Docket No. 50-271
BVY 03-115

Attachment 2

Vermont Yankee Nuclear Power Station

Technical Specification Proposed Change No. 257

Calculation VYC-0693A – APRM Neutron Monitoring Trip Loops

VY CALCULATION TITLE PAGE

VYC-0693A	2	N/A	N/A
VY Calculation Number	Revision Number	Vendor Calculation Number	Revision Number

Title: APRM Neutron Monitoring Trip Loops

QA Status: ☒ SC ☐ NNS ☐ OQA   Operating Cycle Number* N/A

* The Operating Cycle Number should only be entered here if the results of the calculation only apply during a specific operating cycle otherwise enter "N/A".

Calculation Supports A Design Change/Specification? ☒ Yes ☐ No   MM 2003-028
VYDC/MM/TM/Spec No.

Implementation Required? ☑ Yes ~~☒ No~~ JG 12/2/03   Calculation Done as a Study Only? ☐ Yes ☒ No

Safety Evaluation Number: N/A

Superseded Calculation Number, Title and Revision: VYC- 693A Rev. 1 APRM Neutron Monitoring Trip Loops

For Revisions: List CCNs, IIJs, or SAs incorporated/superseded by this revision:

Computer Code(s): N/A

Are there open items in this calculation/revision? ☐ Yes ☒ No

Review and Approval: (Print and Sign Name)

Preparer: Jerry Voss *Jerry D. Voss* Date: 11/18/2003

Interdiscipline Reviewer(s): See Attachment 7.7 Date:

Independent Reviewers(s Kirk Melson *Kirk Melson* Date: 11/19/2003

Approved: JG R.T. VIBERT / *R.T. Vibert* Date: 12/2/03

Accepted (only for AP 0017 calculations performed by vendors) ☒ N/A

Date:

Final Turnover to DCC (Section 2):

1) All open items, if any, have been closed.

2) Implementation Confirmation (Section 2.3.4)   Total No. Pages in Package (including attachments)

☐ Calculation accurately reflects existing plant configuration, (confirmation method indicated below)

☐ Walkdown ☐ As-Built input review ☐ Discussion with (Print Name)

OR

☐ N/A, calculation does not reflect existing plant configuration

3) Resolution of documents identified in the Design Output Documents Section of VYAPF 0017.07 has been initiated as required (Section 2.3.6, 2.3.7)

Printed Name / Signature / Date

Page 1 of ______ Pages*

* For calculations performed using AP 0017 this is the number of pages in the body of the calculation. For vendor calculations, this is the number of pages of AP 0017 forms added. (Title page, review forms, data sheets, 50.59, etc.)

VY CALCULATION DATABASE INPUT FORM

Place this form in the calculation package immediately following the Title page or CCN form.

VYC-693A	2	N/A	N/A
VY Calculation/CCN Number	Revision Number	Vendor Calculation Number	Revision Number

Vendor Name:________________________ PO Number:

Originating Department:

Critical References Impacted: ☐ UFSAR ☐ DBD ☐ Reload. "Check" the appropriate box if any critical document is identified in the tables below.

EMPAC Asset/Equipment ID Number(s):

EMPAC Asset/System ID Number(s):

Keywords:

For Revision/CCN only: Are deletions to General References, Design Input Documents or Design Output Documents required? ☐ Yes† ☒ No

Design Input Documents and General References - The following documents provide design input or supporting information to this calculation. (Refer to Appendix A, sections 3.2.7 and section 4)

* Reference #	** DOC #	REV #	***Document Title (including Date, if applicable)	Significant Difference Review ††	**** Affected Program	Critical Reference (✓)
6.15	GE-NE-0000-0012-0531-01-01	1	May 2003 Project Task Report "Entergy Nuclear Operations Incorporated Vermont Yankee Nuclear Power Station ARTS/MELLLA" Task T0506: NSSS TS Instrument Setpoints.	N/A	N/A	
6.16	GE-NE-0000-0016-5688-01	0j	August 2003 Project Task Report "Entergy Nuclear Operations Incorporated Vermont Yankee Nuclear Power Station Extended Power Uprate" Task T0506: NSSS TS Instrument Setpoints.	N/A	N/A	
6.27	VYC-0690	2	Recirculation Flow Loop Uncertainties to APRM			
6.29	NEDC-33089P		"Vermont Yankee Nuclear Power Station APRM/RBM/Technical Specifications Maximum Extended Load Line Limit Analysis (ARTS/MELLLA)," March 2003			
6.30	NEDC-33090P	0	"Safety Analysis Report for Vermont Yankee Nuclear Power Station Constant Pressure Power Uprate," September 2003			
6.26	OP-2429	14	Recirculation Flow System Baseline Data Collection and Instrument Calibration.			
6.17	GE Performance Specification 25A5903	1	"Flow Control Trip Reference (FCTR) Card".			
6.31	BVY 03-23	0	March 20, 2003, Technical Specification Proposed Change No. 257 Implementation of ARTS/MELLLA at VY.			
6.32	BVY 03-80	0	September 10, 2003, Technical Specification Proposed Change No. 263 Extended Power Uprate.			

Design Output Documents - This calculation provides output to the following documents. (Refer to Appendix A, section 5)

* Reference #	** DOC #	REV #	Document Title (including Date, if applicable)	**** Affected Program	†††Critical Reference (✓)
6.25	OP 4308	21	APRM Monitor Calibration.		

* Reference # - Assigned by preparer to identify the reference in the body of the calculation.

** Doc # - Identifying number on the document, if any (e.g., 5920-0264, G191172, VYC-1286)

*** Document Title - List the specific documentation in this column. "See attached list" is not acceptable. Design Input/Output Documents should identify the specific design input document used in the calculation or the specific document affected by the calculation and not simply reference the document (e.g., VYDC, MM) that the calculation was written to support. If a DBD is used as a general reference, include the most current interim change number after the title.

**** Affected Program - List the affected program or the program that reference is related to or part of.

† If "yes," attach a copy of "VY Calculation Data" marked-up to reflect deletion (See Section 3.1.8 for Revision and 5.2.3.18 for CCNs).

†† If the listed input is a calculation listed in the calculation database that is not a calculation of record (see definition), place a check mark in this space to indicate completion of the required significant difference review. (see Appendix A, section 4.1.4.4.3). Otherwise, enter "N/A."

††† If the reference is UFSAR, DBD or Reload (IASD or OPL), check Critical Reference column and check UFSAR, DBD or Reload, as appropriate, on this form (above).

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Rev. No.	Approval Date	Reason & Description of Change
0		Initial issue, Reflects new methodology described in Instrument Uncertainty and Setpoints Design Guide, Rev. 0 This sub-calculation (VYC-693A) only addresses the associated trips, with the analog output uncertainties remaining in the parent calculation (VYC-693).
1		Revised to allow the use of N=44 in the RBM flow bias equation (Setpoint $\leq$ 0.66(W-ΔW) + N), and to reflect the use of M&TE to set the Flow Bias value in testing the RBM rod blocks. References to any specific operating cycle or COLR report were removed since this calculation is valid for any cycle where the value of N is between 42 and 44.
2		Incorporated VYC-693A CCNs 1, 2, 3 and 4. CCN 2 attachment M and table revisions had no impact on this revision of the calculation since the CCN was based on the flow bias equations used prior to ARTS/MELLLA or EPU. This revision includes the Analytical Limits and calculates Allowable Values (ITS) Trip Setpoints and As-Found Tolerances (CTS) to support ARTS/MELLLA and EPU. The APRM Rod Blocks have been removed from the Technical Specifications. The Rod Block Monitor has been maintained in Technical Specifications; However, the Rod Block Monitor will be treated as an indicated value (without instrument error) for settings.

1. PURPOSE

1.1 Calculation Objectives

This calculation has been developed in support of the Vermont Yankee Setpoints program and covers the APRM/LPRM (Average Power Range Monitor/Local Power Range Monitor) neutron monitoring loops. This calculation has the following major objectives:

1) Document the instrument loop functions and the basis for the setpoints and operator decision points associated with those functions.

2) Establish the total loop uncertainty for each increasing[1] Setpoint and verify consistency with the design basis

3) Calculate the limiting setpoints and operator decision points.

4) Evaluate the adequacy of existing Setpoint Administrative Limits and procedural decision points.

5) Provide As-Left and As-Found tolerances for use in instrument calibration and functional test procedures. Verify and document process corrections, instrument scaling, and calibration methods. The errors determined in this calculation are based on the vendor defined operating characteristics.

6) This calculation does not include evaluations of the analog indicators or recorder functions. The accuracy of the trip functions determined by this calculation will be used as input for generic evaluations for alarm response, operating procedures, off normal operating procedures and EOP impact.

[1] Low (decreasing) setpoints are not reviewed. They are indicative of a gross failure. Therefore, it is not necessary to determine uncertainty.

1.2 System and Components

This calculation applies to the Power Range Monitoring Instrumentation of the Neutron Monitoring System. The specific components to be addressed are:

Table 1: System Components

REF.	TAG NUMBER	RACK/ CABINET	SYS	DESCRIPTION	MFG.	MODEL NO.	CWD
6.18	ND-2-1-104 (80 items)	In-Core	NM	LPRM Detector	GE	N/A	674, 675
6.18	LPRM	9-14	NM	Local Power Range Monitor	GE	135B9824G2	676, 676A, 677, 677A
6.18	APRM A, C, E, B, D, F	9-14	NM	Average Power Range Monitor	GE	920D453G1 920D453G2	678, 679, 680, 688, 692, 693

1.3 Instrument Loop Function

Attachment A has a simplified loop diagram of the instruments and components described below.

1.3.1 Normal Operations

During normal operation the APRMs provide the control room operators with indications of the average reactor power from about two percent to 125 percent via recorders on the operators console. This analog information is also provided to the plant computer. In addition, the APRMs are capable of generating trips when various conditions are exceeded. These trips are:

- Scram on APRM Upscale
- Scram on APRM Downscale (Run Mode)
- Scram on APRM Inoperative
- Scram on APRM Upscale when the RMSS is not in Run (Reduced)
- Rod Block on APRM Upscale
- Rod Block on APRM Downscale
- Rod Block on APRM Upscale when the RMSS is not in Run (Reduced)

During normal operation the RBMs provide the control room operators with indications of the local average power immediately surrounding a control rod that has been selected for withdrawal. The RBM promotes controlled rod withdrawal by issuing rod withdrawal block signals if the reactor operator does not respond correctly to prompts requiring operator action. The RBM issues rod withdrawal block signals on:

- RBM Upscale
- RBM Downscale

The Rod Blocks associated with APRM and the Rod Block Monitor are not credited for plant protection. The APRM Rod Blocks have been removed from Technical Specifications (and placed in the VY Technical Requirements Manual The Rod Block Monitor is maintained in Technical Specifications; however, the setting for the RBM is treated as an indicated values (without instrument error applied to the setting). Therefore, only the APRM trips will be evaluated in this calculation.

The purpose of the APRM flow biased rod block function is to avoid a condition that would require Reactor Protection System action if allowed to proceed. The APRM flow biased rod block setting is selected to initiate a rod block before the APRM high neutron flux scram setting is reached. The APRM flow biased rod block setpoint value listed in the TRM is the maximum nominal trip setpoint allowable. Calibration tolerances have been established for this setpoint that will render the setpoint acceptable above or below the nominal value. The uncertainty associated with the difference between the APRM flow biased scram and rod block functions is limited to the uncertainty associated with the trip circuitry. Common equipment (such as detectors, LPRMs, flow input and averaging circuits) will affect both functions equally.

VY has implemented long-term thermal hydraulic stability solution Option I-D. Option I-D is only applicable to plants that can demonstrate that core wide mode instability is the predominant mode and regional mode instability is not expected. Solution application includes demonstrating that the APRM High Flux (Flow Bias) scram line, considered an analytical limit, provides adequate Safety Limit MCPR protection.

1.3.2 Functions During an Accident

The APRMs are assumed to provide the scram initiation signal (120 % power) for the mitigation of the Control Rod Drop Accident, which, according to Reference 6.4, Section 14.6.2, is only of concern when the reactor is operating at less than the RWM Low Power Setpoint (LPSP).

1.3.3 Post-Accident or EOP Functions

The APRMs are not required for Post Accident Functions. The APRMs applicability to the EOPs will be addressed outside of this calculation.

2 METHODS AND ASSUMPTIONS

This Calculation has been prepared in accordance with the Governing Procedures and Programs listed in step 2.1. Standard methods employed in this calculation are explained in the "Vermont Yankee Instrument Uncertainty and Setpoints Design Guide" [Ref.6.1]. This calculation is performed using the Class 1 graded approach since one of the functions (reactor scram) performed by the APRM loops is classified as Class 1, Nuclear Safety Related.

2.1 Governing Procedures and Programs

2.1.1 Vermont Yankee Instrument Uncertainty and Setpoints Design Guide. (Ref. 6.1)

2.1.2 Vermont Yankee Engineering Procedure, AP-0017, Calculations and Analyses (Ref. 6.9).

2.2 Criteria

2.2.1 Analytical Limits and Technical Specification Limits

The Analytical Limits (AL) for the APRM Scram Flow Bias and Fixed trip are established per the Rod Drop Accident and Core Stability Analysis, and are defined in Ref. 6.15 for ARTS/MELLLA conditions and 6.16 for Extended Power Uprate conditions. This AL value will be used to establish Limiting Setpoints (LSp) and an Allowable Value (AV) for use in the Technical Specifications (TS) as discussed below.

This calculation will use ISA-S-67.04.02 Method 1 for combination of errors to determine a Trip Setpoint and an Allowable Value for Technical Specification values associated with APRM Flow Bias and Scram setpoints. The Limiting Trip Setpoint and the Allowable Value for a process increasing to a limit will be calculated as follows:

AV	=	AL-effective uncertainty for all devices and errors not confirmed during surveillance testing.
LSp	=	AV - effective uncertainty for testing conditions, including devices tested only.
LSp	<	$AV - (CT_1 + CT_2 + CT_n)$ Confirmation of margin between LSp and AV.

