis and recirculation flow inputs from the APRM chassis. The RBM chassis generates the high, intermediate and low power RBM rod block signals and also the Flow Comparator alarm signal. All calculations in the RBM chassis are performed digitally, so no additional processing error is introduced. There are no separate RBM Trip Units whose accuracy, calibration and drift errors need to be considered.

3.7 Impact of NUMAC Instrument Channel on Setpoint Calculations

As described above, the new PRNM configuration shown in Figure 1 uses the same input flux and flow sensors, but the NUMAC electronic chassis that process these inputs signal are quite different than the old analog electronics. The NUMAC based PRNM has different values for electronic accuracy, calibration and drift errors, and these lead to different values for overall channel accuracy, calibration and drift errors.

The functions (trip, rod block, etc.) essentially remain the same with the new PRNM except for replacement of the flow-biased APRM scram and scram clamp functions with an APRM flux upscale scram function and a Simulated Thermal Power (STP) flow-biased scram and scram clamp functions and use of STP as the input to the rod block logic functions in place of APRM flux. Also, since only the processing electronics change, incorporation of PRNM electronics does not change process monitoring (PMA) and process element (PEA) errors, for the trip and rod block functions. However some of these errors have changed in this document compared to earlier calculations because of changes in setpoint calculation methods. The new electronics has different electronic error values, which lead to different channel error values. This in turn leads to different margins between the Analytic Limit and the Nominal Trip Setpoints (NTSP) and between the Analytic Limit and the Allowable Value (AV). The new NTSP and AV values are calculated in this document.

4.0 COMPUTER CALCULATION

N/A. For information only, let it be noted that a Win95Excel97 file is utilized in the generation of this calculation. While this calculational tool is not designated a "computer calculation", it is nonetheless based on official, off-the-shelf, commercially available software. The results then undergo normal design verification.

5.0 ASSUMPTIONS

5.1 Assumptions confirmed as part of the setpoint calculation verification process.

5.1.1 All individual uncertainty expressions apply to the overall component [LPRM, FT, PRNM (including entire chassis, electronics, signal conditioning, digitizing, etc.)] and are at 2-sigma unless otherwise stated in Section 7. Ultimately, individual uncertainty expressions feed into channel uncertainty, which is normalized to 2-sigma and process units for subsequent calculation of AV, NTSP. (In Section 7, all specification values for the NUMAC equipment are treated as 3-sigma values, and include all effects of environmental factors identified in the related specifications. The NUMAC design and specification process is based on specifying worst case values (i.e., better than 3-sigma). In the setpoint methodology, these types of specifications are treated as 3-sigma values. For the FT, uncertainties defined in Ref. 6.6.1 are considered 3-sigma, based on Ref. 6.1 and 6.2.1). This calculation uses the original drift specification for Rosemount 1153 transmitters of +/- 0.25% for 6 months (3 sigma value). This specification is more conservative than the current Rosemount Specification of +/- 0.20% for 30 months (2 sigma value) and is therefore acceptable. Sigma, called s, is given in the right-hand column of Section 7 for each term (column H in the Win95Excel97 file).

5.1.2 All calibration uncertainty expressions are 3-sigma by commonly- accepted practice, due to control by 100% testing and NIST traceability. Calibration uncertainty terms include CEi, CEstdi, STOLi (which includes AGAF). (As in the case of other uncertainty terms, pertinent sigma is given in the right-hand column of Section 7).

5.1.3 Per Ref. 6.2.3, AGAF limits are +/- 2% power.

5.1.4 The setpoint analyses justify a NTSP/IS equal to the AV/TRM for the RBM LTSP, ITSP and HTSP trip functions. RBM LTSP, ITSP and HTSP NTSP/IS are limited to 123.0%, 117.0% and 111.0% respectively due to section A.2.8.2.1.1 of MELLL/ARTS Topical Report NEDC-32193P (Ref. 6.3.5). Thus, NTSP/IS values shown in Section 2 can not exceed these limits.

5.1.5 The NTSP shown in paragraph 2.2.a is the desired power level at or above which the RBM rod block is to be automatically unbypassed (an "upscale" trip). Because the NUMAC RBM processes the Low Power Setpoint as a downscale function (tripping on decreasing power), the trip "reset" point is the effective upscale trip. The trip has a deadband of 1.0% (resolution of 0.1%), so the trip will reset when the power level exceeds the trip setpoint by at least 1.1%. Therefore, to achieve the effective NTSP in 2.2.a for an increasing signal, the entered setpoint must be 1.1% lower than the value in 2.2.a.

5.1.6 The APRM downscale trip function, a "decreasing" trip with a 1.0% deadband and a resolution of 0.1%, is used for both the Neutron Flux Downscale Alarm Rod Block, a decreasing trip (2.1.g-1) and for the Neutron Flux Downscale Trip RRCS, an increasing trip. ***A single setpoint is used for both applications.*** The effective NTSP for the Rod Block (2.1.g-1) is the setpoint value entered in the hardware. However, the effective NTSP for the RRCS Trip (2.1.g-2) is the Rod Block "reset" value, which is 1.1% higher than the setpoint value entered into the hardware. Based on Ref. 6.5.4, this calculation calculates the Rod Block AV and Rod Block NTSP (2.1.g-1). The NTSP for the RRCS Trip (2.1.g-2) is calculated by adding 1.1% to the Rod Block NTSP. This calculation then confirms that the calculated RRCS Trip NTSP supports the design basis RRCS Trip AV stated in Ref. 6.5.4.

5.2 Assumptions requiring confirmation as part of the LGS mod process.

5.2.1 The calibration intervals maximum boundary values (and therefore the bases for VD expressions) are as follows: for flow channel FT and PRNM RFM, 30-months; for PRNM APRM, 700-hrs (approximately 1-month); for PRNM RBM, 4-hrs [insignificant time-interval for drift in RBM trip function since RBM re-initializes (nulls) after each usage]. These intervals are expected to cover operational requirements (intervals less than these are therefore covered by this calculation).

5.2.2 Calibration temperature interval is 65-90 deg F, based on PECO calibration practices, Ref. 6.2.3. The calibration uncertainties (i.e., CEi, CEstdi, STOLi) used in this calculation are/will be based on Ref. 6.2.3 expected calibration for the NUMAC-PRNM. Accuracy Ratio (ratio of CEi to CEstdi) is considered to be unity (1). For the DMM, CEi = Ai based on standard practice per Ref. 6.2.1.

5.2.3 Since overall channel uncertainties are relatively minimal for digital equipment, and settings are digitally entered into equipment, additional margin is considered negligible and ATSP = NTSP. Hence, STOL/LAZ (setting tolerances and leave-alone-zones) does not apply for PRNM (i.e., STOL/LAZ is assumed to = 0). STOLi = Ai for FT-related calibration = 0.08 mAdc based on standard practice per Ref. 6.2.1. Ref. 6.2.3 is affected in the sense that future PRNM calibration procedures will have to reflect this assumption.

5.2.4 References 6.5.1 (all), 6.6.1, 6.8.1, and 6.9.1 apply to the installed PRNM system.

6.0 References

6.1 GE Report NEDC-31336P-A, GE Proprietary Information, September 1996, GE Instrument Setpoint Methodology.

6.2 PECO/Exelon Procedures

6.2.1 Exelon Procedures CC-AA-309, Rev. 9, Control of Design Analyses, CC-AA-309-1001, Rev. 5, Guidelines for Preparation and Processing Design Analyses, and CC-MA-103-2001, Rev. 0, Setpoint Methodology for Peach Bottom Atomic Power Station and Limerick Generating Station (These procedures supersede PECO Nuclear Procedure NE-C-420 Rev 3, Design Calculations [including exhibits, mainly NE-C-420-4])

6.2.2 Exelon Procedure CC-AA-102, Rev. 19, Design Input and Configuration Change Impact Screening, CC-AA-103, Rev. 20, Configuration Change Control for Permanent Physical Plant Changes, and CC-AA-103-2001, Rev. 3, Setpoint Change Control (These procedures supersede PECO Modifications Procedure MOD-C-08 Rev 1, Setpoint Changes (no exhibits))

6.2.3 PECO Plant Procedures and Practices covering Surveillance Test and Calibration

6.2.3.1 Procedures and Practices for Recirculation Drive Flow Equipment

6.2.3.2 Procedures and Practices for NUMAC PRNM Equipment

6.2.3.2.1 ST-2-074-420-1, Rev. 28, Calibration Check of APRM 1 Flow Bias Signal

6.2.3.2.2 ST-2-074-421-1, Rev. 24, Calibration Check of APRM 2 Flow Bias Signal

6.2.3.2.3 ST-2-074-422-1, Rev. 27, Calibration Check of APRM 3 Flow Bias Signal

6.2.3.2.4 ST-2-074-423-1, Rev. 26, Calibration Check of APRM 4 Flow Bias Signal

6.2.3.2.5 ST-2-074-420-2, Rev. 18, Calibration Check of APRM 1 Flow Bias Signal

6.2.3.2.6 ST-2-074-421-2, Rev. 17, Calibration Check of APRM 2 Flow Bias Signal
6.2.3.2.7 ST-2-074-422-2, Rev. 17, Calibration Check of APRM 3 Flow Bias Signal
6.2.3.2.8 ST-2-074-423-2, Rev. 20, Calibration Check of APRM 4 Flow Bias Signal
6.2.3.2.9 ST-2-074-426-1, Rev. 11, Calibration/Functional Check of Average Power Range Monitor 1 (APRM 1)
6.2.3.2.10 ST-2-074-427-1, Rev. 10, Calibration/Functional Check of Average Power Range Monitor 2 (APRM 2)
6.2.3.2.11 ST-2-074-428-1, Rev. 11, Calibration/Functional Check of Average Power Range Monitor 3 (APRM 3)
6.2.3.2.12 ST-2-074-429-1, Rev. 13, Calibration/Functional Check of Average Power Range Monitor 4 (APRM 4)
6.2.3.2.13 ST-2-074-426-2, Rev. 05, Calibration/Functional Check of Average Power Range Monitor 1 (APRM 1)
6.2.3.2.14 ST-2-074-427-2, Rev. 04, Calibration/Functional Check of Average Power Range Monitor 2 (APRM 2)
6.2.3.2.15 ST-2-074-428-2, Rev. 04, Calibration/Functional Check of Average Power Range Monitor 3 (APRM 3)
6.2.3.2.16 ST-2-074-429-2, Rev. 05, Calibration/Functional Check of Average Power Range Monitor 4 (APRM 4)
6.2.3.2.17 IC-11-00740, Rev. 10, Calibration and Alignment of NUMAC Power Range Neutron Monitor

6.3 Pre-Existing Calculations/Bases
6.3.1 PECO Noise Data Bases
6.3.1.1 PECO Time History Plot and Tabular Trend Report, Recirculation Drive B037/A1, B038/A2, B039/B1, B040/B2 Mass Flow (Mlbm/hr) for LGS-2, 1 sec time grid, 31-Jan-94 from 10:20:00.000 to 10:20:30.000 (Attachment 4: contained in Win95Excel97 file of this calc, and originally extracted from Calc LE0082, Rev. 5)
6.3.1.2 PECO Statistical Analysis Report, APRMs A, B, C, D, E, F Flux (%P) for LGS-2, 0.250 sec time grid, 26-Aug-93 from 07:00:00.000 to 07:10:00.000 (from 08/26/93 fax, S. Tanner PECO, 20 pages; 1 page extract, summary page, utilized herein as basis for neutron noise – Attachment 3)
6.3.2 PECO Calculation LE-0082 Rev. 5, GE NSSS Setpoints Required to Support Power Re-Rate for LGS-1&2 (specifically calculation #7, pertaining to NMS), dated 6-19-98 (INFO ONLY – SUPERSEDED BY CALCULATION HEREIN)
6.3.3 PECO Calculation LE-0049 Rev. 0, Limerick Rod Block Flow Biased Setpoints, dated 11-16-92 (INFO ONLY ---SUPERSEDED BY CALCULATION HEREIN)
6.3.4 GE Report NEDC-32224P, "Safety Review for Limerick Generation Station Units 1 and 2, 110% Increased Core Flow Operation and Final Feedwater Temperature Reduction", Revision 1, October 1994 [Exelon Doc. G-080-VC-00029, Rev. 0]
6.3.5 GE Report NEDC-32193P,"MELLL and ARTS Improvement Program Analyses for Limerick Generating Station Units 1 and 2", Revision 2, October 1993 [Exelon Doc. G-080-VC-00395]
6.3.6 GE Report NEDC-32225P, "Power Rerate Safety Analysis Report for Limerick Generating Station Units 1 & 2", Revision 1, September 1993 [Exelon Doc. N-00E-177-00001, Rev. 0]