All terms are as currently defined in the VY Setpoint Design Guide.

2.2.2 Numerical combinations for the calculations of instrument error, calibration error, loop error, effective error and other associated values have been calculated using Microsoft Excel. Representative calculations in Attachment(s) B were manually verified using a hand calculator, Microsoft Excel stores numbers with at least 15 digits of accuracy, all calculation outputs displayed within this calculation are rounded from the values stored by Excel. Rounding errors induced by Excel are assumed to be negligible within this calculation.

2.2.3 No errors were found in the manual verification of the calculations performed with the Software in Attachment B. Physical evidence of the review is provided by check marks or other indications next to each verified calculation. Where multiple calculations are generated by copying cells or formulas selected samples have been verified.

2.2.4 Technical Specification Table 4.1.2 requires the performance of a Heat Balance, for calibration of the APRM output signal, once every 7 days. The calibration of the APRMs to Core Thermal Power (CTP) is performed under OP-4400. As a part of this procedure, the individual APRM gains are adjusted such that the individual APRMs read conservatively to the adjusted % rated CTP (+2, -0%).

The adjustments made to the APRM gains automatically compensate (normalize) the LPRM detector/amplifier output signal. Therefore, since the heat balance is perfomed every 7 days, the amount of LPRM drift that needs to be considered is only 8 days (7 days + 25% extension). The current LPRM drift value is valid for 700 hours. However, since there is insufficient information to estimate the reduction in this drift value for 8 days, the 700 hour drift value will be used in the calculation.

2.2.5 Primary Element Accuracy (PEA)

APRM Channel

PEA is a combination of sensor sensitivity and sensor non-linearity uncertainties. The sensitivity of the detectors decreases with neutron fluence. From Reference 6.13, Section 4.5, the average sensitivity loss, and its 2-sigma variation, for all GE LPRM detectors has been determined to be:

Sensor Sensitivity Loss = -0.33% (bias term)
±0.20% (random term)

The detector non-linearity and its 2 sigma variation (in the power range) has been determined to be:

Sensor Non-linearity = -0.49% (bias term)
±1.0% (random term)

The first part of these detector errors represent bias type errors which apply to all detectors, whereas the second part are random errors that represent variability amongst sensors. Assuming a worst case scenario where the APRM has the minimum number of operational detectors, the PEA, which on a percent of power basis is simply obtained by adding the bias terms and taking the SRSS of the random terms, is calculated below. In the calculation, the random error is reduced by the square root of the minimum number of operable LPRMs to one APRM channel which is 9 per Reference 6.7, Table 3.1.1, Note 5.

$$PEA = (0.33 + 0.49) \pm \left(\frac{1}{\sqrt{9}}\right)\left(\sqrt{(0.20^2 + 1^2)}\right)$$

$$PEA = -0.82 \pm 0.34\% RP$$

2.2.6 Process Measurement Accuracy (PMA)

APRM

PMA is a combination of APRM tracking error and the uncertainty due to neutron noise. From Reference 6.4, Section 14.5.1.3.1, the most severe event for which the APRMs are assumed to provide the scram signal is the Closure of All Main Steam Line Isolation Valves with failure of the valve position scram. Reference 6.13, Section 4.5 states that for the MSIV closure transient event, the APRM tracking error is 1.11% and the uncertainty due to neutron noise is typically 2.0%. The tracking error is the uncertainty of the maximum deviation of APRM readings with LPRM failures or bypasses during a power transient. The neutron noise is the global neutron flux noise in the reactor core with a typical dominant

frequency of approximately 0.3 to 0.5 Hertz and typical maximum peak-to-peak amplitude of approximately 5 to 10 percent.

$$PMA = \sqrt{(2.0^2 + 1.11^2)} = 2.29\% RP$$

2.2.7 The Flow Control Trip Reference Card (FCTR) for the APRM fixed and flow biased scrams is being replaced. The replacement card is designed to operate with a 1% maximum error signal and 0.1% timing accuracy (Ref. 6.17). The 1% error signal includes both device accuracy and drift for a 36-month interval. General Electric has provided additional information (Attachment 7.7) indicating that the reference accuracy (or setting tolerance) for the FCTR is 0.5% of calibrated span.

Control Room (CR) Indication (FI-2-159A, B and FR-2-154) is scaled for a flow rate of 0-41,800 GPM. Rated Recirculation Drive Flow (100%) is defined as the required Drive Flow to achieve 48 MPPH (Reference TS 2.1.A.1.a). Such things as core design, changes in core and piping resistance, jet pump fouling, etc, affect the relationship between Core Flow and Drive Flow. Therefore, since the rated recirculation drive flow value could change, the percentage of rated flow for CR flow indication will vary. OP 2429 normalizes the total recirculation drive flow (output of summers FSUM-2-110A&B) such that the input to the APRM system is 125% of rated flow (as determined by OP 2429). This is consistent with functional testing of the APRM Flow Bias Setpoints and flow indication obtained from the APRM system (chosen via selector switch). Because of this normalization the spans between the drive flow input (VYC-690 errors) and the core flow input are assumed to be equal.

2.2.8 Technical Specification Table 4.1.2 requires the performance of a heat balance, for calibration of the APRM output signal, once every 7 days. The calibration of the APRMs to Core Thermal Power (CTP) is performed under OP 4400. The procedure begins by the calculation of CTP by performing an energy balance on the Nuclear Boiler System. Next, % rated CTP is determined (CTP/Rated CTP MWth * 100). Then % rated CTP is divided by the applicable scale factor to find the adjusted % rated CTP. Finally, the individual APRM gains are adjusted such that the individual APRMs read conservatively to the adjusted % rated CTP (+2, -0%). The adjustments made to the APRM gains automatically compensate (normalize) the LPRM detector/amplifier output signal. Therefore, since the heat balance is performed every 7 days, the amount of LPRM drift that needs to be considered is only 8 days (7 days + 25% extension). The uncertainty associated with the heat balance (2% of Reactor Power) is included in the transient analysis (REF. 6.19). Therefore, this uncertainty is not included in this uncertainty calculation.

2.2.9 Calibration tolerance for reactor flow biased power settings are + 0.5% CS or (0.625% RP). The tolerances for trips are $\pm$0.4% CS (0.5% RP) per Ref. 6.25 and 6.23.

2.3 Assumptions

2.3.1 Calibration of instruments is assumed to be at a temperature within the ranges shown in the following table.

Table 2: Plant Area(s)		
Plant Area	**Minimum**	**Maximum**
Control Room	60 °F	80 °F

2.3.2 The temperature variation within a cabinet is the same as the variation of the room in which it is located. The temperature difference between the room and the cabinet is therefore constant. Calibration data are collected with the equipment at the operating temperature of the cabinet.

2.3.3 The vendor does not state a separate value for Humidity Effect (HE). Therefore, it is considered to be included in the accuracy and drift terms.

2.3.4 OP4305 does not give a tolerance for setting the value of the flow signal, because the flow signal is adjusted as close as possible using M&TE. This calculation assumes that only M&TE with a total accuracy of better than 0.25% of reading will be used to adjust the flow signal. Therefore, this uncertainty is assumed to be 0.25 %. This 0.25 % will be combined with the random portion of the VYC-690 flow input. This signal error will then be converted to %RP before being combined for each of the different power to flow lines. However, since the M&TE error affects the overall accuracy and the acceptance criteria for the flow bias setpoints, M&TE with accuracy of 0.05% of span will be used for setting the flow signal value.

2.3.5 All of the Power Range Neutron Monitoring System electronic equipment affected by this calculation are located in areas considered to be mild environment (control room). The LPRM detectors are the only components exposed to high radiation and they were designed for this purpose. Therefore, there are no Radiation Effects (RE) applicable to this calculation.

2.3.6 The APRM scrams are not assumed to operate for safe shutdown or for other seismic events. For operational basis earthquakes, this calculation assumes that the APRMs, LPRMs and trip functions will be recalibrated prior to continued operation. Therefore, seismic error for Neutron Monitoring is not considered in this calculation.

2.3.7 Dead Band (DB) or Readability Uncertainty (RD) are only applicable to that portion of a calculation involving indicators and recorders. Therefore, they do not apply to this calculation.

2.3.8 Temperature Effect (TE) is not provided as a separate term by the vendor so it is assumed to be included in one of the given accuracy or drift terms.

2.3.9 The Barometric Pressure Effect (PB) is not applicable to this calculation (Section 3.6.9 of Ref. 6.1).

2.3.10 None of the Process Static Pressure Effects (SP) are applicable to this calculation (Section 3.6.13 of Ref. 6.1).

2.3.11 Power Supply Voltage Effect (VE) is considered to be included in the accuracy and drift terms since the vendor does not give a separate value for VE.

2.3.12 VYC-1758 (Reference 6.20) shows DMM's available to support the APRM calibration with total device error of better than ±0.05% CS (10 VDC Range). Therefore, the SRSS of 2 DMM's required for the calibration per Ref. 6.25 result in an M&TE uncertainty of ±0.071% CS.

2.3.13 The neutron monitoring system is located in the control room with the exception of the sensing devices, which are located in the reactor. Therefore, unless otherwise stated, this calculation will use the set of specifications related to the Control Room environment in Ref. 6.1.

2.3.14 Technical Specification Table 3.1.1 defines the Limit for APRM High Flux Reduced as equal to 15 % RP. This value has been assumed to be the Analytical Limit for this calculation.

3 INPUT DATA

Data used to calculate loop uncertainties, process corrections, setpoints, and decision points are tabulated below with the applicable reference or basis

3.1 Process, Loop Data and Analytical Limits

Presented below are the input values required to calculate the Limiting Setpoints (Analytical Limits and those parameters such as calibration frequency that are common to all loop components).

Table 3: Process Data and Analytical Limits		
Basis	**Description**	**Data**
Ref. 6.3	Process Span (PS)	0 to 125 % RP
	Analytical Limits	
ARTS/MELLLA	APRM High Flux Scram (Two Loop Ops)	
Reference 6.15	Core Flow 0 to ≤ 31.1 %	< 0.4Wd+64.4%
	Core Flow 31.1 to ≤ 54.0 %	< 1.28Wd+37.0%
	Core Flow 54.0 to ≤ 75 %	< 0.66Wd+70.5%
	Core Flow > 75%	Maximum of 120%
	APRM High Flux Scram (Single Loop Ops)	
	Core Flow 0 to ≤ 39.1 %	< 0.4Wd+61.2%
	Core Flow 39.1 to ≤ 61.9 %	< 1.28Wd+26.8%
	Core Flow 61.9 to ≤ 83.0 %	< 0.66Wd+65.2%
	Core Flow >83%	Maximum of 120%
Extended Power	APRM High Flux Scram (Two Loop Ops)	
Uprate (EPU)	Core Flow 0 to ≤ 30.9 %	< 0.33Wd+53.7%
Reference 6.16.	Core Flow 30.9 to ≤ 66.7 %	< 1.07Wd+30.8%
	Core Flow 66.7 to ≤ 99 %	< 0.55Wd+65.5%
	Core Flow > 99%	Maximum of 120%
	APRM High Flux Scram (Single Loop Ops)	
	Core Flow 0 to ≤ 39.1 %	< 0.33Wd+51.1%
	Core Flow 39.1 to ≤ 61.7 %	< 1.07Wd+22.2%
	Core Flow 61.7 to ≤ 119.4 %	< 0.55Wd+54.3%
	Core Flow >119.4	Maximum of 120%
Assumption 2.3.13	APRM High Flux Scram (Reduced)	≤15 % Power

3.2 Environmental Conditions

The following table identifies the limiting environmental conditions expected for each loop instrument.

Table 4: Environmental Input Data		
Basis	**Description**	**Data**
Ref. 6.1, Table 2	Normal Drywell Temperature (Below 270 ft) Normal Reactor Building Temperature (Occupied Area)	160°F 106°F
Ref. 6.5	Normal Radiation	N/A (Assumption 2.2.6)
Ref. 6.6	Accident Radiation	N/A (Assumption 2.2.6)

3.3 Primary Elements ND-2-1-104 Data

Table 5: Primary Element Input Data		
Basis	**Description**	**Data**
Ref. 6.2 Ref. 6.3	Maximum Temperature Nominal Operating Neutron Flux Maximum Operating Gamma Flux Accuracy (PEA)	600°F 1.2×10^{12} to 2.8×10^{14} nv 1.2×10^{9}R/hr See Text

3.4 LPRM Data

Table 6: LPRM Input Data		
Basis	**Description**	**Data**
Ref. 6.2	Accuracy Drift	±0.8% CS ±0.8% CS/700 hrs

3.5 APRM A, B, C, D, E, F, Data

Table 7: APRM Input Data		
Basis	**Description**	**Data**
Ref. 6.11	Averaging Circuitry Accuracy Drift	 ±0.80% CS ±0.5% CS/2 weeks
Ref. 6.33	Trip Circuits (Reduced Scram) Analyzed Drift	 ±0.5% CS/ 3 months (13 weeks)
Ref. 6.11 25A5903 Rev. 1 (Assumption 2.2.19)	Trip Circuits (Flow Biased) Accuracy and Drift	±1.0% CS (0 to 100% flow) valid for 36 months. Timing error not used.
Ref. 6.7 Table 4.1.2 & 4.1.1	Calibration Interval: APRM High Flux Scram Trips LPRM Reactor Heat Balance	 3 months (13 weeks) 2000MWD/T Weekly

3.6 Flow Bias Error Data

The following information is copied or extrapolated from VYC-690 Rev. 2. The accuracy associated with the cardinal flow rates for ARTS/MELLLA and EPU are used in the spreadsheet as an additional error associated with calculation of the APRM setpoints. Errors in VYC-0690 (as listed below) have been calculated based on an assumed maximum total recirculation span of 83,600 gpm (41,800 gpm per loop) to ensure maximum accuracy for recirculation flow indication in the control room. However, the calculation of flow bias for the APRMs is based on an ideal flow of 65,000 gpm (32,500gpm per loop). Therefore to compensate for the difference in reference values for the errors associated with the flow bias a multiplier of 1.286 is used. As discussed in Section 2.2.7, the input into the FCTR is then scaled, during the core flow to recirculation flow verification, to 125% of recirculation flow. This multiplication has been performed in the spreadsheets that perform the detailed calculations for this document. The error is also multiplied by the specific flow correction value (i.e. if the flow formula is 0.33Wd+53.7 EPU 0-39.1% flow, then the random flow error would be multiplied by 0.33) in this same step.

Table 8: Flow Input Errors Two Recirculation Pumps Running		
% Core Flow	Random Error [% Calibrated Span]	Bias Error [% Calibrated Span]
20	0.7266	0.4501
30.9	0.5941	0.2937
31.1	0.5927	0.2919
39.1	0.5513	0.2327
54	0.5143	0.1688
66.7	0.4994	0.1367
75	0.4934	0.1216
83	0.4891	0.1099
99	0.4834	0.0922
119.4	0.4791	0.0764

Table 9: Flow Input Errors One Recirculation Pump Running		
% Core Flow	Random Error [% Calibrated Span]	Bias Error [% Calibrated Span]
20	0.4673	0.1137
37.5	0.4358	0.0608
39.1*	0.434776	0.058368
40	0.4342	0.057
60	0.4277	0.038
61.7 *	0.427428	0.03698
61.9 *	0.427396	0.03686
62.5	0.4273	0.0365

* Values linearly interpolated from VYC-0690 Ref. 6.27

4 CALCULATION DETAIL

The detailed calculations of the APRM loop uncertainties, setpoints, testing tolerances, and margins have been performed using Microsoft Excel spreadsheets and are documented as Attachment B.

5 RESULTS AND CONCLUSIONS

5.1 Allowable Value

The Allowable Value for each required point has been determined and the results are presented in the table below. Since this is a major revision of the method and calculation of Allowable Values and Setpoints no comparison to existing values has been performed.

Table 10: Allowable Values			
Output Instrument	**% RxP**	**mV**	**Curve % RxP**
APRM A, B, C, D, E, F Scram Trips			
ARTS/MELLLA Flow Biased			
APRM High Flux Scram (Two Loop Ops)			
Core Flow 0 to ≤31.1 % (point based on 25% flow)	71.1	5.688	< 0.4Wd+61.10%
Core Flow 31.1 to ≤54.0 % (point based on 50 % flow)	97.3	7.785	< 1.28Wd+33.31%
Core Flow 54.0 to ≤75 % (point based on 70% flow)	113.5	9.078	< 0.66Wd+67.28%
Core Flow > 75%	117.0	9.357	N/A
APRM High Flux Scram (Single Loop Ops)			
Core Flow 0 to ≤39.1 % (point based on 25% flow)	68.1	5.447	< 0.4Wd+58.09%
Core Flow 39.1 to ≤61.9 % (point based on 50% flow)	87.6	7.005	< 1.28Wd+23.56%
Core Flow 61.9 to ≤83.0 % (point based on 70% flow)	108.3	8.664	< 0.66Wd+62.10%
Core Flow > 83.0%	117.0	9.357	N/A
EPU Flow Biased			
APRM High Flux Scram (Two Loop Ops)			
Core Flow 0 to ≤30.9 % (point based on 25% flow)	58.7	4.696	< 0.33Wd+50.45%
Core Flow 30.9 to ≤66.7 % (point based on 50% flow)	80.7	6.458	< 1.07Wd+27.23%
Core Flow 66.7 to ≤99.0 % (point based on 75% flow)	103.6	8.287	< 0.55Wd+62.34%
Core Flow > 99.0%	117.0	9.357	N/A
APRM High Flux Scram (Single Loop Ops)			
Core Flow 0 to ≤39.1 % (point based on 25% flow)	56.3	4.500	< 0.33Wd+48.00%
Core Flow 39.1 to ≤61.7 % (point based on 50% flow)	72.5	5.801	< 1.07Wd+19.01%
Core Flow 61.7 to ≤119.4 % (point based on 75% flow)	92.5	7.398	< 0.55Wd+51.22%
Core Flow > 119.4%	117.0	9.357	N/A

Note: % CS is calculated based on multiplying the calculated Vdc terms in attachments 7.2 by 10 (100% Span / 10Vdc).

5.2 Setpoint Evaluation

Results are presented below for the Limiting Setpoint (LSp).

Table 11: APRM Fixed Scram (Reduced) Trip Setpoint Results	
Description	
ITS: Analytical Limit (AL); CTS: Tech. Spec. Limit (TS)	≤ 15.0
Limiting Setpoint (LSp)	11.72
ITS: Allowable Value (AV)	12.97
Margin to LSp (M_1)	+0.345
Existing Setpoint	11.375
New Setpoint	N/A
Margin to Normal Operations	There is no stable operating point when the reactor is in the "Startup" mode.

These results are presented graphically in Figure 1.

Table 12: Limiting Setpoints and Calibration Cardinal Points			
Output Instrument	**% RxP**	**mV**	**Curve % RxP**
APRM A, B, C, D, E, F Scram Trips			
ARTS/MELLLA Flow Biased			
APRM High Flux Scram (Two Loop Ops)			
Core Flow 0 to ≤ 31.1 % (point based on 25% flow)	69.9	5.588	< 0.4Wd+59.85%
Core Flow 31.1 to ≤54.0 % (point based on 50 % flow)	96.1	7.685	< 1.28Wd+32.06%
Core Flow 54.0 to ≤75 % (point based on 70% flow)	112.2	8.978	< 0.66Wd+66.03%
Core Flow > 75%	115.7	9.257	N/A
APRM High Flux Scram (Single Loop Ops)			
Core Flow 0 to ≤39.1 % (point based on 25% flow)	66.8	5.347	< 0.4Wd+56.84%
Core Flow 39.1 to ≤61.9 % (point based on 50% flow)	86.3	6.905	< 1.28Wd+22.31%
Core Flow 61.9 to ≤83.0 % (point based on 70% flow)	107.1	8.564	< 0.66Wd+60.85%
Core Flow > 83.0%	115.7	9.257	N/A
EPU Flow Biased			
APRM High Flux Scram (Two Loop Ops)			
Core Flow 0 to ≤30.9 % (point based on 25% flow)	57.5	4.596	< 0.33Wd+49.20%
Core Flow 30.9 to ≤66.7 % (point based on 50% flow)	79.5	6.358	< 1.07Wd+25.98%
Core Flow 66.7 to ≤99.0 % (point based on 75% flow)	102.3	8.187	< 0.55Wd+61.09%
Core Flow > 99.0%	115.7	9.257	N/A
APRM High Flux Scram (Single Loop Ops)			
Core Flow 0 to ≤39.1 % (point based on 25% flow)	55.0	4.400	< 0.33Wd+46.75%
Core Flow 39.1 to ≤61.7 % (point based on 50% flow)	71.3	5.701	< 1.07Wd+17.76%
Core Flow 61.7 to ≤119.4 % (point based on 75% flow)	91.2	7.298	< 0.55Wd+49.97%
Core Flow > 119.4%	115.7	9.257	N/A

Note: Due to the small difference between As-Left and As-Found allowances, rounding of setpoints is not recommended.

5.3 Calibration and Test Results

Test As-Found tolerances (FT) and As-Left tolerances (CT) are for the Fixed Scram (Clamp and Reduced settings) are defined in Tables 13 and 14.

Table 13: Calibration Tolerances		
As Left (CT)		
Description	**Limits Vdc**	**Limits % RP**
APRM Fixed Scram (Reduced) Trip	0.04 Vdc	0.5 % RP

Table 14: Calibration Tolerances		
As Found (FT)		
Description	**Limits Vdc**	**Limits % RP**
APRM Fixed Scram (Reduced) Trip	0.1 Vdc	1.25%

Table 15: Calibration Points, As-Left and As-Found					
Output Instrument	Setting Vdc	As-Left Min	As-Left Max	As-Found Min	As-Found Max
APRM A, B, C, D, E, F Scram Trips					
ARTS/MELLLA Flow Biased					
APRM High Flux Scram (Two Loop Ops)					
Core Flow 0 to ≤ 31.1 % (point based on 25% flow)	5.588	5.538	5.638	5.488	5.688
Core Flow 31.1 to ≤54.0 % (point based on 50 % flow)	7.685	7.635	7.735	7.585	7.785
Core Flow 54.0 to ≤75 % (point based on 70% flow)	8.978	8.928	9.028	8.878	9.078
Core Flow > 75%	9.257	9.207	9.307	9.157	9.357
APRM High Flux Scram (Single Loop Ops)					
Core Flow 0 to ≤39.1 % (point based on 25% flow)	5.347	5.297	5.397	5.247	5.447
Core Flow 39.1 to ≤61.9 % (point based on 50% flow)	6.905	6.855	6.955	6.805	7.005
Core Flow 61.9 to ≤83.0 % (point based on 70% flow)	8.564	8.514	8.614	8.464	8.664
Core Flow > 83.0%	9.257	9.207	9.307	9.157	9.357
EPU Flow Biased					
APRM High Flux Scram (Two Loop Ops)					
ow 0 to ≤30.9 % (point based on 25% flow)	4.596	4.546	4.646	4.496	4.696
Core Flow 30.9 to ≤66.7 % (point based on 50% flow)	6.358	6.308	6.408	6.258	6.458
Core Flow 66.7 to ≤99.0 % (point based on 75% flow)	8.187	8.137	8.237	8.087	8.287
Core Flow > 99.0%	9.257	9.207	9.307	9.157	9.357
APRM High Flux Scram (Single Loop Ops)					
Core Flow 0 to ≤39.1 % (point based on 25% flow)	4.400	4.350	4.450	4.300	4.500
Core Flow 39.1 to ≤61.7 % (point based on 50% flow)	5.701	5.651	5.751	5.601	5.801
Core Flow 61.7 to ≤119.4 % (point based on 75% flow)	7.298	7.248	7.348	7.198	7.398
Core Flow > 119.4%	9.257	9.207	9.307	9.157	9.357

Note: Recirculation drive flow input to APRM can be determined by the equation
RDF (Vdc) = % flow/125 * 10.

Table 16: Total Loop Uncertainty and Non-Test Error		
Output Instrument	TLU % RxP	Non Test % RxP
APRM A, B, C, D, E, F Scram Trips		
ARTS/MELLLA Flow Biased		
APRM High Flux Scram (Two Loop Ops)		
Core Flow 0 to ≤ 31.1 % (point based on 25% flow)	-4.55%	-3.30%
Core Flow 31.1 to ≤54.0 % (point based on 50 % flow)	-4.94%	-3.69%
Core Flow 54.0 to ≤75 % (point based on 70% flow)	-4.47%	-3.22%
Core Flow > 75%	-4.29%	-3.04%
APRM High Flux Scram (Single Loop Ops)		
Core Flow 0 to ≤39.1 % (point based on 25% flow)	-4.36%	-3.11%
Core Flow 39.1 to ≤61.9 % (point based on 50% flow)	-4.49%	-3.24%
Core Flow 61.9 to ≤83.0 % (point based on 70% flow)	-4.35%	-3.10%
Core Flow > 83.0%	-4.29%	-3.04%

Table 16: Total Loop Uncertainty and Non-Test Error		
Output Instrument	TLU % RxP	Non Test % RxP
EPU Flow Biased		
APRM High Flux Scram (Two Loop Ops)		
Core Flow 0 to ≤30.9 % (point based on 25% flow)	-4.50%	-3.25%
Core Flow 30.9 to ≤66.7 % (point based on 50% flow)	-4.82%	-3.57%
Core Flow 66.7 to ≤99.0 % (point based on 75% flow)	-4.41%	-3.16%
Core Flow > 99.0%	-4.29%	-3.04%
APRM High Flux Scram (Single Loop Ops)		
Core Flow 0 to ≤39.1 % (point based on 25% flow)	-4.35%	-3.10%
Core Flow 39.1 to ≤61.7 % (point based on 50% flow)	-4.44%	-3.19%
Core Flow 61.7 to ≤119.4 % (point based on 75% flow)	-4.33%	-3.08%
Core Flow > 119.4%	-4.29%	-3.04%

Table 17: Total Loop Uncertainty and Non-Test Error		
Output Instrument	TLU % CS	Non Test % CS
APRM A, B, C, D, E, F Scram Trips		
ARTS/MELLLA Flow Biased		
High Flux Scram (Two Loop Ops)		
Core Flow 0 to ≤ 31.1 % (point based on 25% flow)	-3.64%	-2.64%
Core Flow 31.1 to ≤54.0 % (point based on 50 % flow)	-3.95%	-2.95%
Core Flow 54.0 to ≤75 % (point based on 70% flow)	-3.58%	-2.58%
Core Flow > 75%	-3.43%	-2.43%
APRM High Flux Scram (Single Loop Ops)		
Core Flow 0 to ≤39.1 % (point based on 25% flow)	-3.49%	-2.49%
Core Flow 39.1 to ≤61.9 % (point based on 50% flow)	-3.59%	-2.59%
Core Flow 61.9 to ≤83.0 % (point based on 70% flow)	-3.48%	-2.48%
Core Flow > 83.0%	-3.43%	-2.43%
EPU Flow Biased		
APRM High Flux Scram (Two Loop Ops)		
Core Flow 0 to ≤30.9 % (point based on 25% flow)	-3.60%	-2.60%
Core Flow 30.9 to ≤66.7 % (point based on 50% flow)	-3.85%	-2.85%
Core Flow 66.7 to ≤99.0 % (point based on 75% flow)	-3.53%	-2.53%
Core Flow > 99.0%	-3.43%	-2.43%
APRM High Flux Scram (Single Loop Ops)		
Core Flow 0 to ≤39.1 % (point based on 25% flow)	-3.48%	-2.48%
Core Flow 39.1 to ≤61.7 % (point based on 50% flow)	-3.56%	-2.56%
Core Flow 61.7 to ≤119.4 % (point based on 75% flow)	-3.47%	-2.47%
Core Flow > 119.4%	-3.43%	-2.43%

5.4 Calculation Review and Impact Consideration

5.4.1 This calculation evaluates the uncertainty of loop components for design changes including Extended Power Uprate. The uncertainty determined by this calculation

will be used as input for the Reactor Scram Flow Biased and the APRM Fixed Scram (Reduced) Trip Setpoint and Allowable Value results.