6.4 Plant Documents
6.4.1 Technical Specifications for LGS-1&2
6.4.2 UFSAR for LGS-1&2

6.5 GE Design Specifications
6.5.1 NUMAC Documents
6.5.1.1 24A5221 Rev 7, NUMAC PRNM System Generic RS [Exelon Doc. G-080-VC-00034 Rev. 0]
6.5.1.2 24A5221HHO Rev 0, NUMAC PRNM System Specific RSDS, LGS-1&2 [Exelon Doc. G-080-VC-00033]
6.5.1.3 25A5916 Rev 3, NUMAC APRM Generic PS
6.5.1.4 25A5916ER0 Rev 1, NUMAC APRM Specific PSDS
6.5.1.5 25A5917 Rev 2, NUMAC RBM Generic PS
6.5.1.6 25A5917ER0 Rev 1, NUMAC RBM Specific PSDS
6.5.1.7 25A5041 Rev 1, NUMAC OPRM Generic PS [Exelon Doc. G-080-VC-00108, Rev. 0]
6.5.1.8 25A5041AA Rev 1 NUMAC OPRM Generic DSDS [Exelon Doc. G-080-VC-00109, Rev. 0]
6.5.2 NOT USED
6.5.3 GE various internal data, including DRFs C51-00136(4.42) and A00-01932-2
6.5.4 PRNM System Setpoints, Bases for Analytical Limits/Allowable Values/Design Bases, APRM Neutron Flux and Simulated Thermal Power (STP) Scram and Rod Block, Recirculation Flow Upscale and Comparison, RBM, for LGS 1 & 2, Rev. 0, dated Aug. 19, 1999 (GE DRF C51-00215-00 (5.6))
6.5.5 PRNM System Bases for RBM Downscale Trip Tech Spec Deletion and Reduced Setpoint, Rev. 0, dated 1/8/99 (GE DRF C51-00214-00 (5.7))
6.5.6 Exelon Nuclear Limerick Units 1 and 2 Thermal Power Optimization Project Task Report – Task T0500: Neutron Monitoring System, Rev. 1, dated December 2009 (GE DRF 0000-0096-1273, Exelon Doc. LEAM-MUR-0041 Rev. 0)
6.5.7 Exelon Nuclear Limerick Units 1 and 2 Thermal Power Optimization Project Task Report – Task T0506: Instrument Setpoints, Rev. 0, dated December 2009 (GE DRF 0000-0096-3796, Exelon Doc. LEAM-MUR-0046, Rev. 0)

6.6 Vendor Documents
6.6.1 Rosemount Model 1153DB5RJN0039, various PDS associated with FT

6.7 NOT USED.

6.8 PECO Documents
6.8.1 LGS Mod # P00224, Design Input Document, Rev. 0
6.8.2 8031-M-1-C51-4010-H-2, Rev. 4, Neutron Monitoring System Design Spec. Data Sheet

6.9 Micellaneous Documents
6.9.1 ASME Fluid Meters, Sixth Edition, 1971
6.9.2 Technical Specification Task Force Improved Standard Technical Specifications, TSTF-493, Revision 4.

7.0 CALCULATION

7.1 Methods

7.1.1 The accuracy due to flow noise and flux noise (for PMA) is calculated from the LGS-2 data in Ref. 6.3.1, normalized to 2-sigma and process units.

7.1.2 The conversion of the flow error to power is modified by the 0.65 factor, the slope of the equation that converts flow to APRM power setpoints (Ref. 6.5.6).

7.1.3 OL for STA evaluation of scram functions is typically the rod block NTSP.

7.1.4 Unless otherwise noted, the units used in this document for each instrument function are given in the tables of Section 2.0, above [essentially either percent of the rated thermal power (%P), or percent of the rated recirculation flow (%W or %Q)].

7.1.5 Unless otherwise noted, the uncertainty values used in calculations in Section 7 are two (2) sigma ± values (random).

7.1.6 A flow uncertainty correction factor κ (or K) is utilized to correct for dp uncertainties (as a function of flow) for terms upstream of square root processing, based on Ref. 6.5.3.

7.1.7 Final calculated values (e.g. AV, NTSP) are rounded: 1) in direction of conservatism (i.e., away from the ANL/DB), and 2) to one decimal place. Intermediate calculated values (uncertainty terms, etc.) are sometimes found to introduce unnecessary and unwanted over-conservatisms and hence are not rounded.

7.1.8 Methodologies utilized in this calculation are based on Ref. 6.1 and 6.2.1, and include various and sundry traditional and ongoing approaches that have evolved over the course of time, up to the present time [collectively referred to as "grandfather", and herein consisting mainly (but not entirely) of Ref. 6.5.3].

7.1.9 through 7.1.11 NOT USED.

7.1.12 Per Ref. 6.9.1 Section II-III-60, elbow flow element uncertainty (PEA) is 4% of rated loop flow (considered to be at 2-sigma).

7.1.13 3-sigma terms (e.g., PRNM chassis electronics uncertainty, certain individual influences of FT uncertainty, calibration, etc.) are normalized to 2-sigma terms (e.g., loop terms for LA, LD, etc.) via factor of 2/3 per Ref. 6.1 and 6.2.1.

7.1.14 Individual influences of uncertainty are combined via SRSS to yield LA, LD, etc. e.g., loop accuracy LA=2 *SRSS [(VA/s), (ATE/s), (SPE/s), ...] where VA, ATE, etc. are the individual

influences of accuracy uncertainty, and s is the individual sigma affiliated with each individual influence term, per Ref. 6.1 and 6.2.1.

7.1.15 AV and NTSP are determined via expressions contained in Ref. 6.1 and 6.2.1.

7.1.16 PEA is a combination of the LPRM sensor sensitivity (time-dependent, and therefore called drift PEA) and sensor non-linearity (called accuracy PEA) uncertainties. For RBM trip functions, since RBM relative readings are short term, drift PEA is zero.

7.1.17 Uncertainties (e.g., for PEA, genVA, etc.) associated with inputs (either LPRM detector or recirculation drive flow) to PRNM, utilize the algorithm of $1/\sqrt{N}$ to establish the overall genA on a % rated basis, where N is the number of inputs to PRNM [e.g., LPRMs to either APRM (20 minimum) or RBM (2 minimum), with minimum used for conservatism and to account for sensor failure; or recirculation drive flow loops to RFM (2)]. While usage of this approach is readily-accepted for LPRMs, the basis for its application for recirculation drive flow loops is not obvious. The basis is illustrated, by an example, as follows:

let hypothetical individual rated loop flow = 1000 gpm, hence for a two-loop system rated total flow = 2000 gpm; if loop uncertainty = ±10% rated loop flow = ±100 gpm, then total uncertainty = $\sqrt{2}$ *100 = ±141.4 gpm, or 141.4/2000 = ±7.07% rated total flow = ±10% rated loop flow/$\sqrt{2}$.

7.1.18 Uncertainty associated with the flow transmitter inputs to the calibration resistor/flow electronics network of PRNM is recognized in semi-automatic calibration INOP-CAL mode, the uncertainty of which is included in the overall specifications of PRNM uncertainty.

7.1.19 PRNM uncertainty specifications consider the various and sundry effects of the following: operating environmental factors, signal filtering, time constants, gain adjustment factors, power supply variation, sensor cable insulation resistance, digital signal processing considerations (time delays for A/D and D/A conversion, sampling frequency, signal processing topology, signal discriminator algorithms, and digital signal bit-length), etc.

7.1.20 The NUMAC PRNM electronic chassis introduces essentially no additional uncertainty beyond the uncertainty associated with the LPRM flux inputs; hence, chassis uncertainty terms identified as VA, L and H in the calculation are considered negligible (i.e., enveloped by the LPRM uncertainty terms).

7.1.21 As a follow-on to Section 7.1.20, above, the LPRM uncertainty specification applies because it introduces uncertainty at the input of the NUMAC PRNM chassis; the uncertainty term, for example, is called genA, modified by the minimum number of LPRMs as illustrated in Section 7.1.17, above.

7.1.22 Various PMA are summarized as follows:

a) PMA errors for APRM flux and power measurement process are caused by APRM tracking error and the uncertainty due to neutron noise, for the MSIV transient and for the loss of feedwater heater transient.

b) PMA errors for flow measurements is flow noise, which is also included in APRM STP flow-biased functions.

c) PMA for RBM, which is a relative flux measurement, is due to: 1) uncertainty due to neutron noise; 2) the error calculated by comparing the non-failed reading to readings with different combinations of LPRM failure. Subgroups of RBM (i.e., Power and Trip) are as follows:

1) PMA for RBM Power Measurement: The RBM Power setpoints are internal setpoints that choose the high, intermediate and low power zones in which the RBM Trip setpoints apply. RBM power setpoints are required during normal steady state operation and do not need to consider error due to fast transients. Thus the transient error due to tracking does not need to be considered, and only neutron noise remains.

2) PMA for RBM Trip setpoints is the PMA considering only the LPRM readings; neutron noise does not apply.

7.1.23 As-Left / As-Found Tolerance Determination Associated with STP APRM Flow-Biased Scram and Rod Block Actuations Only

Per Section 4.13 of References 6.2.3.2.9 through 6.2.3.2.16, the STP APRM flow-biased actuation points are checked by applying a simulated total recirculation flow input along with a simulated power input. The simulated flow input is kept constant while the simulated power input is adjusted while monitoring the point of actuation. The PRNM is a digital system with digital processing, and as such, actuation point settings are not affected by instrument accuracy, drift, and calibration equipment errors. As indicated by Table 10 of References 6.2.3.2.9 through 6.2.3.2.16, there is a potential for actuation point effects due to instrument accuracy, drift, and calibration equipment errors, however, these effects are not due to errors associated with actuation point settings. These effects are due to errors associated with aligning calibration voltages with an external standard as defined in section 4.7.30 of References 6.2.3.2.9 through 6.2.3.2.16. Therefore, ALT/AFT for the STP APRM flow-biased trip point calibration checks are not applicable.

Per References 6.2.3.2.1 through 6.2.3.2.8, the calibration of the RFM instrument loop is checked by applying variable test pressure inputs at the inputs of the recirculation flow transmitters while monitoring total recirculation flow rates on the APRM chassis display. As such, this calculation will determine ALT/AFT associated with the RFM loop calibration check from the input of the flow transmitters to the output indication of total recirculation flow. The ALT for the RFM loop calibration check is determined by the SRSS of the loop reference accuracy, loop calibration equipment errors, and the loop calibration equipment reading errors. The AFT is determined by the SRSS of the loop reference accuracy, loop instrument drift, loop calibration equipment errors, and the loop calibration equipment reading errors. This methodology is in accordance with Section 4.0, Option A, of Reference 6.9.2. (Reference 6.9.2 is currently pending NRC approval). Equations utilized are:

$$\text{RFM LALT} = \pm[(\text{RFM } A_{REF})^2 + (\text{RFM CE})^2 + (\text{RFM } CE_{\text{READING ERROR}})^2]^{0.5}$$

$$\text{RFM LAFT} = \pm[(\text{RFM } A_{REF})^2 + (\text{RFM VD})^2 + (\text{RFM CE})^2 + (\text{RFM } CE_{\text{READING ERROR}})^2]^{0.5}$$

All uncertainties used in the ALT/AFT determination are considered to be 2-sigma (2σ) values.

7.2 Calculation File (Win95Excel97)

[begins on next page]

CHANNEL INSTRUMENT ERRORS (LA, LD)

FT DEVICE UNCERTAINTY CALCULATION — Ref 6.1,6.2.1,6.6.1,6.8.1

	model	range code	output code	URL	SP	units
FT	1153DB	5	R	750	225.00	in WC

A	TERM	EXPRESSION				units in WC	s indiv effect
		% URL			% SP		
	A1				0.5	1.125	3
T range (F)	ATE1n	0.75	+		0.5		
65		per		100	F		
106				dTA			
norm		} eval over		16	F	1.080	3
T range (F)	ATE1t						
65							
106							
trip		} eval over		16	F	1.080	3
line pressure							
1200	psig						
					systematic span		
	SPNE1				0.75		
		(note: systematic span effect is calibrated out)					
				effect			
		zero			random span		
(SRSS)	SPE1	0.2	+		0.5	2.250	3
		per		1000	psig		
		eval at		1200	psig line pressure		
	OPE1	N/A				0.000	3
		eval at		1200	psig line pressure		
(change in	24 Vdc	regulated power supply output voltage)				negligible	
	PSE1				0.005	0.000	3
		per		1	Vdc		
		} eval over		0	dVdc		
	HTE1	N/A			N/A	0.000	2
	RE1	N/A				0.000	2

(if rad TID <= 22000000)

	SEIS1	N/A			0.000	2
(if ZPA <= 2)						
		N/A			0.000	2
		N/A			0.000	2
						overall normalization
	A norm	*(SRSS)(above terms) =*			*1.825*	*2*
	trip				*1.825*	*2*
D						indiv effect
	D1	0.25			4.193	3
{ TS		per	6	-months		
-months	24	} eval over	30	-months for	25 % grace period	
T range (F)	DTE1	0.75	+ 0.5		1.688	3
65		per	100 F			
90			dTD			
		} eval over	25 F			
	D	*(SRSS)(above terms) =*			*3.013*	*2*

PRNM

PRNM Channel (Figure 1) [% flux (power) at 2-sigma unless otherwise noted]

					Ref
					6.5.1,6.5.3
a) channel instrument accuracy (LA)					s
APRM ch 1,2,3,4	RBM ch A,B				indiv effect
1) PRNM (LPRMs, APRM/RBM, trip)	digital black box--acc uncert		negligible	(fixed)	3
gen1 VA =	0.00 % FS			APRM	
FS =	0	to	125	% rated P	
gen1 VA =	0.00 % FS			RBM	
FS =	0	to	125	% rated P	
gen1 L =	0.00 % FS			APRM	
gen1 L =	0.00 % FS			RBM	
gen A =	0.00 % rated P			APRM	
gen A =	0.00 % rated P			RBM	
trip1 VA =	0.00 % FS			APRM	
FS =	0	to	125	% rated P	
trip1 VA =	0.00 % FS			RBM	
FS =	0	to	125	% rated P	
trip1 H =	0.00 % FS			APRM	
trip1 H =	0.00 % FS			RBM	
trip A =	0.00 % rated P			APRM	
trip A =	0.00 % rated P			RBM	

LPRM	flux electronics, uncert on inputs signal linear processing as determined by the PRNM instr	
envir2 A =	0.800 % FS	

gen2 L =	0.800% FS		
FS = 0 to 125 % rated P			
gen A = LPRM(APRM) =	0.211 % rated P	20 LPRMs minimum	
LPRM(RBM) =	0.667 % rated P	2 LPRMs minimum	
2) RFM (flow – for APRM fb)		(fb)	3
FT: span 225.00 in WC =	16 mAdc		
FTA = 1.825 in WC =	0.811 % SP	[e.g., FT-43-(1)(2)N014(24)A-D]	
resistor gen A =	0.112 % FS		
envir2 A =	0.800 % FS		
gen2 L =	0.800 % FS		
(SRSS)	1.110 % FS		2
K corr = 1.006 at	75 % loop Q		
flow conversion model:			
sq rt out = 0.600 Vdc at	75 % loop Q		
RFM flow inputs:	2	(for standard TLO)	
dV sum out = 1 / sqrt 2*31.25*0.016*1.006*1.110% / 0.600			
dV sum out = 0.0066 Vdc =	0.822 % rated Q	0.800 Vdc at 100% rated Q	
hence, flow error = dP = coeff*dW			
FCTR slope =	0.65 (W coefficient)		
	0.534 % rated P		

RFM flow electronics, uncert on inputs signal sq rt processing as determined by the PRNM instr

3) RFM (flow – for flow trip)		(flow)	3
envir3 A =	0.00 % FS		
gen3 L =	0.00 % FS		
FS = 0 to 125 % loop Q			
gen A =	0.00 % rated Q	2 loop recirc (for standard TLO)	
trip3 VA =	0.00 % FS		
FS = 0 to 125 % rated Q			
trip3 H =	0.00 % FS		
trip A =	0.00 % rated Q		
FT: span 225.00 in WC =	16 mAdc		
FTA = 1.825 in WC =	0.811 % SP	[e.g., FT-43-(1)(2)N014(24)A-D]	
resistor gen A =	0.112 % FS		
envir2 A	0.800 % FS		
gen2 L =	0.800 % FS		
K corr = 1.006 at	75 % loop Q		
flow conversion model:			
sq rt out = 0.600 Vdc at	75 % loop Q		
RFM flow inputs:	2	(for standard TLO)	

dV sum out = 0.0066 Vdc = 0.822 % rated Q 0.800 Vdc at 100 % rated Q

a) channel instrument accuracy (LA)

	(APRM)	0.211 % rated P (fixed)
	(APRM, RFM)	0.574 % rated P (fb)
	(RBM)	0.211 % rated P (RBM power)
	(RBM)	0.667 % rated P (RBM trip)
	(RFM)	0.822 % rated Q (flow)

b) channel instrument drift (LD) Ref 6.5.1, 6.5.3

1) PRNM (LPRMs, APRM/RBM, trip) digital black box –drift in PRNM signal between calib 3

gen1 VD =	0.5 % FS	
FS = 0 to 125 % rated P		
gen D =	0.417 % rated P	APRM
gen1 VD =	0.0 % FS	
gen D =	0.000 % rated P	RBM
LPRM *N/A –not used in this calc*		
gen2 VD =	0.0 % FS	
FS = 0 to 125 % rated P		
gen D = LPRM(APRM) =	0.000 % rated P	20 LPRMs minimum
LPRM(RBM) =	0.000 % rated P	2 LPRMs minimum

2) RFM (flow – for APRM fb) 3

FT: span 225.00 in WC =	16 mAdc	
FTD = 3.013 in WC =	1.339 % SP	
resistor gen1 VD = N/A		
gen3 VD =	1.789 % FS	
(SRSS)	1.793 % FS	2
K corr = 1.009 at	75 % loop Q	

flow conversion model:

sq rt out = 0.600 Vdc at	75 % loop Q	
RFM flow inputs:	2	(for standard TLO)

dV sum out = 1 / sqrt 2*31.25*0.016*1.009*1.793% / 0.600

dV sum out = 0.0107 Vdc = 1.333 % rated Q 0.800 Vdc at 100% rated Q

hence, flow error = dP = coeff*dW

FCTR slope =	0.65 (W coefficient)
	0.8665 % rated P

RFM flow electronics, uncert on inputs signal sq rt processing as determined by the PRNM instr

3) RFM (flow – for flow trip) 3

gen4 VD =	0.000 % FS

FS = 0 to 125 % loop Q

gen D =	0.000 % rated Q	2 loop recirc: (for standard TLO)
FT: span 225.00 in WC =	16 mAdc	
FTD = 3.013 in WC =	1.339 % SP	
Resistor gen1 VD = N/A		
gen3 VD =	1.789 % FS	
K corr = 1.009 at	75 % loop Q	
flow conversion model:		
sq rt out = 0.600 Vdc at	75 % loop Q	
RFM flow inputs:	2	(for standard TLO)
dV sum out = 1 / sqrt 2*31.25*0.016*1.009*1.793% / 0.600		
dV sum out = 0.0107 Vdc =	1.333 % rated Q	0.800 Vdc at 100% rated Q

b) channel instrument drift (LD)

(APRM)	0.417 % rated P	(fixed)
(APRM, RFM)	0.962 % rated P	(fb)
(RBM)	0.417 % rated P	(RBM power)
(RBM)	0.000 % rated P	(RBM trip)
(RFM)	1.333 % rated Q	(flow)

SUMMARY OF CHANNEL INSTRUMENT ERRORS

a) channel instrument accuracy (LA)

APRM functions	0.211 % rated P	(fixed)
	0.574 % rated P	(fb)
RBM power functions	0.211 % rated P	(RBM power)
RBM trip functions	0.667 % rated P	(RBM trip)
RFM functions	0.822 % rated Q	(flow)

b) channel instrument drift (LD)

APRM functions	0.417 % rated P	(fixed)
	0.962 % rated P	(fb)
RBM power functions	0.417 % rated P	(RBM power)
RBM trip functions	0.000 % rated P	(RBM trip)
RFM functions	1.333 % rated Q	(flow)

CHANNEL CALIBRATION ERRORS (CA)

	Ref
	6.1, 6.2, 6.3, 6.5
all cal uncertainties are	s
	indiv effect
	3

channel 1: APRM Channels

parameter / analog summary:

LPRM in	APRM out	RBM out
mAdc	Vdc	Vdc

0.0	0.000	0.000
3.0	1.000	1.000

INOP-CAL mode, essentially no uncertainty

LPRMs cal uncertainty	0.0 % rated P
APRM cal uncertainty	0.0 % rated P

CE = 0.000 % rated P
let CEstd = CE = 0.000 % rated P

STOLi: FS = 0 to 125 % rated P

	% rated P		
STOL1 =	0.000	(LGAF)	6.5.3
STOL2 =	0.000	INOP-CAL	
STOL3 =	0.000	APRM downscale neut	
STOL3 =	0.000	APRM setdown neut/stp	
STOL3 =	0.000	APRM fixed hi-hi neut	
STOL3 =	0.000	APRM fb stp clmp	
STOL3 =	0.000	APRM fb stp scram/rb	
STOL4 =	0.000	(AGAF)	

	% rated P	
STOL = sqrt (STOLi^2)	2.00	APRM downscale neut
	2.00	APRM setdown neut/stp
	2.00	APRM fixed hi-hi neut
	2.00	APRM fb stp clmp
	2.00	APRM fb stp scram/rb
CA = (2/3) * sqrt (STOL^2 + CE^2 + CEstd^2) =	1.333	% rated P APRM downscale neut
	1.333	% rated P APRM setdown neut/stp
	1.333	% rated P APRM fixed hi-hi neut
	1.333	% rated P APRM fb stp clmp
Incl P comp from Q ch 1a below >>>>>	1.575	% rated P APRM fb stp scram/rb

channel 2: RBM Channels

		% rated P	
APRM input			
APRM fb stp clmp to	3s	2.00	(RBM power)
		0.00	(RBM trip)

STOLi: FS = 0 to 125 % rated P

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		% rated P		
STOL1 =	N/A			
STOL2 =		0.0	INOP-CAL	
STOL3 =		0.0	RBM low	(RBM power)
STOL3 =		0.0	RBM inter	(RBM power)
STOL3 =		0.0	RBM high	(RBM power)
STOL3 =		0.0	RBM low	(RBM trip)
STOL3 =		0.0	RBM inter	(RBM trip)
STOL3 =		0.0	RBM high	(RBM trip)
STOL3 =		0.0	RBM downscl	(RBM trip)
STOL4 =	N/A			

STOL = sqrt (STOLi^2) =

% rated P		
0.0	RBM low	(RBM power)
0.0	RBM inter	(RBM power)
0.0	RBM high	(RBM power)
0.0	RBM low	(RBM trip)
0.0	RBM inter	(RBM trip)
0.0	RBM high	(RBM trip)
0.0	RBM downscl	(RBM trip)

CA = (2/3) * sqrt (STOL^2 + APRM^2) =

1.333 % rated P	RBM low	(RBM power)
1.333 % rated P	RBM inter	(RBM power)
1.333 % rated P	RBM high	(RBM power)

CA = (2/3) * sqrt (STOL^2) =

0.000 % rated P	RBM low	(RBM trip)
0.000 % rated P	RBM inter	(RBM trip)
0.000 % rated P	RBM high	(RBM trip)
0.000 % rated P	RBM downscl	(RBM trip)

channel 1a: APRM Channels RFM Flow Reference Channel

parameter / analog summary:

FE out	FT in	FT out	RFM in	RFM out		*cal*	
gpm	atm in WC	mAdc	mAdc	Vdc	mAdc	*Vdc*	*ohms*
0	0.00	4.0	0.4	0.000	0.000	*0.0*	*0.0*
55000	225.00	20.0	2.0	1.000	1.000	*10.0*	*1620.0*

(for standard TLO)

recirc FEs ——>	FTs ——>	PRNM	high precision resistor	
number:				
2				
boundary temp (F):				
90	CE1A,B CE1A,Bstd (Heise 710A)	CE2A,B CE2A,Bstd (Fluke 8050)	CE3 CE3std (Fluke 8050)	CE4 CE4std (Fluke 8050)

For DPI/PG: 0.00 % input + 0.10 % FS of 2772.9 in WC 6.2.1 CE spec

CE1A,B 2.773 in WC over span of 225.00 in WC

let DPI/PG=A1? no

=		1.232 % FS of	125 % loop Q	
		=	1.541 % loop Q	
For DMM:	20.000 mAdc	125 % loop Q		6.2.1 std prac
CE2A,B	0.00 % input +	0.13 % range of	20 mAdc	
	0.026 mAdc over span of		16 mAdc	
	let DMM=A1? Yes			
=		0.500 % FS of	125 % loop Q	
		=	0.625 % loop Q	
For DMM:	10.000 Vdc	125 % loop Q		6.2.1 std prac
CE3	0.00 % input +	0.13 % range of	20 Vdc	
	0.026 Vdc over span of		10 Vdc	
=		0.500 % FS of	125 % loop Q	
		=	0.625 % loop Q	
For DMM:	1620.0 ohms	125 % loop Q		6.2.1 std prac
CE4	0.00 % input +	0.13 % range of	2000 ohms	
	2.6 ohms over span of		1620.0 ohms	
=		0.500 % FS of	125 % loop Q	
		=	0.625 % loop Q	

	% loop Q	% rated Q
CE =	1.883	1.331
let CEstd = CE =	1.883	1.331

STOLi 6.2.1 std prac

	analog	% FS	% loop Q
STOL1 =	N/A		
STOL2 =	0.08	0.500	0.625
STOL3 =	0.000	0.000	0.000
STOL4 =	0.0	0.000	0.000

	% loop Q	% rated Q
STOL = sqrt (STOLi^2) =	0.625	0.442

CA = (2/3)*sqrt(STOL^2 + CE^2 + CEstd^2) = 1.289 % rated Q *3 s* *1.934 % rated Q* *1.257 % rated P*

PROCESS MEASUREMENT ACCURACY (PMA) VALIDATION Ref 6.1, 6.5.3

channel 1: APRM Channels

The PMA is a combination of the APRM tracking error and the uncertainty due to flow noise and neutron noise.

$$\frac{s}{\text{indiv effect}}{2}$$

For the loss of Feedwater heating event, the APRM system is designed to have a tracking error of not more than 1.11 % power in response to a 20% flow control maneuver with a limiting control rod pattern. This shall hold true for all cases including that the LPRM sensors are failed or bypassed to the minimum number required in each APRM. The neutron noise is considered to be negligible to that for neutron flux; therefore 0.000 % power including filtering of neutron noise for STP.