5.4.2 The Design Input Considerations of ARTS/MELLLA and the VY Extended Power Uprate as well as the change in the methodology used to develop Limiting Setpoints and Allowable Values have been considered in this calculation. The setpoints developed in this calculation are not applicable until the VY licensing amendments BVY 03-80 for Extended Power Uprate and BVY 03-23 ARTS/MELLLA are approved (as applicable).

5.4.3 The function of the instruments covered by this calculation is an assumed input in the Reload Licensing Analysis. This analysis does not assess conformance to 10 CFR 50.46, "Acceptance Criteria for ECCS for Light Water Nuclear Power Reactors," and Appendix K, "ECCS Evaluation Models". The results of this calculation do not identify errors or require changes to the Reload Licensing Analysis. Therefore, the reporting requirements of 10 CFR 50.46 are not applicable.

5.4.4 A review of the Vermont Yankee Event Report Database was conducted to identify any Event Reports that would impact this calculation. This review identified no event reports, associated with these components.

5.4.5 Precursor calculations used for design input to this calculation are not impacted by the results of this calculation. Any applicable interactions due to changes in precursor calculations will be addressed per AP 0017 during the change process for those calculations. Calculation VYC-0690 [Ref. 6.27] provides direct input to the flow errors used for this calculation.

5.5 Summary of Requirements

5.5.1 The current calibration procedure, OP 4308, Rev. 21 [Ref 6.25] requires update to accurately reflect the LSp and As-Found and As-Left tolerances. A precaution should be added to Ref. 6.25 to ensure that M&TE with an accuracy better than 0.05% of span is used to set the flow bias input value during calibration.

5.5.2 This calculation is not an implementing document and a 50.59 screen or evaluation is not required. The output of this calculation is implemented through update to applicable plant documents (i.e., OP 4308, FSAR). The downstream process that updates applicable output documents will satisfy the 50.59 evaluation requirements.

5.6 Summary of Recommendations

5.6.1 Based on the results of this calculation the following changes should be made to the evaluated trip setpoints:

5.6.1.1 APRM Flow Biased Scram Trip Setpoint.

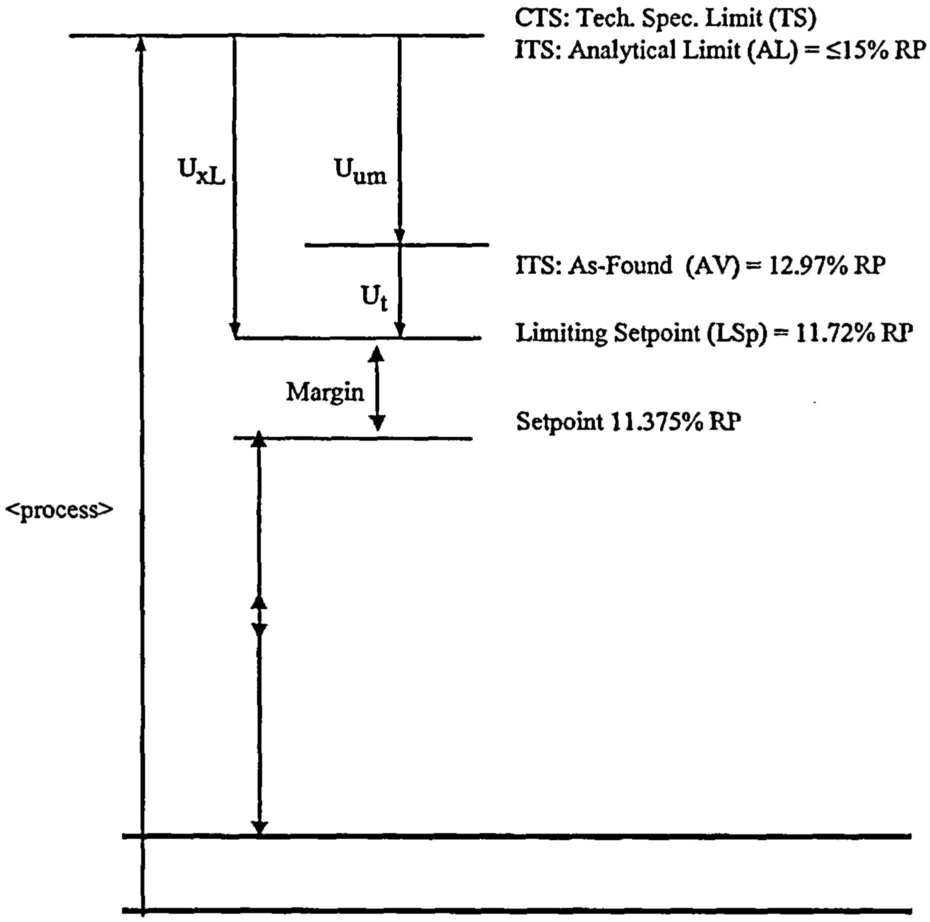
5.6.1.1.1 The formula to develop the curve for the APRM Flow Biased Scram Trip setpoints must be changed in accordance with Table 12 for the specific application of ARTS/MELLA or Extended Power Uprate.

5.6.1.1.2 Revise the As-Left and As-Found tolerances as defined in Table 15 for the new calibration points.

5.6.1.2 APRM Fixed Scram (Reduced).

5.6.1.2.1 Trip setpoints must be changed in accordance with Table 12. The values for Allowable Value and Limiting Setpoint do not change for this function for ARTS/MELLLA or EPU.

5.6.1.2.2 Revise the As-Left and As-Found tolerances as defined in Table 15 for the new calibration points.



Normal Range of Operation

Figure 1

APRM Fixed Scram (Reduced) Setpoint

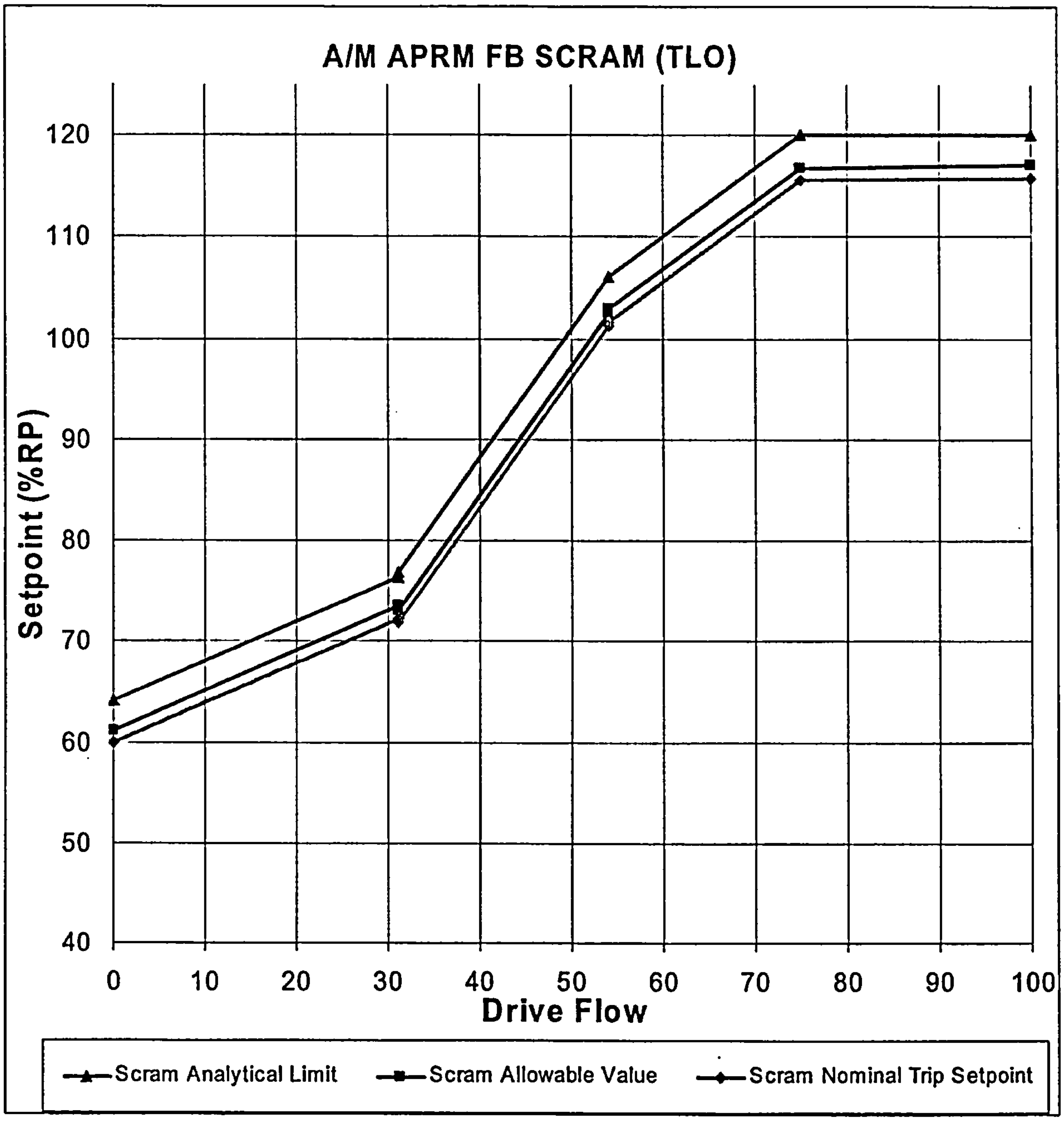


Figure 2

APRM Flow Bias Scram Analytical Limit, Allowable Value, Nominal Trip Setpoint (ARTS/MELLLA) Two Recirculation Loops

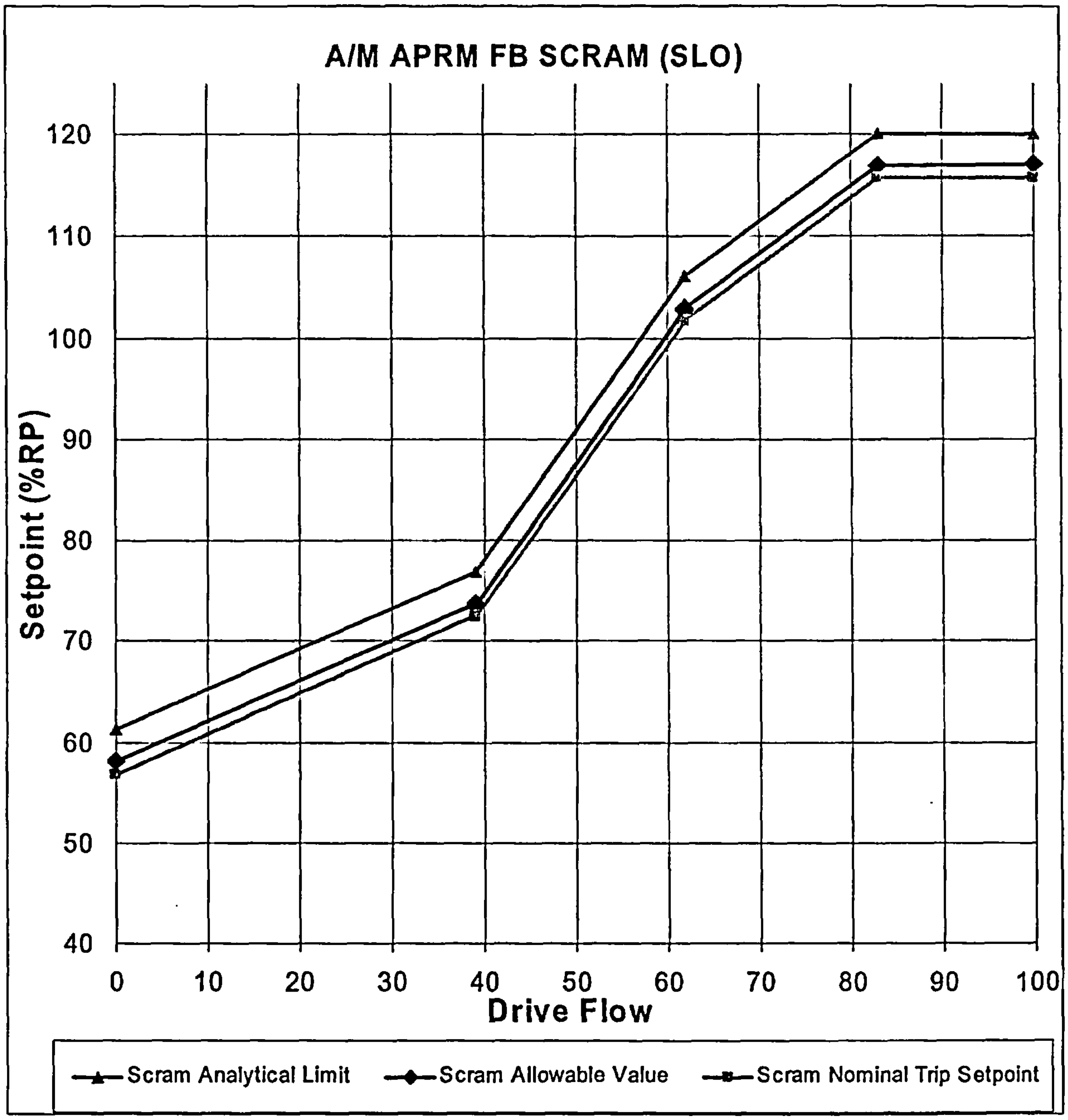


Figure 3

APRM Flow Bias Scram Analytical Limit, Allowable Value, Nominal Trip Setpoint (ARTS/MELLLA) One Recirculation Loop