Per below, flow noise contrib'n is 0.846 % power. Hence,

For heat flux STP PMA = 1.110 % rated P (fixed)
1.396 % rated P (fb)

For the MSIV closure event, the APRM tracking error is 1.11% power, the neutron noise is 1.220% power based on actual LGS-2 plant data, and the flow noise is 1.301 % rated Q (0.846 % power) based on actual LGS-2 plant data. Combining by SRSS yields

for neutron flux PMA = 1.649 % rated P (fixed)
1.854 % rated P (fb)

(for SLO): dW

(W coefficient) 0.65 (W -7.6) + y-intercept (Ref. 6.5.6)
0.65W - 5 + y-intercept (rounded from 4.94 to 5 – See Note below)

	bias		random
	-5% rated P	(fb)(for SLO)	N/A

channel 2: RBM channels

tracking	0 % rated P	at	2 s	(RBM power)
neutron noise same as above:	1.220 % rated P	at	2 s	(RBM power)
	1.220 % rated P			(RBM power)
neutron noise N/A	0 % rated P	at	2 s	(RBM trip)
LPRM readings	1.0 % rated P	at	3 s	(RBM trip)
	PMA = 0.667 % rated P			(RBM trip)

channel 1a: APRM Channels RFM Flow Reference Channel

The flow noise, based on actual plant data, is:
PMA = 1.301 % rated Q

PRIMARY ELEMENT ACCURACY (PEA) VALIDATION

Ref
6.1, 6.5.3

channel 1: APRM Channels [NA200/NA300 LPRMs]

s
indiv effect
2

PEA is a combination of the LPRM sensor sensitivity and sensor non-linearity uncertainties.

	bias		random		
They are:	0.33	+/-	0.20% and	*sen-sen*	dpea
	0.49	+/-	1.00%, respectively	*sen-non-lin*	apea

Also, since N1 = minimum number of LPRM to one APRM channel = 20
Therefore, overall PEA = (0.33 + 0.49) +/- (1/sqrt N1) * sqrt(0.20^2 + 1^2)

Note: The 5% rated P bias for SLO is consistent with the input identified in Section 3.2.2 of this calculation.

		bias		random		
PEA	=	0.82	+/-	0.228	% rated P	(fixed)
				1.852	% rated P	(fb)

or, separated into drift and accuracy components:

dpea	=	0.33	+/-	0.045	% rated P	
apea	=	0.49	+/-	0.224	% rated P	(fixed)
				1.852	% rated P	(fb)

channel 2: RBM Channels
PEA is a combination of the LPRM sensor sensitivity and sensor non-linearity uncertainties.
(RBM power) They are:

0.33	+/-	0.20% and		sen-sen	dpea
N/A 0.00	+/-	1.00%, respectively		sen-non-lin	apea

		bias		random		
PEA	=	0.33	+/-	0.228	% rated P	(RBM power)

or, separated into drift and accuracy components:

dpea	=	0.33	+/-	0.045	% rated P	(RBM power)
apea	=	0.00	+/-	0.224	% rated P	(RBM power)

(RBM trip) They are:

N/A 0.00	+/-	0.00% and		sen-sen	dpea
0.49	+/-	1.00%, respectively		sen-non-lin	apea

Also, since N2 = minimum number of LPRM to one
RBM channel = 2

		bias		random		
PEA	=	0.49	+/-	0.707	% rated P	(RBM trip)

or, separated into drift and accuracy components:

dpea	=	0.00	+/-	0.000	% rated P	(RBM trip)
apea	=	0.49	+/-	0.707	% rated P	(RBM trip)

channel 1a: APRM Channels RFM Flow Reference Channel
PEA is the FE:

FE error:	4	% loop Q		(each elbow)	
FE error:			2.828% rated Q	2 loop recirc:	
			2.828	% rated Q	
	*	0.65	=	1.838	% rated P

NOMINAL TRIP SETPOINT (NTSP) AND ALLOWABLE VALUE (AV) Ref 6.1,6.2,6.3,6.5,6.7

channel 1: APRM Channels
a-1) APRM STP Flow-Biased - Upscale (flow-biased) (scram)

DB=	0.65	W+	65.1	%rated P		6.5.6

NTSP = DB - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+PEArandom^2+LD^2)+PEAbias]

=	0.65	W+	65.1	-	terms above
=	0.65	W+	61.797	61.47	(for LER)
	0.65	W+		61.43	(for LER incl margin to chosen AV)
					See Note below
let NTSP =	0.65	W+	61.7	%rated P	*conditional*

Note: This margin value of 0.04 has been used in Revision 0 of this calculation and is conservative. Therefore, the value is included in Revision 1 of this calculation.

AV = DB - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+APEArandom^2)+APEAbias]

	=	0.65	W+	65.1	-	terms above
	=	0.65	W+	62.26		
let AV	=	0.65	W+	62.2	% rated P	

b-1) APRM STP Flow-Biased - Upscale (flow-biased) (rod block)

DB =		0.65	W+	57.6	% rated P	N/A; entered for AV/NTSP

NTSP = DB - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+PEArandom^2+LD^2)+PEAbias]

	=	0.65	W+	57.6	-	terms above
	=	0.65	W+	54.30	53.97	(for LER)
	=	0.65	W+		53.93	(for LER incl margin to chosen AV) See Note below
let NTSP	=	0.65	W+	54.3	% rated P	6.5.7

AV = DB - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+APEArandorm^2)+APEAbias]

	=	0.65	W+	57.6	-	terms above
	=	0.65	W+	54.76		
let AV	=	0.65	W+	54.7	% rated P	

c) APRM STP Flow-Biased - Upscale (flow-biased clamp) (scram)

DB =		119.0			% rated P	6.5.4

NTSP = DB - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+PEArandom^2+LD^2)+PEAbias]

	=	119.0	-	terms above	
	=	116.69	116.49	(for LER)	
			116.43	(for LER incl margin to chosen AV)	
let NTSP	=	116.6	% rated P	*conditional*	

AV = DB -[(1.645/2)*SQRT(LA^2+CA^2+PMA^2+APEArandom^2)+APEAbias]

	=		119.0	-	terms above
	=		117.06		
let AV	=		117.0	% rated P	

d) APRM STP Flow-Biased - Upscale (flow-biased clamp) (rod block)

DB =		110.4	% rated P	N/A; entered for AV/NTSP

NTSP = DB - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+PEArandom^2+LD^2)+PEAbias]

	=	110.4	-	terms above	
	=	108.09	107.89	(for LER)	
			107.83	(for LER incl margin to chosen AV)	
let NTSP	=	108.0	% rated P	6.5.4	

AV = DB - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+APEArandom^2)+APEAbias]

	=	110.4	-	terms above	
	=	108.46			
let AV	=	108.4	% rated P		

e) APRM Neutron Flux Upscale Trip - setdown (scram)

ANL =	22.3	% rated P	N/A; entered for AV/NTSP

Note: This margin value of 0.04 has been used in Revision 0 of this calculation and is conservative. Therefore, the value is included in Revision 1 of this calculation.

NTSP = ANL - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+PEArandom^2+LD^2)+PEAbias]

=	22.3	-	terms above	
=	19.68	19.48	(for LER)	
		19.43	(for LER incl margin to chosen AV)	
let NTSP =	15.0 % rated P			6.5.4

AV = ANL - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+APEArandom^2)+APEAbias]

=	22.3	-	terms above	
=	20.05			
let AV =	20.0 % rated P			6.5.4

f) APRM STP Upscale Alarm - setdown (rod block)

ANL = *15.0* % rated P *N/A; entered for AV/NTSP*

NTSP = ANL - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+PEArandom^2+LD^2)+PEAbias]

=	15.0	-	terms above	
=	12.69	12.49	(for LER)	
		12.43	(for LER incl margin to chosen AV)	
let NTSP =	12.0 % rated P			6.5.4

AV = ANL - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+APEArandom^2)+APEAbias]

=	15.0	-	terms above	
=	13.06			
let AV =	13.0 % rated P			6.5.4

g-1) APRM Neutron Flux Downscale Alarm (rod block)

DB = 0.5 % rated P 6.5.4

NTSP = DB + [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+PEArandom^2+LD^2)]

=	0.5	+	terms above	
=	2.30	2.83	(for LER)	
		3.37	(for LER incl margin to chosen AV)	
let NTSP =	3.2 % rated P			

AV = DB + [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+APEArandom^2)]

=	0.5	+	terms above	
=	2.26			
let AV =	2.8 % rated P			

g-2) APRM Neutron Flux Downscale Trip (RRCS)

DB = *7.3* % rated P *N/A; entered for AV/NTSP*

NTSP = DB - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+PEArandom^2+LD^2)+PEAbias]
- (deadband + min STP resolution)

=	7.3	+	terms above	
=	4.68	4.48	(for LER)	
		4.43	(for LER incl margin to chosen AV)	

let D = 1.0 % rated P
let Res = 0.1 % rated P

for overall effect of: 1.1 % rated P Asm 5.1.5
let NTSP = 4.3 % rated P 6.5.4

AV = DB - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+APEArandom^2)+APEAbias]
= 7.3 + terms above
= 5.05
let AV = 5.0 % rated P 6.5.4

h) APRM Neutron Flux Upscale Trip (scram)

ANL = 121.0 % rated P 6.5.4

NTSP = ANL - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+PEArandom^2+LD^2)+PEAbias]
= 121.0 - terms above
= 118.38 118.18 (for LER)
118.13 (for LER incl margin to chosen AV)
let NTSP = 118.3 % rated P *conditional*

AV = ANL - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+APEArandom^2)+APEAbias]
= 121.0 - terms above
= 118.75
let AV = 118.7 % rated P

channel 2: RBM Channels

a) RBM Low Power Setpoint

ANL = 30.0 % rated P 6.3.5

NTSP = ANL - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+PEArandom^2+LD^2)+PEAbias]
- (deadband + min STP resolution)
= 30.0 - terms above
= 28.12 27.58 (for LER)
27.49 (for LER incl margin to chosen AV)

shall the calculated value be entered into the equipment? no

(therefore, the calculated value is the effective value at which the actual trip occurs; i.e., rb un-bypass)

let D = n/a % rated P
let Res = n/a % rated P
for overall effect of: 0.0 % rated P Asm 5.1.6
let NTSP = 28.1 % rated P *conditional*

AV = ANL - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+APEArandom^2)+APEAbias]
- (deadband + min STP resolution)
= 30.0 - terms above
= 28.49
let AV = 28.4 % rated P

b) RBM Intermediate Power Setpoint

ANL = 65.0 % rated P 6.3.5

NTSP = ANL - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+PEArandom^2+LD^2)+PEAbias]
= 65.0 - terms above
= 63.12 62.58 (for LER)

62.49 (for LER incl margin to chosen AV)

let NTSP = 63.1 % rated P *conditional*

AV = ANL - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+APEArandom^2)+APEAbias]
= 65.0 - terms above
= 63.49

let AV = 63.4 % rated P

c) RBM High Power Setpoint

ANL = 85.0 % rated P 6.3.5

NTSP = ANL - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+PEArandom^2+LD^2)+PEAbias]
= 85.0 - terms above
= 83.12 82.58 (for LER)
82.49 (for LER incl margin to chosen AV)

let NTSP = 83.1 % rated P *conditional*

AV = ANL - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+APEArandom^2)+APEAbias]
= 85.0 - terms above
= 83.49

let AV = 83.4 % rated P

note: for all RBM trip setpoints, use MCPR of *1.20* as example;
margins are the same for other MCPRs

Asm 5.1.4

d) RBM Low Trip Setpoint

ANL = 117.0 % rated P 6.3.5

NTSP = ANL - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+PEArandom^2+LD^2)+PEAbias]
= 117.0 - terms above
= 115.54 115.11 (for LER)
115.07 (for LER incl margin to chosen AV)

let NTSP = 115.5 % rated P *conditional*

AV = ANL - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+APEArandom^2)+APEAbias]
= 117.0 - terms above
= 115.54

let AV = 115.5 % rated P

d) RBM Low Trip Setpoint

MCPR	*AL*	*AV*	*NTSP*	
1.20	117.0	115.5	115.5	w/ filter, 0.1<tau c1<=0.55 sec
	118.0	*116.5*	*116.5*	*w/o filter, tau c1<=0.1 sec*
1.25	120.0	118.5	118.5	w/ filter, 0.1<tau c1<=0.55 sec
	121.0	*119.5*	*119.5*	*w/o filter, tau c1<=0.1 sec*
1.30	123.0	121.5	121.5	w/ filter, 0.1<tau c1<=0.55 sec
	124.0	*122.5*	*122.5*	*w/o filter, tau c1<=0.1 sec*
1.35	125.8	124.3	124.3	w/ filter, 0.1<tau c1<=0.55 sec
	127.0	*125.5*	*125.5*	*w/o filter, tau c1<=0.1 sec*

e) RBM Intermediate Trip Setpoint

ANL = 111.2 % rated P 6.3.5

NTSP = ANL - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+PEArandom^2+LD^2)+PEAbias]

=	111.2	-	terms above
=	109.74	109.31	(for LER)
		109.27	(for LER incl margin to chosen AV)

let NTSP = **109.7 % rated P** *conditional*

AV = ANL - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+APEArandom^2)+APEAbias]

=	111.2	-	terms above
=	109.74		

let AV = **109.7 % rated P**

e) RBM Intermediate Trip Setpoint

MCPR	AL	AV	NTSP	
1.20	111.2	109.7	109.7	w/ filter, 0.1<tau c1<=0.55 sec
	112.0	*110.5*	*110.5*	*w/o filter, tau c1<=0.1 sec*
1.25	115.2	113.7	113.7	w/ filter, 0.1<tau c1<=0.55 sec
	116.0	*114.5*	*114.5*	*w/o filter, tau c1<=0.1 sec*
1.30	118.0	116.5	116.5	w/ filter, 0.1<tau c1<=0.55 sec
	119.0	*117.5*	*117.5*	*w/o filter, tau c1<=0.1 sec*
1.35	121.0	119.5	119.5	w/ filter, 0.1<tau c1<=0.55 sec
	122.0	*120.5*	*120.5*	*w/o filter, tau c1<=0.1 sec*

f) RBM High Trip Setpoint

ANL = 107.4 % rated P 6.3.5

NTSP = ANL - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+PEArandom^2+LD^2)+PEAbias]

=	107.4	-	terms above
=	105.94	105.51	(for LER)
		105.47	(for LER incl margin to chosen AV)

let NTSP = **105.9 % rated P** *conditional*

AV = ANL - [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+APEArandom^2)+APEAbias]

=	107.4	-	terms above
=	105.94		

let AV = **105.9 % rated P**

f) RBM High Trip Setpoint

MCPR	AL	AV	NTSP	
1.20	107.4	105.9	105.9	w/ filter, 0.1<tau c1<=0.55 sec
	108.0	*106.5*	*106.5*	*w/o filter, tau c1<=0.1 sec*
1.25	110.2	108.7	108.7	w/ filter, 0.1<tau c1<=0.55 sec
	111.0	*109.5*	*109.5*	*w/o filter, tau c1<=0.1 sec*
1.30	113.2	111.7	111.7	w/ filter, 0.1<tau c1<=0.55 sec
	114.0	*112.5*	*112.5*	*w/o filter, tau c1<=0.1 sec*
1.35	116.0	114.5	114.5	w/ filter, 0.1<tau c1<=0.55 sec
	117.0	*115.5*	*115.5*	*w/o filter, tau c1<=0.1 sec*

g) RBM Downscale Trip Setpoint

DB = 1.0 % rated P N/A; entered for AV/NTSP
IS = DB + [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+PEArandom^2+LD^2)]
= 1.0 + terms above
= 1.97 89.40 (for LER)
89.43 (for LER incl margin to chosen AV)
let NTSP = 5.0 % rated P

TS = DB + [(1.645/2)*SQRT(LA^2+CA^2+PMA^2+APEArandom^2)]
= 1.0 + terms above
= 1.97
let AV = 2.0 % rated P

LICENSEE EVENT REPORT (LER) AVOIDANCE EVALUATION Ref 6.1

channel 1: APRM Channels

a-1) APRM STP Flow Biased - Upscale (flow-biased) (scram)

Sigma (LER) = (1/2)*SQRT(LA^2+CA^2+LD^2)
= 0.966
Z = abs(AV-NTSP)/Sigma(LER) = 0.48
Since this value of Z does not correspond to a probability of more than 90% (one-sided normal distribution) for a multiple chnl (0.81 – See Note below), the NTSP is adjusted as follows:

NTSP = AV- 0.81*Sigma (LER) = 61.47

b-1) APRM STP Flow-Biased - Upscale (flow-biased) (rod block)

Sigma (LER) = (1/2)*SQRT(LA^2+CA^2+LD^2)
= 0.966
Z = abs(AV-NTSP)/Sigma(LER) = 0.48
Since this value of Z does not correspond to a probability of more than 90% (one-sided normal distribution) for a multiple chnl (0.81 – See Note below), the NTSP is adjusted as follows:
NTSP = AV- 0.81 *Sigma (LER) = 53.97

c) APRM STP Flow-Biased - Upscale (flow-biased clamp) (scram)

Sigma (LER) = (1/2)*SQRT(LA^2+CA^2+LD^2)
= 0.71
Z = abs(AV-NTSP)/Sigma(LER) = 0.52
Since this value of Z does not correspond to a probability of more than 90% (one-sided normal distribution) for a multiple chnl (0.81), the NTSP is adjusted as follows:
NTSP = AV- 0.81 *Sigma (LER) = 116.49

d) APRM STP Flow-Biased - Upscale (flow-biased clamp) (rod block)

Sigma (LER) = (1/2)*SQRT(LA^2+CA^2+LD^2)
= 0.71
Note: This value of 0.81 has been used in Revision 0 of this calculation and is a conservative z-value corresponding to a multi-channel probability greater than or equal to 0.90 for LER avoidance. Therefore, this value will be included in Revision 1.

Z = abs(AV-NTSP)/Sigma (LER) = 0.52

Since this value of Z does not correspond to a probability of more than 90% (one-sided normal distribution) for a multiple chnl (0.81), the NTSP is adjusted as follows:
NTSP = AV - 0.81 *Sigma (LER) = 107.89

e) APRM Neutron Flux Upscale Trip - setdown (scram)

Sigma (LER)= (1/2)*SQRT(LA^2+CA^2+LD^2)
= 0.71
Z = abs(AV-NTSP)/Sigma (LER) = 0.51

Since this value of Z does not correspond to a probability of more than 90% (one-sided normal distribution) for a multiple chnl (0.81), the NTSP is adjusted as follows:
NTSP = AV - 0.81 *Sigma (LER) = 19.48

f) APRM STP Upscale Alarm - setdown (rod block)

Sigma (LER)= (1/2)*SQRT(LA^2+CA^2+LD^2)
= 0.71
Z = abs(AV-NTSP)/Sigma (LER) = 0.52

Since this value of Z does not correspond to a probability of more than 90% (one-sided normal distribution) for a multiple chnl (0.81), the NTSP is adjusted as follows:
NTSP = AV - 0.81 *Sigma (LER) = 12.49

g-1) APRM Neutron Flux Downscale Alarm (rod block)

Sigma (LER)= (1/2)*SQRT(LA^2+CA^2+LD^2)
= 0.71
Z = abs(AV-NTSP)/Sigma (LER) = 0.05

Since this value of Z does not correspond to a probability of more than 90% (one-sided normal distribution) for a multiple chnl (0.81), the NTSP is adjusted as follows:
NTSP = AV + 0.81 *Sigma (LER) = 2.83

g-2) APRM Neutron Flux Downscale Trip (RRCS)

Sigma (LER)= (1/2)*SQRT(LA^2+CA^2+LD^2)
= 0.71
Z = abs(AV-NTSP)/Sigma (LER) = 0.51

Since this value of Z does not correspond to a probability of more than 90% (one-sided normal distribution) for a multiple chnl (0.81), the NTSP is adjusted as follows:
NTSP = AV + 0.81 *Sigma (LER) = 4.48

h) APRM Neutron Flux Upscale Trip (scram)

Sigma (LER)= (1/2)*SQRT(LA^2+CA^2+LD^2)
= 0.71
Z = abs(AV-NTSP)/Sigma (LER) = 0.51

Since this value of Z does not correspond to a probability of more than 90% (one-sided normal distribution) for a multiple chnl (0.81), the NTSP is adjusted as follows:
NTSP = AV + 0.81 *Sigma (LER) = 118.18

channel 2: RBM Channels

a) RBM Low Power Setpoint

Sigma (LER)= (1/2)*SQRT(LA^2+CA^2+LD^2)
= 0.71
Z = abs(AV-NTSP)/Sigma (LER) = 0.52

Since this value of Z does not correspond to a probability of more than 90% (one-sided normal distribution) for a single chnl (1.29), the NTSP is adjusted as follows:

NTSP = AV - 1.290 *Sigma (LER) = 27.58

b) RBM Intermediate Power Setpoint

Sigma (LER)= (1/2)*SQRT(LA^2+CA^2+LD^2)
= 0.71
Z = abs(AV-NTSP)/Sigma (LER) = 0.52

Since this value of Z does not correspond to a probability of more than 90% (one-sided normal distribution) for a single chnl (1.29), the NTSP is adjusted as follows:

NTSP = AV - 1.290 *Sigma (LER) = 62.58

c) RBM High Power Setpoint

Sigma (LER)= (1/2)*SQRT(LA^2+CA^2+LD^2)
= 0.71
Z = abs(AV-NTSP)/Sigma (LER) = 0.52

Since this value of Z does not correspond to a probability of more than 90% (one-sided normal distribution) for a single chnl (1.29), the NTSP is adjusted as follows:

NTSP = AV - 1.290 *Sigma (LER) = 82.58

d) RBM Low Trip Setpoint

Sigma (LER)= (1/2)*SQRT(LA^2+CA^2+LD^2)
= 0.33
Z = abs(AV-NTSP)/Sigma (LER) = 0.00

Since this value of Z does not correspond to a probability of more than 90% (one-sided normal distribution) for a single chnl (1.29), the NTSP is adjusted as follows:

NTSP = AV - 1.290 *Sigma (LER) = 115.11

e) RBM Intermediate Trip Setpoint

Sigma (LER)= (1/2)*SQRT(LA^2+CA^2+LD^2)
= 0.33
Z = abs(AV-NTSP)/Sigma (LER) = 0.00

Since this value of Z does not correspond to a probability of more than 90% (one-sided normal distribution) for a single chnl (1.29), the NTSP is adjusted as follows:

NTSP = AV- 1.290 *Sigma (LER) = 109.31

f) RBM High Trip Setpoint

Sigma (LER) = (1/2)*SQRT(LA^2+CA^2+LD^2)
= 0.33
Z = abs(AV-NTSP)/Sigma (LER)= 0.00

Since this value of Z does not correspond to a probability of more than 90% (one-sided normal distribution) for a single chnl (1.29), the NTSP is adjusted as follows:

NTSP = AV- 1.290 *Sigma (LER) = 105.51

g) RBM Downscale Trip Setpoint

Sigma (LER) = (1/2)*SQRT(LA^2+CA^2+LD^2)
= 0.33
Z = abs(AV-NTSP)/Sigma(LER) = 0.00

Since this value of Z does not correspond to a probability of more than 90% (one-sided normal distribution) for a multiple chnl (1.29), the NTSP is adjusted as follows:

IS = TS + 1.290 *Sigma (LER) = 89.40

SPURIOUS TRIP AVOIDANCE (STA) EVALUATION Ref 6.1,6.3,6.4,6.5

channel 1: APRM Channels

a-1) APRM STP Flow-Biased - Upscale (flow-biased) (scram)

OL = 0.65 W+ 54.3 % rated P

Sigma (STA) = (1/2)*SQRT(LA^2+CA^2+PMA^2+PEArandom^2+LD^2)