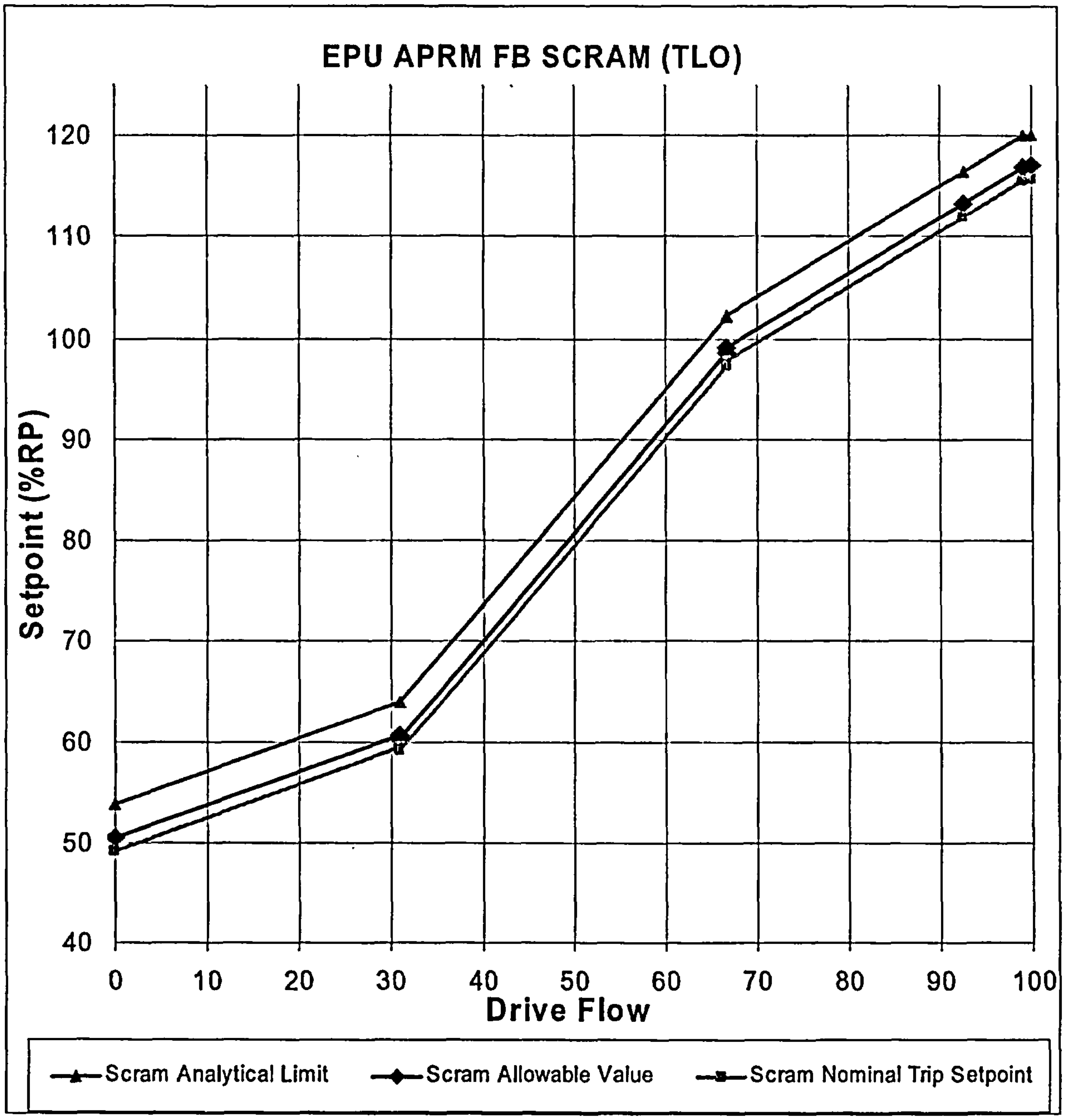


Figure 4

APRM Flow Bias Scram Analytical Limit, Allowable Value, Nominal Trip Setpoint (EPU) Two Recirculation Loops

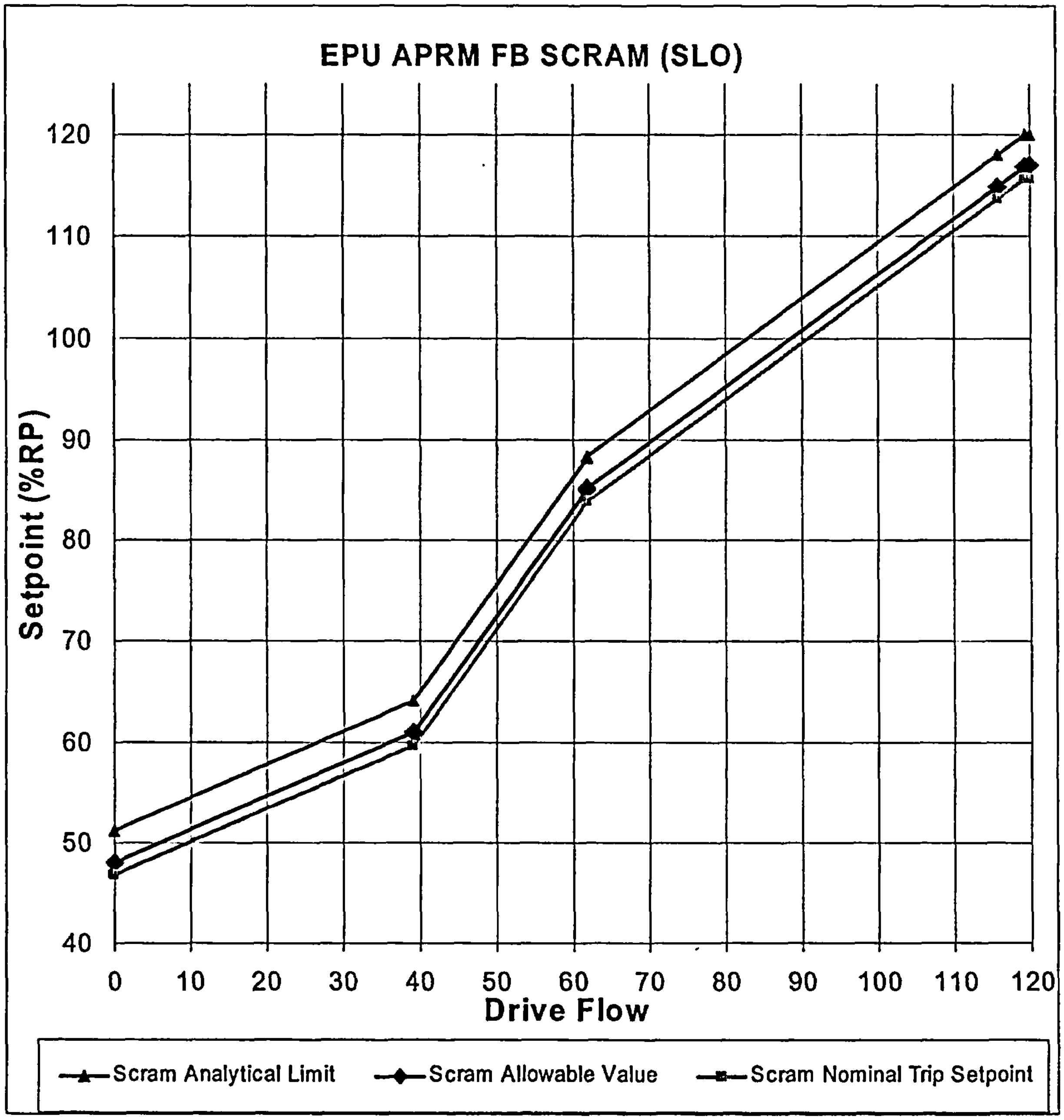


Figure 5

APRM Flow Bias Scram Analytical Limit, Allowable Value, Nominal Trip Setpoint (EPU) One Recirculation Loop

6 REFERENCES

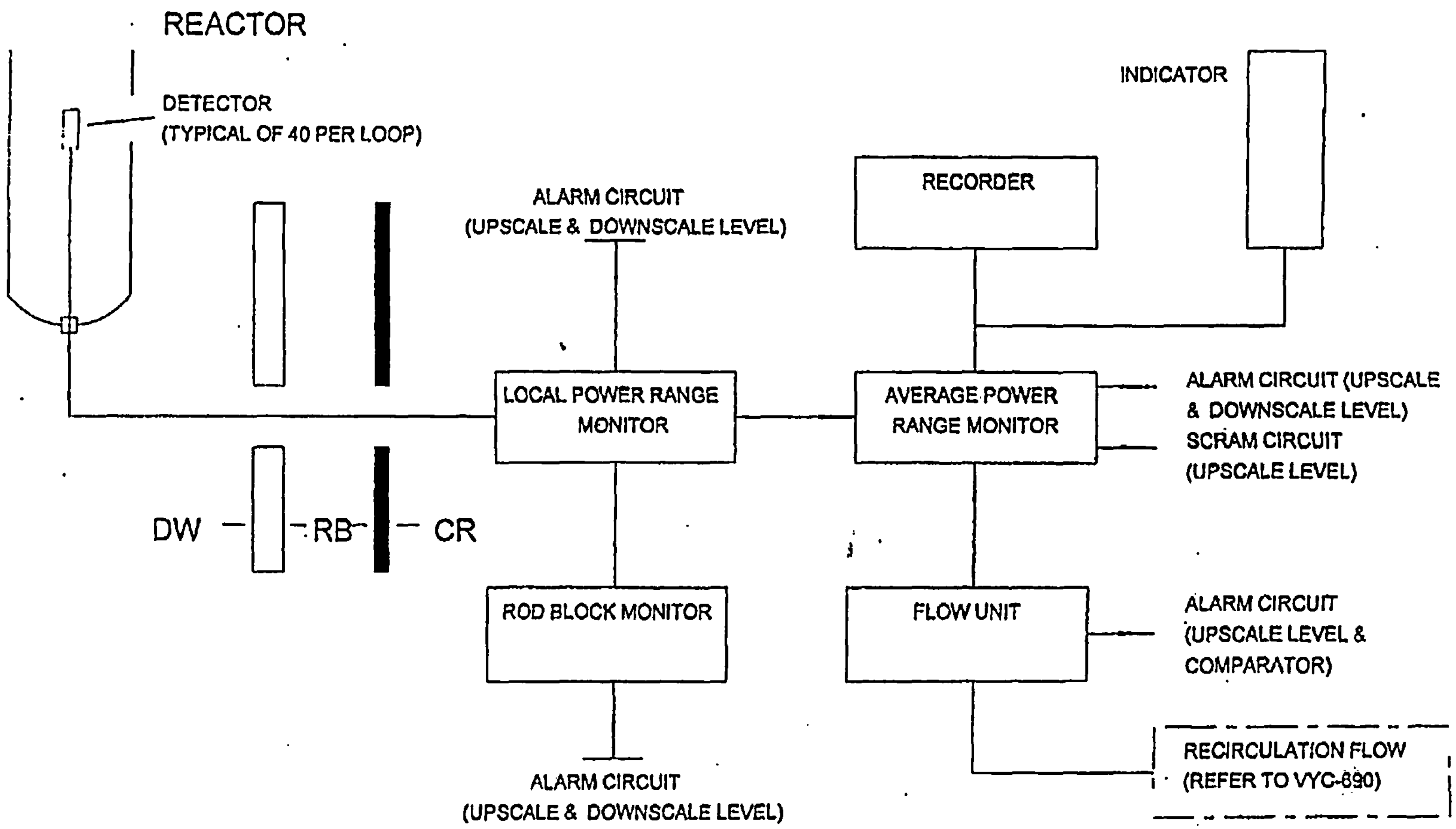
6.1 "Instrument Uncertainty and Setpoints Design Guide," Vermont Yankee, Rev. 1.
6.2 Design Specification 22A1366, Rev. 3, "Neutron Monitoring System"
6.3 Design Specification - Data Sheet 22A1366AF, Rev. 1, "Neutron Monitoring System"
6.4 "Vermont Yankee Updated Final Safety Analysis Report, Rev.17."
6.5 "Vermont Yankee Environmental Qualification Program Manual," Rev. 38.
6.6 "Vermont Yankee Design Basis Radiation Dose Specification," Yankee Nuclear Services Calculation VYC-193. Rev. 4
6.7 Vermont Yankee Technical Specifications through Amendment 212.
6.8 Not Used
6.9 AP-0017 Calculations and Analyses Rev. 8 LPC 2.
6.10 Not Used
6.11 Design and Performance Specification 175A1259, Rev. 1, "APRM".
6.12 Not Used.
6.13 General Electric Instrument Setpoint Methodology, NEDC-31336 (GE Proprietary), October 1986, Section 3.19 and 4.5.
6.14 NEDE-24011-P-A-14, June 2000, General Electric Standard Application for Reactor Fuel (GESTAR II).
6.15 GE-NE-0000-0012-0531-01-01 Revision 2 November 2003 Project Task Report "Entergy Nuclear Operations Incorporated Vermont Yankee Nuclear Power Station ARTS/MELLLA" Task T0506: NSSS TS Instrument Setpoints.
6.16 GE-NE-0000-0016-5688-01 Revision 0 August 2003 Project Task Report "Entergy Nuclear Operations Incorporated Vermont Yankee Nuclear Power Station Extended Power Uprate" Task T0506: NSSS TS Instrument Setpoints.
6.17 GE Performance Specification 25A5903 Rev. 1, "Flow Control Trip Reference (FCTR) Card".
6.18 EMPAC Database.
6.19 Core Operating Limit Report (COLR).
6.20 Measuring & Testing Equipment Uncertainty Calculation, VYC-1758 Rev. 0.
6.21 Not Used.
6.22 Not Used
6.23 OP-43108 Rev. 6, APRM Functional/Calibration (RMSS not in run).
6.24 OP-4400, Rev 21, Calibration of APRM System to Core Thermal Power.
6.25 OP 4308 Rev. 21 APRM Monitor Calibration.
6.26 OP-2429 Rev. 14 "Recirculation Flow System Baseline Data Collection and Instrument Calibration."
6.27 VYC-690 Rev. 2 "Recirculation Flow Loop Uncertainties to APRM".
6.28 NEDE-24011-P-A-14, June 2000, General Electric Standard Application for Reactor Fuel (GESTAR II).
6.29 NEDC-33089P, "Vermont Yankee Nuclear Power Station APRM/RBM/Technical Specifications Maximum Extended Load Line Limit Analysis (ARTS/MELLLA)," March 2003.
6.30 NEDC-33090P, Rev. 0, "Safety Analysis Report for Vermont Yankee Nuclear Power Station Constant Pressure Power Uprate," September 2003
6.31 BVY 03-23 March 20, 2003, Technical Specification Proposed Change No. 257 Implementation of ARTS/MELLLA at VY

6.32 BVY 03-80 September 10, 2003, Technical Specification Proposed Change No. 263 Extended Power Uprate.
6.33 VYC-2252, Rev. 0 "Drift Calculation for Average Power Range Monitors."