= 1.509
Z = abs(OL-NTSP)/Sigma(STA) = 4.97
Since this value of Z corresponds to a probability of more than 95% (one-sided normal distribution) for a single chnl (1.645), the NTSP satisfies STA criteria.

c) APRM STP Flow-Biased - Upscale (flow-biased clamp) (scram)

OL = 108.0 % rated P

Sigma (STA) = (1/2)*SQRT(LA^2+CA^2+PMA^2+PEArandom^2+LD^2)
= 0.91
Z = abs(OL-NTSP)/Sigma(STA) = 9.50

Since this value of Z corresponds to a probability of more than 95% (one-sided normal distribution) for a single chnl (1.645), the NTSP satisfies STA criteria.

e) APRM Neutron Flux Upscale Trip-setdown (scram)
OL = 12.0 % rated P

Sigma (STA) = (1/2)*SQRT(LA^2+CA^2+PMA^2+PEArandom^2+LD^2)
= 1.09
Z = abs(OL-NTSP)/Sigma (STA) = 2.75

Since this value of Z corresponds to a probability of more than 95% (one-sided normal distribution) for a single chnl (1.645), the NTSP satisfies STA criteria.

h) APRM Neutron Flux Upscale Trip (scram)

OL = 110.4 % rated P

Sigma (STA) = (1/2)*SQRT(LA^2+CA^2+PMA^2+PEArandom^2+LD^2)
= 1.09
Z = abs(OL-NTSP)/Sigma (STA) = 7.60

Since this value of Z corresponds to a probability of more than 95% (one-sided normal distribution) for a single chnl (1.645), the NTSP satisfies STA criteria.

b-1) APRM STP Flow-Biased - Upscale (flow-biased) (rod block)
d) APRM STP Flow-Biased - Upscale (flow-biased clamp) (rod block)
f) APRM STP Upscale Alarm - setdown (rod block)
g-1) APRM Neutron Flux Downscale Alarm (rod block)
g-2) APRM Neutron Flux Downscale Trip (RRCS)

APRM rod-block channels do not have trips which cause reactor scram; therefore, STA is N/A.

channel 2: RBM Channels
RBM channels do not have trips which cause reactor scram; therefore, STA is N/A.

channel 1a: APRM Channels RFM Flow Reference Channel
RFM channels do not have trips which cause reactor scram; therefore, STA is N/A.

however, the flow upscale values are historically evaluated from STA/LER criteria:
values are calculated from the OL; see STA and LER evaluations, below

channel 1: APRM Channels

i) RFM Upscale Level Alarm (rod block)
w/ STA:
OL = 110.0 % rated Q 6.3.4

NTSP = OL + (1.645/2)*SQRT(LA^2+CA^2+PMA^2+PEA^2+LD^2)
= 110.0 + terms above
= 113.06

let NTSP = 113.4 % rated Q 6.3.4

w/o LER
AV = NTSP + [1.645/2][SQRT(LA^2+CA^2+PMA^2+PEA^2+LD^2)-SQRT(LA^2+CA^2+PMA^2+PEA^2)]*

= *113.4* + *terms above*
= *113.60 w/o LER*

w/ LER
Sigma (LER)= (1/2)*SQRT(LA^2+CA^2+LD^2)
= 1.01
Z =
distribution) for a multiple chnl (0.81)

AV = NTSP + Z*sigma (LER)
= 113.4 + Z*sigma (LER)
= 114.22 w/ LER *113.60 w/o LER*
let AV = 115.6 % rated Q 6.3.4

channel 2: RBM Channels

h) RFM Compare Level Alarm 2 (for standard TLO)

DB = *14.6* % rated Q *N/A; entered for AV/NTSP*

NTSP = DB - (1.645/2)*SQRT[2*(LA^2+CA^2+PMA^2+PEA^2+LD^2)]
= 14.6 - terms above
= 10.28 8.71 (for LER)
8.65 (for LER incl margin to chosen AV)
let NTSP = 10.0 % rated Q 6.4.1

AV = DB - (1.645/2)*SQRT[2*(LA^2+CA^2+PMA^2+PEA^2)]
= 14.6 - terms above
= 10.57
let AV = *10.5* % rated Q

h) RFM Compare Level Alarm

Sigma (LER)= (1/2)*SQRT(LA^2+CA^2+LD^2)
= 1.43
Z = abs(AV-NTSP)/Sigma (LER) = 0.20

Since this value of Z does not correspond to a probability of more than 90% (one-sided normal distribution) for a single chnl (1.29), the NTSP is adjusted as follows:
NTSP = AV - 1.290 *Sigma (LER) = 8.71

END

7.3 ALT / AFT for RFM Instrument Loop

The ALT / AFT for the RFM Instrument loop is determined per methodology provided in section 7.1.23.

7.3.1 RFM Loop Reference Accuracy

Per Ref. 6.6.1, recirculation flow transmitter reference accuracy is ±0.25% SP. Per section 7.2, additional accuracy specifications associated with the RFM instrument loop includes "resistor gen A", "envir2 A", and "gen 2 L". Therefore,

FT A_{REF}	= 0.25% SP
resistor gen A	= 0.112 % FS
envir2 A	= 0.800 % FS
gen 2 L	= 0.800 % FS

Combining terms via the SRSS method,

$$\text{RFM A}_{\text{REF SRSS}} = \pm[(\text{FT A}_{REF})^2 + (\text{resistor gen A})^2 + (\text{envir2 A})^2 + (\text{gen 2 L})^2]^{0.5}$$
$$= \pm[(0.25)^2 + (0.112)^2 + (0.800)^2 + (0.800)^2]^{0.5} \text{ \% FS}$$
$$= \pm 1.164064 \text{ \% FS}$$

"RFM $A_{REF SRSS}$" is propagated through the RFM utilizing the same methodology used in section 7.2 for determining the RFM channel instrument accuracy (LA).

$$\text{RFM A'}_{\text{REF OUT}} = [(1.006*\text{SRSS}_{FT}*31.25*0.016) / (100*0.6*2^{0.5})]*(125 \text{ \% rated Q})$$
$$= \pm[(1.006*1.164064*31.25*0.016) / (100*0.6*2^{0.5})]*(125 \text{ \% rated Q})$$
$$= \pm 0.862559 \text{ \% rated Q}$$

In addition to "RFM $A'_{REF OUT}$", accuracy of the APRM chassis display is also included when determining total RFM loop reference accuracy. Per section 5.12 of Reference 6.2.3.2.17, the accuracy of each of the two flow channels displays ("Flow A" and "Flow B") is ±1.0 % loop Q. This error is propagated through the summing algorithm of the RFM utilizing the method provided in section 7.17 and combined with "RFM $A'_{REF OUT}$" via SRSS as follows:

$$\text{RFM A}_{\text{REF OUT}} = \pm[(0.862559)^2 + (1.0 / 2^{0.5})^2]^{0.5} \text{ \% rated Q}$$
$$= \pm 1.115351 \text{ \% rated Q}$$

7.3.2 RFM Loop Vendor Drift

Per Section 5.1.1 and Ref. 6.6.1, transmitter vendor drift specification is 0.20% URL for 30 months. This is less conservative than the vendor drift specification used when determining total instrument uncertainty (0.25% for 6 months) and will therefore provide ALT/AFT that are less likely to mask indication of degraded instrument performance. Per Ref. 6.4.1, the maximum calibration interval is 30 months (24 months plus 25% extension). Therefore,

$$\text{FT VD} = \pm 0.20\% * (\text{URL/SP}) * \text{\% SP}$$

Per section 7.2,

$$\text{URL} = 750 \text{ in WC}$$

SP = 225 in WC

Therefore,

FT VD = ±0.20% * (750 in WC) /(225 in WC) % SP
= ±0.666667 % SP

Per section 7.2, an additional contributor to loop instrument drift is,

gen3 VD = 1.789 % FS

Since the PRNM is a digital system, the drift associated with the APRM chassis display used to monitor recirculation flow is considered to be zero.

Combining drift terms via the SRSS method,

$RFM\ VD_{SRSS} = \pm[(FT\ VD)^2 + (gen3\ VD)^2]^{0.5}$
$= \pm[(0.666667)^2 + (1.789)^2]^{0.5}$ % FS
= ±1.909179 % FS

"$RFM\ VD_{SRSS}$" is propagated through the RFM utilizing the same methodology used in section 7.2 for determining the RFM channel instrument drift (LD).

$RFM\ VD_{OUT} = [(1.009*SRSS_{FT}*31.25*0.016) / (100*0.6*2^{0.5})]*(125\ \%\ rated\ Q)$
$= \pm[(1.009*1.909179*31.25*0.016) / (100*0.6*2^{0.5})]*(125\ \%\ rated\ Q)$
= ±1.418899 % rated Q

7.3.3 RFM Loop Calibration Equipment Error

Per References 6.2.3.2.1-6.2.3.2.8, the calibration of the RFM instrument loop is checked by applying variable test pressure inputs at the inputs of the recirculation flow transmitters while monitoring total recirculation flow rates the at the APRM chassis display. As such, CE error will consists of errors associated with the pressure gauges used to measure the applied test pressures at the transmitter inputs.

Per References 6.2.3.2.1-6.2.3.2.8, the accuracy of the test gauges used to measure the applied pressures is required to be greater than or equal to ±1.15 in WC. Per calculation section 7.2, SP is 225 in WC. Therefore,

CE_{GAUGE} = ±(1.15 in WC/225 in WC)*100% SP
= ±0.511111 % SP

"CE_{GAUGE}" is propagated through the RFM utilizing the same methodology used in section 7.2 for determining the RFM Flow Reference Channel calibration error (channel 1a).

RFM CE_{OUT} $= (CE_{GAUGE} * 125\ \%\ \text{loop Q}) / (2^{0.5})$
$= \pm(0.511111\ \%\ SP * 125\ \%\ \text{loop Q}) / (100 * 2^{0.5})$
$= \pm 0.451763\ \%\ \text{rated Q}$

7.3.4 RFM Loop Calibration Equipment Readability

Reading error associated with reading the test gauges is considered to be included in the CE_{GAUGE} term. Reading error associated with reading the APRM Chassis display (total recirculation flow) is equal to the resolution of the display. Per References 6.2.3.2.1-6.2.3.2.8, the readings are in a resolution of 0.1 % Flow (or 0.1 % rated Q). Therefore,

RFM $CE_{READING\ ERROR} = \pm 0.1\ \%\ \text{rated Q}$

7.3.5 Determination of ALT and AFT for the RFM loop calibration check

Utilizing methodology in section 7.1.23,

RFM LALT $= \pm[(\text{RFM } A_{REF\ OUT})^2 + (\text{RFM } CE_{OUT})^2 + (\text{RFM } CE_{READING\ ERROR})^2]^{0.5}$
$= \pm[(1.115351)^2 + (0.451763)^2 + (0.1)^2]^{0.5}\ \%\ \text{rated Q}$
$= \pm 1.207517\ \%\ \text{rated Q}$
$= \pm 1.3\ \%\ \text{rated Q}$ (rounded upward to nearest 0.1% which is consistent with readability of indication)

RFM LAFT $= \pm[(\text{RFM } A_{REF\ OUT})^2 + (\text{RFM } VD_{OUT})^2 + (\text{RFM } CE_{OUT})^2 + (\text{RFM } CE_{READING\ ERROR})^2]^{0.5}$
$= \pm[(1.115351)^2 + (1.418899)^2 + (0.451763)^2 + (0.1)^2]^{0.5}\ \%\ \text{rated Q}$
$= \pm 1.863162\ \%\ \text{rated Q}$
$= \pm 1.9\ \%\ \text{rated Q}$ (rounded upward to nearest 0.1% which is consistent with readability of indication)

Note: LALT = LAZ

8.0 ATTACHMENTS

1. Universal Glossary
2. Bases Document (Ref 6.5.4)
3. Neutron Noise Data Summary (1 page from pre-existing fax, Ref. 6.3.1.2)
4. Flow Noise Data (Ref. 6.3.1.1)
5. Guidelines for Stability Option III "Enabled Region" (TAC M92882)
6. Minimum Number of Operable OPRM Cells for Option III Stability at Limerick 1 & 2
7. Bases Document (Ref. 6.5.5)

LGS 1 & 2
NUMAC PRNM Setpoint Study

ATTACHMENT 1
UNIVERSAL GLOSSARY

A	ampere; Accuracy; vessel "A" side
AAV	Allowable Allowable Value (this is not a redundancy)
A_i	Individual Device Accuracy
ABA	Amplitude-Based (core instability detection) Algorithm (a portion of OPRM ODA)
a-c	alternating-current
ACRS	Advisory Committee on Reactor Safeguards
A/D	Analog-to-Digital
ADS	Automatic Depressurization System
AFT	As-Found Tolerance
AGAF	APRM Gain Adjustment Factor
AL	Analytical Limit
A_L	Loop/Channel Accuracy
ALT	As-Left Tolerance
A/M	ARTS/MELLL
amb	ambient
AN	Loop Accuracy During Normal Conditions
ANL	Analytical Limit
ANSI	American National Standards Institute
AOO	Anticipated Operational Occurrences
AOT	Anticipated Operational Transients
APEA	Accuracy (random) portion of PEA
APED	Atomic Power Equipment Department
Appx	Appendix
APRE	Accuracy of Pre-Amp
APRM	Average Power Range Monitor
APT	Acceptable Performance Tolerance (synonymous with LAT)
AR	Accuracy Ratio (used in calibration to denote ratio between C and C_{STD})
ARE	Aging Rate Error
ARI	Alternate Rod Insertion
ARM	Area Radiation Monitor
ARTS	APRM/RBM/Technical Specification
Asm	Assumption
ASME	American Society of Mechanical Engineers
ASP	Allowable Setpoint; Analog Signal Processor; Automatic Signal Processor
AT	Loop Accuracy During Trip Conditions
ATE	Accuracy Temperature Effect
atm	standard atmosphere (14.696 psia)
ATR	Accuracy of (Flow) Transmitter (including Flow Element)
ATSP	Actual Trip Setpoint
ATU	Accuracy of Trip Unit
ATWS	Anticipated Transient Without Scram
aux	auxiliary

LGS 1 & 2
NUMAC PRNM Setpoint Study

ATTACHMENT 1
UNIVERSAL GLOSSARY

AV	Allowable Value (Tech Spec or TRM Limit)
B	vessel "B" side
bar	bar [unit of pressure (14.504 psia)]
BE	Battery Error
Bldg	Building
BPWS	Banked Position Withdrawal Sequence
BOS	bottom-of-scale
BS	Bias Span Effect
Btu	British Thermal Unit
BV	Bounding Value
BWR	Boiling Water Reactor
BWROG	Boiling Water Reactor Owners' Group
byp	bypass
c	vessel coefficient of linear thermal expansion
C	Calibration Tool Error; Degrees Celsius; Conformity; Closure; Discharge Coefficient
CA	Calibration Accuracy
CAL	Calibration Tolerance
calib	calibration
C_i	Individual Device Calibration
cb	control building
cc	cubic centimeter (synonymous with ml)
CC	Condensing Chamber
CDB	Component Data Base
CDCI	Common Data and Control Interface
CE	Channel Error; Calibration Equipment
CF	(static pressure span shift) correction factor
CFR	Code of Federal Regulations
ch	(instrument) channel
CHC	Constant Head Chamber
chk	check
Ci	Curie
CIM	Computer Interface Module
CJ	cold junction
C_L	Loop/Channel Calibration Accuracy; center line
cm	centimeters
C/M	Calibration and Monitoring
cntr	counter
COL	Channel Operability Limit
COLR	Core Operating Limits Report
COU	component of uncertainty
cps	counts per second
CPU	Central Processing Unit

ATTACHMENT 1
UNIVERSAL GLOSSARY

Cr	Crosstalk
CR	Current-Rated
CRB	Control Rod Block
CRD	Control Rod Drive (System)
CRDA	Control Rod Drop Accident
CRPC	Control Rod Program Controls
CRSS	Control Rod Selection Signals
CRWB	Control Rod Withdrawal Block
CS	Core Spray (System); Calibrated Span
CSCS	Core Standby Cooling Systems
C_{STD}	Calibration Standard Error (Tool Calibration Error)
CTP	Core Thermal Power
cu	cubic
CU	Channel Uncertainty (at a designated point in the channel)
d	drywell; throat diameter
D	Deadband; pipe diameter
D_i	Individual Device Drift
D/A	Digital-to-Analog
DAS	Data Acquisition System
dB	decibel (ratio of two parameters using logarithms to base 10)
DB	Design Bases
DBA	Design Bases Accident
DBD	Design Bases Document
DBE	Design Bases Event
d-c	direct-current
DC	Design Calculation
DCA	d-c (current) alarm
DCD	Design Change Document [identified by Volume No. (Roman numeral)]
DE	Display Exponent
DFCS	Digital Feedwater Control System
DFS	Divisions of Full Scale
DG	Design Guide
dh	instrument line elevation differential
diff	differential
D_L	Loop/Channel Drift
DL	Design Limit
DMM	Digital Multi-Meter
dp	differential pressure
DPEA	Drift (bias) portion of PEA
dpmin	minimum measurable differential pressure (across FE) [judgment]
DPRE	Drift of Pre-Amplifier
DPS	Design & Performance Spec

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UNIVERSAL GLOSSARY

DR Drift; Decay Ratio
DRF Design Record File
DS Design Specification
DSDS Design Specification Data Sheet
DSP Digital Signal Processor
DTA delta T (accuracy)
DTD delta T (drift)
DTE Drift Temperature Effect
DTR Drift of (Flow) Transmitter
DTU Drift of Trip Unit
dV delta volt (change within the specified power supply voltage requirements)
DVM Digital Volt-Meter
dW delta recirculation drive flow
dw drywell
EAROM Electrically-Alterable Read-Only Memory
ECC Elevation Correlation Chart
ECCS Emergency Core Cooling Systems
ED Elementary Diagram
EDC Engineering Design Change
EDDL Elementary Diagram Device List
EDBS Equipment Data Base System
EDF Equipment Data File
EER Engineering Evaluation Report
elev elevation
ELFS Equivalent Linear Full Scale
ELLLA Extended Load Line Limit Analyses
ELTR Extended Licensing Topical Report
EOC End-Of-(fuel) Cycle
EOP Emergency Operating Procedure
Ep (Calibration) Procedural Effect
EPRI Electric Power Research Institute
EPROM Electrically-Programmable Read-Only Memory
EPU Extended Power Uprate
EQ Equipment Qualification
EQAB Engineering Quality Achievement Board
Eqn equation
EQEDC Equipment Qualification Environmental Design Criteria
ERF Emergency Response Facility
ERFIS ERF Information System
ERIS Emergency Response Information System
ESF Engineered Safety Feature
EUT Equipment Under Test

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eV electron-volt
eval evaluation
E1A Enhanced 1A [reactor stability option (long-term solution)]
F Degrees Fahrenheit; Fluke (calibration tool)
F_a area thermal-expansion factor
FB; fb Flow-Biased
fc corner frequency (of noise filter, PBA)
FC Fast Closure
FCD Functional Control Diagram; Flow Control Diagram
FCS Feedwater Control System
FCTR Flow Control Trip Reference
FD Functional Diagram; Flow Device
FDDI Fiber Direct Data Interface
FDDR Field Deviation Disposition Request
FE Flow Element
FFWTR Final Feedwater Temperature Reduction
FL final
FM Full Meter
FMdp Full Meter dp
FO Fiber Optic
FPS Final Product Spec; Functional Performance Spec
freq frequency
FS Full Scale
FSAR Final Safety Analysis Report
ft feet
FT Flow Transmitter
FTC Flow Trip Card
FU Flow Unit
FW, fw Feedwater
FWHOS Feedwater Heater Out-of Service
FZR Fuel-Zone Range
g local acceleration of gravity; grams; gain
g_0 standard acceleration of gravity (32.1740 ft/sec^2 , by international agreement)
g_c Newtonian dimensional constant (32.1740 lb_m-ft/lb_f-sec^2)
G Gain
GA Gain Accuracy
GAF Gain Adjustment Factor
GAFT Gain Adjustment Factor (Total); Group As-Found Tolerance
GBA Growth-Based (core instability detection) Algorithm (a portion of OPRM ODA)
GEASC GE Advanced Setpoint Calculation
GEITAS GE Instrument Trending Analysis System
gen generic

ATTACHMENT 1
UNIVERSAL GLOSSARY

GESET GE Setpoint Evaluation Tool
GETAB GE Thermal Analysis Basis
GETARS GE Transient Analysis Recording System
GNWS Group Notch Withdrawal Sequence
gpm gallons per minute
GRBA Growth Rate-Based (core instability detection) Algorithm (a portion of OPRM ODA)
GS Gain Stability
h height
H Hysteresis; Heise (calibration tool); overall elevation differential
HE Humidity Effect; Harsh Environment (for EQ)
HELB High Energy Line Break
HHM hand-held monitor
hp high pressure (e.g., turbine)
HPCI High Pressure Coolant Injection (System)
HPCS High Pressure Core Spray (System)
HPSP High Power Setpoint
HTE Harsh Temperature Effect
HTSP High Trip Setpoint
HVAC Heating, Ventilating, and Air-Conditioning
HVPS High-Voltage Power Supply
hr hours
h_w effective differential pressure (in WC)
Hz hertz
H_2O water
I&C Instrumentation and Control
ICD Ion Chamber Detector; Interface Control Drawing
ICF Increased Core Flow
ICPS Ion Chamber Power Supply
ICS Integrated Computer System
ID inside diameter
IDCCSIP inside diameter of the condensing chamber steam inlet pipe
IDS Instrument Data Sheet
IEEE Institute of Electrical and Electronic Engineers
IEC International Electro-technical Commission
IED Instrument Engineering Diagram
IIR Infinite Impulse Response (filter for STP)
IISCP Improved Instrument Setpoint Control Program
in (or ") inches
ind indicator
in HgA inches of mercury (absolute)
INPO Institute of Nuclear Power Operations
in WC inches of water column

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I/O	Input/Output
IPM	Integrated Plant Model
IPSP	Intermediate Power Setpoint
IRA	Insulation Resistance Accuracy Error
IRM	Intermediate Range Monitor
IS	Instrument Setting
ISA	Instrument Society of America
ISO	International Standards Organization
isol	isolation
ISP	Instrument Surveillance Procedure
ITS	Improved Tech-Spec
ITSP	Intermediate Trip Setpoint
I/V	Current-to-Voltage Convertor
I&TU	indicator & trip unit
IWD	Interconnection Wiring Diagram
I0	instrument zero
JP	Jet Pump
k	kilo (E+03;10^3); isentropic exponent
K	Flow Coefficient; flow uncertainty correction factor; constant
kg	kilograms
l	liter
L	Level; Linearity
LA	Loop Accuracy
LACT	level actual
LAFT	Loop As-Found Tolerance
LAL	Lower Analytical Limit
LALT	Loop As-Left Tolerance
LAT	Leave-Alone Tolerance
LAZ	Leave-Alone Zone
lb_f	pound-force
lb_m	pound-mass
LCD	lowest common denominator
LCO	Limiting Condition for Operation
LCR	Loop Calibration Report; Logarithmic-Count Rate
LD	Level Device; Loop Drift
LDM	Leak Detection Monitor (NUMAC)
LDS	Leak Detection System
LDT	Line Designation Table
LE	Load Effect
LER	Licensee Event Report
LFMG	Low-Frequency Motor-Generator
LGAF	LPRM Gain Adjustment Factor

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LI level indication (e.g., water level)
LIMAX level indication maximum (e.g., water level, synonymous with TOS)
LIMIN level indication minimum (e.g., water level, synonymous with BOS)
LISPAN level indication span
LI0 level instrument zero
LLLA Load Line Limit Analyses
LLS Low-Low Set (S/RV)
LMG Level Meter Group
LMR Liquid Metal Reactor
LMRL Lower Meter Reading Limit
LOCA Loss-of-Coolant Accident
lp low pressure (e.g., turbine)
LPAP Low Power Alarm Point
LPCI Low Pressure Coolant Injection (mode of RHR)
LPCS Low Pressure Core Spray (System)
LPRM Local Power Range Monitor
LPSP Low Power Setpoint
LRDRM Liquid Radwaste Discharge Radiation Monitor
LRES Liquid Radwaste Effluent System
LRM Logarithmic Radiation Monitor
LSB Least-Significant Bit
LSD Least-Significant Digit
LSL Licensing Safety Limit (Tech-Spec channel, bounds AL)
LSSS Limiting Safety System Setting
LT Level Transmitter
LTR Licensing Topical Report
LTS Long-Term Stability
LTSP Low Trip Setpoint
LU Loop Uncertainty
LVE Line Voltage Error
LVPS Low-Voltage Power Supply
m mass flow rate; meters; milli (E-03;10^{-3}); months (surveillance interval); overall component (sigma) of statistical adjustment
M Metrology Lab; mega (E+06;10^{6}); months (surveillance interval); margin
M ratio $(\bar{W}_t/W_d) - 1$
mA milliamps d-c
max maximum
MAZE maximum-acceptable zero error
mbar millibar
MCPR Minimum Critical Power Ratio
MCR Main Control Room
MELLLA Maximum Extended Load Line Limit Analyses