7 ATTACHMENTS

7.1 Loop Diagram [1 pg]
7.2 Calculation Detail (B1 through B4) [8 pgs]
7.3 Design Specification 22A1366, Rev. 3, "Neutron Monitoring System" [2 pgs]
7.4 Design Specification - Data Sheet 22A1366AF, Rev. 1, "Neutron Monitoring System"[1 pg]
7.5 Design and Performance Specification 175A1259, Rev. 1, "APRM" [3 pgs]
7.6 GE Performance Specification 25A5903 Rev. 1, "Flow Control Trip Reference (FCTR) Card [23 pg]
7.7 AP-0017 Forms and Interdepartmental Review Form [7 pgs]

LPRM/APRM NEUTRO' ' MONITORING
(APRM LOOPS)



Attachment 7.1
VYC-0693A Rev. 2
Page 1 of 1

VYC-693A

	A	B	C	D	E	F	G	H
1	APRM Scram Calculation for ARTS/MELLLA Two Recirculation Loop Operation.						Values based on Tables 6 and 7 accuracy and drift	
2			SPAN	Setpoint Slope	Analytical Limits	SENSITIVITY	ACCURACY	REPEATABILITY
3	EQUIPMENT I.D.	INSTRUMENT TYPE	%		First Break Point % RP		%CS	%CS
4					0.33*D22+53.7			
5	ND-2-1-104	LPRM DETECTOR						
6		ICPS						
7		LPRM					0.2667%	
8		APRM					0.8000%	
9		<TYPE 5>						
10		FLOW BIASED SCRAM (20-31.1%)	125	0.40	72.40		1.0000%	
11		FLOW BIASED SCRAM (31.1 - 54.0%)	125	1.28	76.81		1.0000%	
12		FLOW BIASED SCRAM (54.0 - 75.0%)	125	0.66	106.14		1.0000%	
13		FLOW BIASED SCRAM (>75.0%)	125	Maximum Value	120.00		1.0000%	
14		FIXED SCRAM (REDUCED)	125	n/a	15.00		1.0000%	
15				%CS				
16	CALIBRATION EQUIPMENT UNCERTAINTY (M&TE)			0.071%	(2.3.12 IN TEXT)			
17	FLOW INPUT UNCERTAINTY BIAS (FROM VYC-690, REV.2)			0.4501	0.2919	0.1688		
18	FLOW INPUT UNCERTAINTY RANDOM (FROM VYC-690, REV.2)			0.7266	0.5927	0.5143	CS FOR FLOW SIGNAL IS 128.6%	
19	FLOW UNCERTAINTY BIAS EFFECT (% Rx POWER)			0.2315%	0.4805%	0.1433%	CS FOR POWER IS 125%	
20	FLOW UNCERTAINTY RANDOM EFFECT (includes 0.25% ST(Sec 2.3.4)) (% Rx POWER)			0.3953%	1.0589%	0.4854%		
21	FLOW SETTING TOLERANCE		0.25	(SQRT(D18^2+C21^2)/100)*1.286*D10	(SQRT(E18^2+$C$21^2)/100)*1.286*D11	(SQRT(F18^2+$C$21^2)/100)*1.286*D12		
22	MINIMUM FLOW VALUES TO BE EVALUATED (% FLOW)			20	31.1	54		
23	FLOW VALUES TO BE EVALUATED (% FLOW)			20-31.1%	31.1-54.0%	54.0-75.0%		
24	MINIMUM NUMBER OF LPRMs PER APRM		9					
25	PRIMARY ELEMENT ACCURACY (%RP) (Section 2.2.5)		0.82%	Bias '+/-	0.340000%			
26	PROCESS MEASUREMENT ACCURACY (%RP) (Section 2.2.6) ±		2.29%					
27								
28	TECH SPEC LIMIT REQUIRED FOR CTS		120.00	% RP				
29	ANALYTIC LIMIT REQUIRED FOR ITS		120.00	% RP				
30								
31	Calculated as calibration tolerance if exists or accuracy of all components.					SRSS of Calibration Terms in % RP	SRSS of Calibration Terms	NON TESTING UNCERTAINTY
32	FLOW BIASED SCRAM (20-31.1%)				E35/$C$10	LOOP TESTING UNCERTAINTY	LOOP TESTING UNCERTAINTY	0.84*SQRT($E$25^2+$C$26^2+$D$20^2+$O$19+$N$16)
33	CALIBRATION EFFECT (CE)			CALIBRATION TOLERANCE	CALIBRATION TOLERANCE	$C$10*SQRT(A35^2)	SQRT(A35^2)	0.84*-SQRT($E$25^2+$C$26^2+$D$20^2+$O$19+$N$16)-$C$25-$D$19
34	%CS			% RP	%CS	% RP	%CS	% RP
35	1.0000%			0.625	0.50%	1.25	1.00%	2.2440%
36	-1.0000%			-0.625	-0.50%	-1.25	-1.00%	-3.2956%
37	G10							
38	-A35							
39								
40	FLOW BIASED SCRAM (31.1 - 54.0%)							
41	CALIBRATION EFFECT (CE)			CALIBRATION TOLERANCE	CALIBRATION TOLERANCE	LOOP TESTING UNCERTAINTY	LOOP TESTING UNCERTAINTY	NON TESTING ERROR
42	%CS			% RP	%CS	% RP	%CS	% RP
43	1.0000%			0.625	0.50%	1.25	1.00%	2.3909%
44	-1.0000%			-0.625	-0.50%	-1.25	-1.00%	-3.6914%
45								
46								
47	FLOW BIASED SCRAM (54.0 - 75.0%)			CALIBRATION				
48	CALIBRATION EFFECT (CE)			TOLERANCE		LOOP TESTING UNCERTAINTY	LOOP TESTING UNCERTAINTY	NON TESTING ERROR
49	%CS			% RP	%CS	% RP	%CS	% RP
50	1.0000%			0.625	0.50%	1.25	1.00%	2.2565%
51	-1.0000%			-0.625	-0.50%	-1.25	-1.00%	-3.2197%
52								
53								
54	FLOW BIASED SCRAM (>75.0%)			CALIBRATION				
55	CALIBRATION EFFECT (CE)			TOLERANCE		LOOP TESTING UNCERTAINTY	LOOP TESTING UNCERTAINTY	NON TESTING ERROR
56	%CS			% RP	%CS	% RP	%CS	% RP
57	1.0000%			0.50	0.40%	1.25	1.00%	2.2193%
58	-1.0000%			-0.50	-0.40%	-1.25	-1.00%	-3.0393%
59								
60	FIXED SCRAM (REDUCED)			CALIBRATION				
61	CALIBRATION EFFECT (CE)			TOLERANCE		LOOP TESTING UNCERTAINTY	LOOP TESTING UNCERTAINTY	NON TESTING ERROR
62	%CS			% RP	%CS	% RP	%CS	% RP
63	1.0000%			0.50	0.40%	1.25	1.00%	2.2193%
64	-1.0000%			-0.50	-0.40%	-1.25	-1.00%	-3.0393%

	I	J	K	L	M	N	O	P	Q	R	S	T
1	Includes bias and random errors.					INSTRUMENTS		AV = AL - SQRT($E$25^2+$C$26^2+$D$20^2+$O$19+$O$10)-$C$25-$D$19				
2	DRIFT	LINEARITY	HYSTERESIS	ENVIRON. EFF.	SEISMIC	SUMS SQUARED (+/-)						
3	%CS	%CS	%CS	%CS	%CS	ACCURACIES	ALL OTHERS		Non Testing Error :	Non Testing Error :		
4						((G5/100*$C$11)^2)	(((I5/100*C8)^2)		E25: Primary Element Accuracy Random Error as a percent of Power			
5						0.00000000	0.00000000		C26 : Process Measurement Accuracy Random Error as a percent of RP			
6						0.00000000	0.00000000		D20: Flow Uncertainty Random Effect [Includes 0.25% ST] as a percent of Rx POWER			
7	0.2667%					0.00001111	0.00001111		O19: Squared combination of all Drift and other terms for LPRM and APRM Converted to percent of RP			
8	0.5000%				0.00	0.00010000	0.00003906		N16: Squared combination of accuracies for all LPRM and APRM averaging circuits Converted to percent of RP.			
9						0.00000000	0.00000000		C25 : Primary Element Accuracy Bias Error as a percent of Power			
10	0.0000%					0.00015625	0.00000000		D19: Flow Uncertainty Bias Effect as a percent of Rx POWER			
11	0.0000%					0.00015625	0.00000000					
12	0.0000%					0.00015625	0.00000000	LSp = AV - $C$10*SQRT(A35^2))				
13	0.0000%					0.00015625	0.00000000					
14	0.0000%					0.00015625	0.00000000		A35: Accuracy of th	A35: Accuracy of the FCTR Card		
15						SUM(N5:N9)	SUM(O5:O9)					
16						0.00011111	0.00005017	Sum of the squares of the APRM/LPRM circuit drift and other errors SUM(P6:P10)				
17							0.00000079	CALIBRATION EQUIPMENT CONVERTED TO % RP AND SQUARED E18^2				
18							(D16/100*C10)^2					
19							0.00005096	Sum of the calibration error and the drift and other circuit errors.				
20							SUM(O16:O17)					
21												
22												
23						Total Loop Uncertainty	Applied Non-Testing Uncertanties					
24			FLOW BIASED SCRAM (20-30.9%)			-4.5456%	-3.2956%					
25			FLOW BIASED SCRAM (30.9 - 66.7%)			-4.9414%	-3.6914%					
26			FLOW BIASED SCRAM (66.7 - 99.0%)			-4.4697%	-3.2197%					
27			FLOW BIASED SCRAM (>99.0%)			-4.2893%	-3.0393%					
28			FIXED SCRAM (REDUCED)			-3.2752%	-3.0393%					
29												
30												
31		Method 1 AV	LIMITING SETPOINT									
32	L35/$C$10*100	ITS: (AV)	LSp	SETPOINT	ALLOWABLE	MARGIN		CTS: AS-FOUND TOLERANCE (FT)				CALIBRATION TOLERANCE
33		% RP	% RP	(O35/125)*10	VALUE	(M2)	O35/C10+J35	S35*10	O35+G35	O35/$C$10+F35	V35*10	O35+E35
34	% CS	$E$10+(L36*100)	N35+G36	Vdc	Vdc	% RP	%CS	VDC	% RP	%CS	VDC	% RP
35	1.795%	69.10	67.85	5.43	5.53	N/A	55.28%	5.53	69.10	54.78%	5.48	68.48
36	-2.636%	N35-($D$10*$D$22)	O35-($D$10*$D$22)				53.28%	5.33	66.60	53.78%	5.38	67.23
37		61.10	59.85									
38	Typical AV and Setpoint Curves	0.4*Wd+61.10	0.4*Wd+59.85									
39												
40		Method 1 AV	LIMITING SETPOINT	SETPOINT	ALLOWABLE	MARGIN		CTS: AS-FOUND TOLERANCE (FT)				CALIBRATION TOLERANCE
41		ITS: (AV)	LSp		VALUE	(M2)					(CT)	
42	% CS	% RP	% RP	Vdc	Vdc	% RP	%CS	VDC	% RP	%CS	VDC	% RP
43	1.9127%	73.12	71.87	5.75	5.85	N/A	58.49%	5.85	73.12	57.99%	5.80	72.49
44	-2.9531%	33.31	32.06				56.49%	5.65	70.62	56.99%	5.70	71.24
45		1.28*Wd+33.31	1.28*Wd+32.06									
46												
47		Method 1 AV	LIMITING SETPOINT	SETPOINT	ALLOWABLE	MARGIN		CTS: AS-FOUND TOLERANCE (FT)				CALIBRATION TOLERANCE
48		ITS: (AV)	LSp		VALUE	(M2)					(CT)	
49	% CS	% RP	% RP	Vdc	Vdc	% RP	%CS	VDC	% RP	%CS	VDC	% RP
50	1.8052%	102.92	101.67	8.13	8.23	N/A	82.34%	8.23	102.92	81.84%	8.18	102.30
51	-2.5758%	67.28	66.03				80.34%	8.03	100.42	80.84%	8.08	101.05
52		0.66*Wd+67.28	0.66*Wd+66.03									
53												
54		Method 1 AV	LIMITING SETPOINT	SETPOINT	ALLOWABLE	MARGIN		CTS: AS-FOUND TOLERANCE (FT)				CALIBRATION TOLERANCE
55		ITS: (AV)	LSp		VALUE	(M2)					(CT)	
56	% CS	% RP	% RP	Vdc	Vdc	% RP	%CS	VDC	% RP	%CS	VDC	% RP
57	1.7755%	116.96	115.71	9.26	9.36	N/A	93.57%	9.36	116.96	92.97%	9.30	116.21
58	-2.4315%						91.57%	9.16	114.46	92.17%	9.22	115.21
59												
60		Method 1 AV	LIMITING SETPOINT	SETPOINT	ALLOWABLE	MARGIN		CTS: AS-FOUND TOLERANCE (FT)				CALIBRATION TOLERANCE
61		ITS: (AV)	LSp		VALUE	(M2)					(CT)	
62	% CS	% RP	% RP	Vdc	Vdc	% RP	%CS	VDC	% RP	%CS	VDC	% RP
63	1.7755%	12.97	11.72	0.94	1.04	N/A	10.38%	1.04	12.97	9.78%	0.98	12.22
64	-2.4315%						8.38%	0.84	10.47	8.98%	0.90	11.22

	A	B	C	D	E	F	G	H
1	APRM Scram Calculation for ARTS/MELLLA Single Recirculation Loop Operation.						Values based on Tables 6 and 7 accuracy and drift	
2			SPAN	Setpoint Slope	Analytical Limits	SENSITIVITY	ACCURACY	REPEATABILITY
3	EQUIPMENT I.D.	INSTRUMENT TYPE	%		First Break Point % RP		%CS	%CS
4					0 33*D22+53.7			
5	ND-2-1-104	LPRM DETECTOR						
6		ICPS						
7		LPRM					0 2667%	
8		APRM					0 8000%	
9		<TYPE 5>						
10		FLOW BIASED SCRAM (20-39 1%)	125	0 40	69.20		1 0000%	
11		FLOW BIASED SCRAM (39.1 - 61 9%)	125	1.28	76 85		1.0000%	
12		FLOW BIASED SCRAM (61.9 - 83 0%)	125	0 66	106 05		1.0000%	
13		FLOW BIASED SCRAM (>83 0%)	125	Minimum Value	120 00		1 0000%	
14		FIXED SCRAM (REDUCED)	125	n/a	15 00		1 0000%	
15	.			%CS				
16	CALIBRATION EQUIPMENT UNCERTAINTY (M&TE)			0.071%	(2.3 12 IN TEXT)			
17	FLOW INPUT UNCERTAINTY BIAS (FROM VYC-690, REV.2)			0 1137	0 058368	0 03686		
18	FLOW INPUT UNCERTAINTY RANDOM (FROM VYC-690, REV.2)			0 4673	0 434776	0 427396	CS FOR FLOW SIGNAL IS 128 6%	
19	FLOW UNCERTAINTY BIAS EFFECT (% Rx POWER)			0 0585%	0 0961%	0 0313%	CS FOR POWER IS 125%	
20	FLOW UNCERTAINTY RANDOM EFFECT [includes 0.25% ST(Sec 2.3 4)] (% Rx POWER)			0.2726%	0 8258%	0.4203%		
21	FLOW SETTING TOLERANCE		0 25	(SQRT(D18^2+C21^2)/100)*1 286*D10	(SQRT(E18^2+$C$21^2)/100)*1.286*D11	(SQRT(F18^2+$C$21^2)/100)*1.286*D12		
22	MINIMUM FLOW VALUES TO BE EVALUATED (% FLOW)			20	39 1	61.9		
23	FLOW VALUES TO BE EVALUATED (% FLOW)			20-39.1%	39.1- 61 9 0%	61 9 - 83 0%		
24	MINIMUM NUMBER OF LPRMs PER APRM		9					
25	PRIMARY ELEMENT ACCURACY (%RP) (Section 2.2.5)		0 82%	Bias +/-	0.340000%			
26	PROCESS MEASUREMENT ACCURACY (%RP) (Section 2.2.6) ±		2 29%					
27								
28	TECH SPEC LIMIT REQUIRED FOR CTS		120 00	% RP				
29	ANALYTIC LIMIT REQUIRED FOR ITS		120 00	% RP				
30								
31	lerance if exists or accuracy of all components				SRSS of Calibration Terms in % RP	SRSS of Calibration Terms	NON TESTING UNCERTAINTY	
32	BIASED SCRAM (20-39.1%)			E35/$C$10	LOOP TESTING UNCERTAINTY	LOOP TESTING UNCERTAINTY	0 84*SQRT($E$25^2+$C$20^2+$D$20^2+$O$19+$N$16)	L35/$C$10*100
33	BRATION EFFECT (CE)		CALIBRATION TOLERANCE	CALIBRATION TOLERANCE	$C$10*SQRT(A35^2)	SQRT(A35^2)	0 84*-SQRT($E$25^2+$C$20^2+$D$20^2+$O$19+$N$16)-$C$25-$D$19	
34	%CS		% RP	%CS	% RP	%CS	% RP	% CS
35	1.0000%		0 625	0 50%	1 25	1 00%	2 2311%	1 785%
36	-1 0000%		-0 625	-0 50%	-1.25	-1 00%	-3 1096%	-2 498%
37	G10							
38	-A35							Typical AV and Setpoint Curves
39								
40	ASED SCRAM (39 1 - 61 9%)							
41	BRATION EFFECT (CE)		CALIBRATION TOLERANCE	CALIBRATION TOLERANCE	LOOP TESTING UNCERTAINTY	LOOP TESTING UNCERTAINTY	NON TESTING ERROR	
42	%CS		% RP	%CS	% RP	%CS	% RP	% CS
43	1.0000%		0 625	0 50%	1.25	1.00%	2.3251%	1 8601%
44	-1 0000%		-0 625	-0 50%	-1 25	-1 00%	-3 2412%	-2 5930%
45								
46								
47	ASED SCRAM (61 9 - 83 0%)		CALIBRATION					
48	BRATION EFFECT (CE)		TOLERANCE		LOOP TESTING UNCERTAINTY	LOOP TESTING UNCERTAINTY	NON TESTING ERROR	
49	%CS		% RP	%CS	% RP	%CS	% RP	% CS
50	1 0000%		0 625	0 50%	1 25	1.00%	2 2472%	1 7978%
51	-1.0000%		-0 625	-0 50%	-1 25	-1 00%	-3 0985%	-2.4788%
52								
53								
54	BIASED SCRAM (>83 0%)		CALIBRATION					
55	BRATION EFFECT (CE)		TOLERANCE		LOOP TESTING UNCERTAINTY	LOOP TESTING UNCERTAINTY	NON TESTING ERROR	
56	%CS		% RP	%CS	% RP	%CS	% RP	% CS
57	1 0000%		0.50	0 40%	1.25	1 00%	2 2193%	1.7755%
58	-1 0000%		-0 50	-0 40%	-1 25	-1.00%	-3 0393%	-2 4315%
59								
60	-D SCRAM (REDUCED)		CALIBRATION					
61	BRATION EFFECT (CE)		TOLERANCE		LOOP TESTING UNCERTAINTY	LOOP TESTING UNCERTAINTY	NON TESTING ERROR	
62	%CS		% RP	%CS	% RP	%CS	% RP	% CS
63	1 0000%		0 50	0 40%	1 25	1 00%	2 2193%	1 7755%
64	-1.0000%		-0 50	-0 40%	-1 25	-1 00%	-3 0393%	-2 4315%

	I	J	K	L	M	N	O	P	Q	R	S	T
1	Includes bias and random errors.					INSTRUMENTS		AV = AL - SQRT($E$25^2+$C$26^2+$D$20^2+$O$19+$O$10)-$C$25-$D$19				
2	DRIFT	LINEARITY	HYSTERESIS	ENVIRON. EFF.	SEISMIC	SUMS SQUARED (+/-)						
3	%CS	%CS	%CS	%CS	%CS	ACCURACIES	ALL OTHERS		Non Testing Error :			
4						((G5/100*$C$11)^2)	((5/100*C8)^2)		E25: Primary Element Accuracy Random Error as a percent of Power			
5						0.00000000	0 00000000		C26 : Process Measurement Accuracy Random Error as a percent of RP			
6						0 00000000	0 00000000		D20: Flow Uncertainty Random Effect [includes 0.25% ST] as a percent of Rx POWER			
7	0 2667%					0 00001111	0 00001111		O19: Squared combination of all Drift and other terms for LPRM and APRM Converted to percent of RP			
8	0 5000%				0 00	0 00010000	0 00003906		N16: Squared combination of accuracies for all LPRM and APRM averaging circuits Converted to percent of RP.			
9						0.00000000	0 00000000		C25 : Primary Element Accuracy Bias Error as a percent of Power			
10	0 0000%					0 00015625	0 00000000		D19: Flow Uncertainty Bias Effect as a percent of Rx POWER			
11	0 0000%					0 00015625	0 00000000					
12	0.0000%					0.00015625	0 00000000	LSp = AV - $C$10*SQRT(A35^2))				
13	0 0000%					0 00015625	0 00000000					
14	0 0000%					0.00015625	0 00000000		A35: Accuracy of the FCTR Card			
15						SUM(N5 N9)	SUM(O5:O9)					
16						0 00011111	0 00005017	Sum of the squares of the APRM/LPRM circuit drift and other errors SUM(P6 P10)				
17							0 00000079	CALIBRATION EQUIPMENT CONVERTED TO % RP AND SQUARED E18^2				
18							(D16/100*C10)^2					
19							0.00005096	Sum of the calibration error and the drift and other circuit errors.				
20							SUM(O16 O17)					
21												
22												
23						Total Loop Uncertainty	Applied Non-Testing Uncertainties					
24			FLOW BIASED SCRAM (20-30 9%)			-4 3596%	-3.1096%					
25			FLOW BIASED SCRAM (30 9 - 66.7%)			-4.4912%	-3.2412%					
26			FLOW BIASED SCRAM (66.7 - 99 0%)			-4 3485%	-3.0985%					
27			FLOW BIASED SCRAM (>99.0%)			-4 2893%	-3 0393%					
28			FIXED SCRAM (REDUCED)			-3 2752%	-3.0393%					
29												
30												
31	Method 1 AV	LIMITING SETPOINT										
32	ITS: (AV)	LSp	SETPOINT	ALLOWABLE	MARGIN	AS-FOUND TOLERANCE (FT)			CALIBRATION TOLERANCE			
33	% RP	% RP	(O35/125)*10	VALUE	(M2)	O35/C10+J35	S35*10	O35+G35	O35/$C$10+F35	V35*10	O35+E35	
34	$E$10+(L36*100)	N35+G36	Vdc	Vdc	% RP	%CS	VDC	% RP	%CS	VDC	% RP	
35	66 09	64 84	5.19	5 29	N/A	52 87%	5.29	66 09	52.37%	5 24	65 47	
36	N35-($D$10*$D$22)	O35-($D$10*$D$22)				50 87%	5 09	63 59	51 37%	5.14	64 22	
37	58 09	56 84										
38	0 4*Wd+58 69	0 4*Wd+ 56 84										
39												
40	Method 1 AV	LIMITING SETPOINT	SETPOINT	ALLOWABLE	MARGIN	AS-FOUND TOLERANCE (FT)			CALIBRATION TOLFRANCE			
41	ITS: (AV)	LSp		VALUE	(M2)				(CT)			
42	% RP	% RP	· Vdc	Vdc	% RP	%CS	VDC	% RP	%CS	VDC	% RP	
43	73 61	72 36	5.79	5 89	N/A	58 89%	5 89	73 61	58.39%	5 84	72 98	
44	23.58	22 31				56 89%	5 69	71.11	57.39%	5 74	71.73	
45	1.28*Wd+23 58	1 28*Wd+22 31										
46												
47	Method 1 AV	LIMITING SETPOINT	SETPOINT	ALLOWABLE	MARGIN	AS-FOUND TOLERANCE (FT)			CALIBRATION TOLERANCE			
48	ITS: (AV)	LSp		VALUE	(M2)				(CT)			
49	% RP	% RP	Vdc	Vdc	% RP	%CS	VDC	% RP	%CS	VDC	% RP	
50	102.96	101 71	8 14	8 24	N/A	82 36%	8 24	102 96	81 86%	8 19	102 33	
51	62.10	60 85				80 36%	8.04	100 46	80 86%	8 09	101 08	
52	0 66*Wd+62.10	0 66*Wd+60.85										
53												
54	Method 1 AV	LIMITING SETPOINT	SETPOINT	ALLOWABLE	MARGIN	AS-FOUND TOLERANCE (FT)			CALIBRATION TOLERANCE			
55	ITS: (AV)	LSp		VALUE	(M2)				(CT)			
56	% RP	% RP	Vdc	Vdc	% RP	%CS	VDC	% RP	%CS	VDC	% RP	
57	116 96	115.71	9 26	9 36	N/A	93.57%	9 36	116 96	92 97%	9 30	116.21	
58						91.57%	9 16	114 46	92.17%	9 22	115 21	
59												
60	Method 1 AV	LIMITING SETPOINT	SETPOINT	ALLOWABLE	MARGIN	AS-FOUND TOLERANCE (FT)			CALIBRATION TOLERANCE			
61	ITS: (AV)	LSp		VALUE	(M2)				(CT)			
62	% RP	% RP	Vdc	Vdc	% RP	%CS	VDC	% RP	%CS	VDC	% RP	
63	12 97	11.72	0 94	1 04	N/A	10 38%	1 04	12 97	9 78%	0 98	12 22	
64						8 38%	0 84	10 47	8 98%	0.90	11 22	