ATTACHMENT 1
UNIVERSAL GLOSSARY

MEOD Maximum Extended Operating Domain
min minimum; minutes
ml milliliter (synonymous with cc)
mm millimeters
MM multi-meter
MPL Master Parts List
Mrad megarads gamma (E+06 rads;10^6 rads)
MSIV Main Steam Isolation Valve
MSL Main Steamline
MSLB Main Steamline Break
MSLRM Main Steamline Radiation Monitor
MSR Moisture Separator Reheater
MST Main Steam Tunnel; Maintenance Surveillance Test
MSV Mean Square Voltage
MTBF Mean Time Between Failure
MTE Maintenance & Test Equipment
MTTR Mean Time to Repair
mV millivolts d-c
MVD Multi-Vendor DAS
MVP Mechanical Vacuum Pumps
MW_e Megawatts-electrical
MW_t Megawatts-thermal
n the number of standard deviations (sigma) used (individual component); sample size
N population size; System Noise
N/A, n/a not applicable; not available
NBR Nuclear Boiler Rated
NBS Nuclear Boiler System; National Bureau of Standards (archaic)
NC normally closed
NED Nuclear Engineering Department
negl negligible
NEMA National Electrical Manufacturers Association
NF Neutron Flux
NIST National Institute of Standards and Technology (formerly NBS)
NL,N/L No Limitation
NMS Neutron Monitoring System
NO normally open
NOP not-on-peg
norm normal
NPS nominal pipe size
NR Narrow Range
NRC Nuclear Regulatory Commission
NSSI Nuclear Steam Supply Interface

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NSSS Nuclear Steam Supply System
NS^4 Nuclear Steam Supply Shutoff System
NTSP Nominal Trip Setpoint
NUMAC Nuclear Measurement Analysis and Control
NUREG Nuclear Regulation
nv Neutron Velocity (flux)
NVRAM non-volatile RAM
nvt Time-Integrated Neutron Flux
NWL Normal Water Level
O Offset
OCF Overlap Correction Factor
ODA Operator Display Assembly; Oscillation Detection Algorithm (synonymous with SA)
OE Other Error
OL Operational Limit
OLM Operating License Manual
OLMCPR Operating Limit MCPR
O&MI Operation and Maintenance Instructions
OOS out-of-service
OPE Overpressure Effect
OPIC Overall Procedure for Instrument Calibration
OPL Operating Parameters for Licensing
OPL-3 OPL covering Transient Protection Parameters Verification
OPL-4 OPL covering ECCS Parameters Verification
OPL-4A OPL covering Containment Analyses Input Parameters Verification
OPL-5 OPL covering Single Failure Evaluation
OPRM (thermal-hydraulic) Oscillation Power Range Monitor (reactor core instability)
ORE Observer Readability Error [accounts for parallax; typically half the minor division on the linear (e.g., indicator/recorder) scale, other than e.g., meniscus, tape measure]
OTS On-The-Spot (change)
p pressure; pico (E-12;10^{-12})
P power
P0 Plant Zero
PBA Period-Based (core instability detection) Algorithm (a portion of OPRM ODA)
PC Process Computer
PCI PRNM Communication Interface
PCIS Primary Containment Isolation System
PCT Peak Clad Temperature
PD Process Diagram
PDIS Pressure Differential Indicating Switch
PDS Product Data Sheet
PDT Pressure Differential Transmitter
PE Position Effect; Primary Element (can also mean PE Error)

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PEA Primary Element Accuracy
P/FM Power/(Core) Flow Map
PG Pressure Gauge
PHD Pulse Height Discriminator
PIC portable indicating controller
P&ID Piping and Instrumentation Diagram
PIS Pressure Indicating Switch
PLA Point Log and Alarm
PLC Programmable Logic Controller
PME Process Measurement Error
PMI Plant Monitoring Instrumentation
PMP Preventive Maintenance Procedure
POP Percent of Point
PPC Plant Process Computer
PPD Purchase Part Drawing
PRM Process Radiation Monitor; Power Range Monitor
PRMS Process Radiation Monitoring System
PRNM Power Range Neutron Monitor
PROM Programmable Read-Only Memory
PS Pressure Switch
PSA Proabilistic Safety Assessment
PSE Power Supply Effect
PSH Pressure Switch (High)
psia pounds per square inch (absolute)
psid pounds per square inch (differential)
psig pounds per square inch (gauge)
PSL Pressure Switch (Low); Process Safety Limit (non-Tech-Spec channel)
pt point
PT Pressure Transmitter
PTDR Pneumatic Time-Delay Relay
PU Power-Uprate
q flow rate (generally volumetric, although sometimes mass)
Q Quantizing Error; RL margin; Recirculation Flow
QLVPS Quad Low-Voltage Power Supply
R rem; Repeatability; Rosemount (transmitter)
RA Reference Accuracy
RAD rads gamma
RAM Random-Access Memory
rb reactor building
RB Rod Block; Reactor Building
RBM Rod Block Monitor
RBVRM Reactor Building Vent Radiation Monitor

ATTACHMENT 1
UNIVERSAL GLOSSARY

rc range code
RCE Readability and Calibration Equipment (Effect)
RCIC Reactor Core Isolation Cooling (System)
RCIP Reactor Capacity Improvement Program (i.e., power uprate)
RC&IS Rod Control & Information System
RCP Rod Control Program
RCPB Reactor Coolant Pressure Boundary
RCS Reactivity Control Systems; Reactor Coolant System
RCTP Rated Core Thermal Power
Rd Readability Error (half the minor scale division)
RD Reset Differential
RDA Rod Drop Accident
RDD Rod and Detector Display
rdg reading
Re_d Reynolds number based on d
Re_D Reynolds number based on D
RE Radiation Effect; Readability Error
rec recorder
REE RFI/EMI Effect
ref pertaining to reference leg; reference
Ref Reference
rem roentgen equivalent man
REP Reactor Engineering Procedure
Repro Reproducibility
Res Resolution
rev revision
RFI/EMI Radio Frequency/Electro-Magnetic Interference
RFM Recirculation Flow Monitor
RG Regulatory Guide
RHR Residual Heat Removal (System)
RI Readability (of the) Indicator (synonymous with ORE)
RIC remote indicating control
RIPDs Reactor Internal Pressure Differentials
RL Required Limit
RLA Reload Licensing Analyses
RLP Reference Leg Penetration
RM Relief Mode (S/RV)
RMCS Reactor Manual Control System
RMS Root Mean Square
R/O (Rosemount trip unit calibration) Read-Out Assembly (calibration tool)
ROM Read-Only Memory
ROU Relay Output Unit

ATTACHMENT 1
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RPCS Rod Pattern Control System
RPIS Rod Position Information System
RPS Reactor Protection System
RPT Recirculation Pump Trip
RPV Reactor Pressure Vessel
RPV0 Reactor Pressure Vessel Zero (Vessel Invert)
RRCS Redundant Reactivity Control System
RRS Reactor Recirculation System
Rs Resolution
RS Random Span Effect
RSCS Rod Sequence Control System
RSD Reactor Steam Dome
RSDP Remote Shutdown Panel
RTI Referred-To-Input
RTO Referred-To-Output
RWCU Reactor Water Cleanup (System)
RWE Rod Withdrawal Error
RWL Rod Withdrawal Limiter; Rx Water Level (process condition)
RWM Rod Worth Minimizer
Rx Reactor
RZ Random Zero Effect
s seconds; sigma (standard deviation); steam
S Sensitivity
SA Setpoint Accuracy (a term found in some calibration procedures); Stability Algorithm (either ABA, GRBA, or PBA of OPRM; synonymous with ODA)
SAR Safety Analyses Report
sat saturated
SBO Station Blackout
S&C sensor & converter
SCIS Secondary Containment Isolation System
SCS Significant Change Summary (ERIS)
SDDF Supplier's Document Data Form
SE Seismic Effect
SEHR Special Emergency Heat Removal
SEIS Seismic Effect
SER Safety Evaluation Report; System Evaluation Report
sec seconds
SGTS Standby Gas Treatment System
SIL Services Information Letter
SL Safety Limit
SLMCPR Safety Limit MCPR
SLO Single-Loop Operation

ATTACHMENT 1
UNIVERSAL GLOSSARY

SM	Setpoint Margin; Safety Mode (of S/RV)
S/N	Serial Number
SP	Calibrated Span; Surveillance Procedure; Setpoint; Special Publication (of NBS)
SPDS	Safety Parameters Display System; Setpoint Data Sheet
SPE	Static Pressure Effect
SPNE	Span Effect
SR	Shutdown Range
SRI	Select Rod Insert
SRM	Source Range Monitor
SRSS	Square Root of the Sum of the Squares
SRU	Signal Resistor Unit
S/RV	(main steam) Safety/Relief Valve
SSA	Safe Shutdown Analyses
St	Stability
ST	Startup Test
STA	Spurious Trip Avoidance
STOL	Setting Tolerance
STP	Surveillance Test Procedure; Simulated Thermal Power (avg NF with 6-sec IIR); standard temperature and pressure (68 F and 1 atm)
sub	subcooled
T	Temperature
t	time
TAF	Top-of-Active-Fuel
T_a	Temperature Change applied to Accuracy
T_d	Temperature Change applied to Drift
tb	turbine building
TBD	to be determined
TC	thermocouple; Temperature Coefficient
tc	time constant
TCIU	Thermocouple Input Unit
TCV	(Main) Turbine Control Valve
td	time delay
TDR	Time-Delay Relay
TDU	Total Device Uncertainty
TE	Temperature Effect; Temperature Element; Trip Environment
TEC	Temperature Equalizing Column
TEF	Temperature Effect Factor
TFSP	Turbine First-Stage Pressure
THP	Time History Plot (ERIS)
TID	Total Integrated Dose (gamma equivalent)
TIP	Traversing In-core Probe
TLD	Test-Loop Diagram

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TLO Two-Loop Operation
TLU Total Loop Uncertainty
TOPPS Tracking Overpower Protection System
TOS top-of-scale
TRA Transient Recording and Analyses
TRAPP Transient Protection Parameters
TrE Trigger Error
TRF Trip Reference Function
TRK Uncertainty due to APRM Tracking
TRM Technical Requirements Manual
TS Technical Specification (Tech-Spec)
TSV (Main) Turbine Stop Valve
TT Temperature Transmitter
TTA Tabular Trend Analysis (ERIS)
turb turbine
u micro (E-06;10^{-6})
UAL Upper Analytical Limit
UMRL Upper Meter Reading Limit
UFN Uncertainty due to Flow Noise
UNL Uncertainty due to Sensor Nonlinearity
UNN Uncertainty due to Neutron Noise
UR Upper Range-Limit; Upset Range
URL Upper Range-Limit
USNRC United States Nuclear Regulatory Commission
USS Uncertainty due to Sensor Sensitivity
v specific volume [e.g., superheated steam, compressed (subcooled) water]
v_f specific volume of saturated water
v_{fg} specific volume of evaporation
v_g specific volume of saturated steam
VA Vendor Accuracy
vac vacuum
Vac volts a-c
var pertaining to variable leg
VD Vendor Drift
Vdc volts d-c
VE Vibration Effect
V/I Voltage-to-Current Convertor
VLN Variable Leg Nozzle (tap)
VLP Variable Leg Penetration
VM voltmeter
VOM volt-ohm meter
VWO (Main Turbine) Valves Wide Open

ATTACHMENT 1
UNIVERSAL GLOSSARY

w	water; with
W,W_d	recirculation drive flow
W_t	coolant core flow
w/o	without
WC	water column [instrument reference condition (at 68 F and 1 atm)]
WR	Wide Range
WRM	Wide Range Monitor
WRNM	Wide Range Neutron Monitor
W&T	Wallace & Tiernan (calibration tool)
WTE	Warmup Time Effect
X	(Setpoint - Instrument Zero)/Calibrated Span (term in xmtr radiation effect algorithm)
xmtr	transmitter
XPU	Extended Power Uprate
XRL	RL drift margin (synonymous with Q)
Y	Calibrated Span/Upper Range-Limit (term in xmtr temperature effect algorithm)
Y_a	frictionless adiabatic isentropic expansion factor, inlet to throat (ratio of compressible fluid flow to incompressible fluid flow)
Z	Measure of Margin in units of Standard Deviations
ZPA	Zero-Period Acceleration
ZS	Zero Stability
----------	***end English, begin Greek***
β	ratio of diameters (d/D)
Δ	delta; differential
ε	period tolerance (of PBA)
γ	isentropic exponent; specific weight [(weight) density]
κ	flow uncertainty correction factor
μ	micro (E-06;10^{-6}); absolute (dynamic) viscosity
ν	kinematic viscosity
ρ	(mass) density
σ	sigma; standard deviation
τ_{c1}	RBM signal filter time constant (adjustable, optional)
$\sqrt{}$	square root extractor (also called square root converter)
Σ	summer
Ω	ohms

END