	A	B	C	D	E	F	G	H
1	APRM Scram Calculation for Extended Power Uprate Two Recirculation Loop Operation.						Values based on Tables 6 and 7 accuracy and drift	
2			SPAN	Setpoint Slope	Analytical Limits	SENSITIVITY	ACCURACY	REPEATABILITY
3	EQUIPMENT I.D.	INSTRUMENT TYPE	%		First Break Point % RP		%CS	%CS
4					0.33*D22+53.7		0.8/SQRT(C24)/100	
5	NO-2-1-104	LPRM DETECTOR						
6		ICPS						
7		LPRM					0.2667%	
8		APRM					0.8000%	
9		<TYPE 5>						
10		FLOW BIASED SCRAM (20-30.9%)	125	0.33	60.30		1.0%	
11		FLOW BIASED SCRAM (30.9 - 66.7%)	125	1.07	63.86		1.0%	
12		FLOW BIASED SCRAM (66.7 - 99.0%)	125	0.55	102.19		1.0%	
13		FLOW BIASED SCRAM (>99.0%)	125	Maximum Value	120.00		1.0%	
14		FIXED SCRAM (REDUCED)	125	n/a	15.00		1.0%	
15								
16	CALIBRATION EQUIPMENT UNCERTAINTY (M&TE)			0.071%	(2.3.12 IN TEXT)			
17	FLOW INPUT UNCERTAINTY BIAS (FROM VYC-690, REV.2)			0.4501	0.2937	0.1367		
18	FLOW INPUT UNCERTAINTY RANDOM (FROM VYC-690, REV.2)			0.7296	0.5941	0.4994	CS FOR FLOW SIGNAL IS 128.6%	
19	FLOW UNCERTAINTY BIAS EFFECT (% Rx POWER)			0.1910%	0.4041%	0.0967%	CS FOR POWER IS 125%	
20	FLOW UNCERTAINTY RANDOM EFFECT [Includes 0.25% ST(Sec 2.3.4)] (% Rx POWER)			0.3261%	0.8869%	0.3950%		
21	FLOW SETTING TOLERANCE		0.25	(SQRT(D18^2+C21^2)/100)*1.286*D10	(SQRT(E18^2+$C$21^2)/100)*1.286*D11	(SQRT(F18^2+$C$21^2)/100)*1.286*D12		
22	MINIMUM FLOW VALUES TO BE EVALUATED (% FLOW)			20	30.9	66.7		
23	FLOW VALUES TO BE EVALUATED (% FLOW)			20-30.9%	30.9-66.7	66.7-99.0		
24	MINIMUM NUMBER OF LPRMs PER APRM		9					
25	PRIMARY ELEMENT ACCURACY (%RP) (Section 2.2.5)		0.82%	Bias +/-	0.340000%			
26	PROCESS MEASUREMENT ACCURACY (%RP) (Section 2.2.6) ±		2.29%					
27								
28	TECH SPEC LIMIT REQUIRED FOR CTS		120.00	% RP				
29	ANALYTIC LIMIT REQUIRED FOR ITS		120.00	% RP				
30								
31	Calculated as calibration tolerance if exists or accuracy of all components.				SRSS of Calibration Terms in % RP	SRSS of Calibration Terms	NON TESTING UNCERTAINTY	
32	FLOW BIASED SCRAM (20-30.0%)			E35/$C$10	LOOP TESTING UNCERTAINTY	LOOP TESTING UNCERTAINTY	0.84*SQRT($E$25^2+$C$20^2+$D$20^2+$D$19+$N$16)	L35/$C$10*100
33	CALIBRATION EFFECT (CE)		CALIBRATION TOLERANCE	CALIBRATION TOLERANCE	$C$10*SQRT(A35^2)	SQRT(A35^2)	0.84*-SQRT($E$25^2+$C$20^2+$D$20^2+$D$19+$N$16)-$C$25-$D$19	
34	%CS		% RP	%CS	% RP	%CS	% RP	% CS
35	1.0000%		0.625	0.50%	1.25	1.00%	2.2392%	1.789%
36	-1.0000%		-0.625	-0.50%	-1.25	-1.00%	-3.2472%	-2.598%
37	G10							
38	-A35							Typical AV and Setpoint Curves
39								
40	FLOW BIASED SCRAM (30.9 - 66.7%)							
41	CALIBRATION EFFECT (CE)		CALIBRATION TOLERANCE	CALIBRATION TOLERANCE	LOOP TESTING UNCERTAINTY	LOOP TESTING UNCERTAINTY	NON TESTING ERROR	
42	%CS		% RP	%CS	% RP	%CS	% RP	% CS
43	1.0000%		0.625	0.50%	1.25	1.00%	2.3410%	1.8728%
44	-1.0000%		-0.625	-0.50%	-1.25	-1.00%	-3.5652%	-2.8521%
45								
46	.							
47	FLOW BIASED SCRAM (66.7 - 99.0%)		CALIBRATION					
48	CALIBRATION EFFECT (CE)		TOLERANCE		LOOP TESTING UNCERTAINTY	LOOP TESTING UNCERTAINTY	NON TESTING ERROR	
49	%CS		% RP	%CS	% RP	%CS	% RP	% CS
50	1.0000%		0.625	0.50%	1.25	1.00%	2.2440%	1.7952%
51	-1.0000%		-0.625	-0.50%	-1.25	-1.00%	-3.1807%	-2.5295%
52								
53								
54	FLOW BIASED SCRAM (>99.0%)		CALIBRATION					
55	CALIBRATION EFFECT (CE)		TOLERANCE		LOOP TESTING UNCERTAINTY	LOOP TESTING UNCERTAINTY	NON TESTING ERROR	
56	%CS		% RP	%CS	% RP	%CS	% RP	% CS
57	1.0000%		0.50	0.40%	1.25	1.00%	2.2193%	1.7755%
58	-1.0000%		0.50	0.40%	-1.25	-1.00%	-3.0393%	-2.4315%
59								
60	FIXED SCRAM (REDUCED)		CALIBRATION					
61	CALIBRATION EFFECT (CE)		TOLERANCE		LOOP TESTING UNCERTAINTY	LOOP TESTING UNCERTAINTY	NON TESTING ERROR	
62	%CS		% RP	%CS	% RP	%CS	% RP	% CS
63	1.0000%		0.50	0.40%	1.25	1.00%	2.2193%	1.7755%
64	-1.0000%		-0.50	-0.40%	-1.25	-1.00%	-3.0393%	-2.4315%

	I	J	K	L	M	N	O	P	Q	R	S	T
1	Includes bias and random errors.					INSTRUMENTS		AV = AL - SQRT($E$25^2+$C$26^2+$D$20^2+$O$19+$O$10)-$C$25-$D$19				
2	DRIFT	LINEARITY	HYSTERESIS	ENVIRON. EFF.	SEISMIC	SUMS SQUARED (+/-)						
3	%CS	%CS	%CS	%CS	%CS	ACCURACIES	ALL OTHERS		Non Testing Error :			
4	0 8/SQRT(C24)/100					((G5/100*$C$11)^2)	((I5/100*C8)^2)		E25: Primary Element Accuracy Random Error as a percent of Power			
5						0.00000000	0 00000000		C26 : Process Measurement Accuracy Random Error as a percent of RP			
6						0 00000000	0.00000000		D20: Flow Uncertainty Random Effect [Includes 0.25% ST] as a percent of Rx POWER			
7	0.2667%					0.00001111	0 00001111		O19: Squared combination of all Drift and other terms for LPRM and APRM Converted to percent of RP			
8	0.5000%					0 00010000	0 00003906		N16: Squared combination of accuracies for all LPRM and APRM averaging circuits Converted to percent of RP.			
9						0 00000000	0 00000000		C25 : Primary Element Accuracy Bias Error as a percent of Power			
10	0 0000%					0.00015625	0 00000000		D19: Flow Uncertainty Bias Effect as a percent of Rx POWER			
11	0 0000%					0 00015625	0 00000000					
12	0 0000%					0.00015625	0.00000000	LSp = AV - $C$10*SQRT(A35^2))				
13	0.0000%					0.00015625	0.00000000					
14	0 0000%					0.00015625	0 00000000		A35: Accuracy of the FCTR Card			
15						SUM(N5 N9)	SUM(O5:O9)					
16						0 00011111	0 00005017	Sum of the squares of the APRM/LPRM circuit drift and other errors SUM(P6 P10)				
17							0 00000079	CALIBRATION EQUIPMENT CONVERTED TO % RP AND SQUARED E18^2				
18							(D16/100*C10)^2					
19							0 00005096	Sum of the calibration error and the drift and other circuit errors.				
20							SUM(O16 O17)					
21												
22												
23						Maximum Total Loop Uncertainty	Applied Non-Testing Uncertainties					
24			FLOW BIASED SCRAM (20-30 9%)			-4.4972%	-3 2472%					
25			FLOW BIASED SCRAM (30 9 - 66.7%)			-4 8152%	-3 5652%					
26			FLOW BIASED SCRAM (66.7 - 99.0%)			-4 4107%	-3.1607%					
27			FLOW BIASED SCRAM (>99 0%)			-4 2893%	-3.0393%					
28			FIXED SCRAM (REDUCED) Old Methodology			-3 2752%	-3 0393%					
29												
30												
31	Method 1 AV	LIMITING SETPOINT										
32	ITS: (AV)	LSp	SETPOINT	ALLOWABLE	MARGIN	CTS: AS-FOUND TOLERANCE (FT)			CALIBRATION TOLERANCE			
33	% RP	% RP	(O35/125)*10	VALUE	(M2)	O35/C10+J35	S35*10	O35+G35	O35/$C$10+F35	V35*10	O35+E35	
34	$E$10+(L36*100)	N35+G36	Vdc	Vdc	% RP	%CS	Vdc	% RP	%CS	Vdc	% RP	
35	57 05	55 88	4 46	4 56	N/A	45 64%	4 56	57 05	45.14%	4 51	56 43	
36	N35-($D$10*$D$22)	O35-($D$10*$D$22)				43 64%	4 36	54 55	44 14%	4 41	55.18	
37	50 45	49 20										
38	0 33*Wd+50 45	0 33*Wd+49 20										
39												
40	Method 1 AV	LIMITING SETPOINT	SETPOINT	ALLOWABLE	MARGIN	CTS: AS-FOUND TOLERANCE (FT)			CALIBRATION TOLERANCE			
41	ITS: (AV)	LSp		VALUE	(M2)				(CT)			
42	% RP	% RP	Vdc	Vdc	% RP	%CS	Vdc	% RP	%CS	Vdc	% RP	
43	60.30	59 05	4 72	4 82	N/A	48 24%	4 82	60.30	47.74%	4.77	59 67	
44	27.23	25 98				46 24%	4 62	57 80	46 74%	4 67	58 42	
45	1 07*Wd+27.23	1.07*Wd+25 98										
46												
47	Method 1 AV	LIMITING SETPOINT	SETPOINT	ALLOWABLE	MARGIN	CTS: AS-FOUND TOLERANCE (FT)			CALIBRATION TOLERANCE			
48	ITS: (AV)	LSp		VALUE	(M2)				(CT)			
49	% RP	% RP	Vdc	Vdc	% RP	%CS	Vdc	% RP	%CS	Vdc	% RP	
50	99 02	97.77	7 82	7 92	N/A	79 22%	7 92	99 02	78 72%	7.87	98 40	
51	62.34	61 09				77 22%	7.72	96 52	77.72%	7 77	97.15	
52	0.55*Wd+62.34	0 55*Wd+61 09										
53												
54	Method 1 AV	LIMITING SETPOINT	SETPOINT	ALLOWABLE	MARGIN	CTS: AS-FOUND TOLERANCE (FT)			CALIBRATION TOLERANCE			
55	ITS: (AV)	LSp		VALUE	(M2)				(CT)			
56	% RP	% RP	Vdc	Vdc	% RP	%CS	Vdc	% RP	%CS	Vdc	% RP	
57	116 96	115.71	9 26	9.36	N/A	93 57%	9 36	116 96	92 97%	9 30	116 21	
58						91.57%	9.16	114 46	92 97%	9 30	116 21	
59												
60	Method 1 AV	LIMITING SETPOINT	SETPOINT	ALLOWABLE	MARGIN	CTS: AS-FOUND TOLERANCE (FT)			CALIBRATION TOLERANCE			
61	ITS: (AV)	LSp		VALUE	(M2)				(CT)			
62	% RP	% RP	Vdc	Vdc	% RP	%CS	Vdc	% RP	%CS	Vdc	% RP	
63	12 97	11.72	0 94	1 04	N/A	10.38%	1.04	12 97	9 78%	0 98	12.22	
64						8 38%	0 84	10 47	8 98%	0 90	11 22	

	A	B	C	D	E	F	G
1			APRM Scram Calculation for Extended Power Uprate Single Recirculation Loop Operation.				Values based on Tables 6 and 7 accuracy and drift
2			SPAN	Setpoint Slope	Analytical Limits	SENSITIVITY	ACCURACY
3	EQUIPMENT I.D.	INSTRUMENT TYPE	%		First Break Point % RP		%CS
4					0 33*D22+53.7		
5	ND-2-1-104	LPRM DETECTOR					
6		ICPS					
7		LPRM					0.2667%
8		APRM					0 8000%
9		<TYPE 5>					
10		FLOW BIASED SCRAM (20-39.1%)	125	0 33	57.70		1.0000%
11		FLOW BIASED SCRAM (39.1 - 61.7%)	125	1.07	64.04		1.0000%
12		FLOW BIASED SCRAM (61.7 - 119 4%)	125	0 55	88 24		1.0000%
13		FLOW BIASED SCRAM (>119.4%)	125	Maximum Value	120 00		1 0000%
14		FIXED SCRAM (REDUCED)	125	n/a	15.00		1 0000%
15				%CS			
16	CALIBRATION EQUIPMENT UNCERTAINTY (M&TE)			0 071%	(2 3 12 IN TEXT)		
17	FLOW INPUT UNCERTAINTY BIAS (FROM VYC-690, REV.2)			0.1137	0 058368	0 03698	
18	FLOW INPUT UNCERTAINTY RANDOM (FROM VYC-690, REV.2)			0.4673	0 434776	0 427428	CS FOR FLOW SIGNAL IS 128 6%
19	FLOW UNCERTAINTY BIAS EFFECT (% Rx POWER)			0 0483%	0 0803%	0 0262%	CS FOR POWER IS 125%
20	FLOW UNCERTAINTY RANDOM EFFECT (Includes 0 25% ST(Sec 2.3 4)) (% Rx POWER)			0.2249%	0 8901%	0.3502%	
21	FLOW SETTING TOLERANCE		0.25	(SORT(D18^2+C21^2)/100)*1 286*D10	(SQRT(E18^2+$C$21^2)/100)*1 286*D11	(SQRT(F18^2+$C$21^2)/100)*1.286*D12	
22	MINIMUM FLOW VALUES TO BE EVALUATED (% FLOW)			20	39.1	61.7	
23	FLOW VALUES TO BE EVALUATED (% FLOW)			20-39.1%	39.1 - 61 7%	61 7 - 119 4	
24	MINIMUM NUMBER OF LPRMs PER APRM		9				
25	PRIMARY ELEMENT ACCURACY (%RP) (Section 2.2.5)		0 82%	Bias +/-	0.340000%		
26	PROCESS MEASUREMENT ACCURACY (%RP) (Section 2.2 6) ±		2 29%				
27							
28	TECH SPEC LIMIT REQUIRED FOR CTS		120 00	% RP			
29	ANALYTIC LIMIT REQUIRED FOR ITS		120 00	% RP			
30							
31	Calculated as calibration tolerance if exists or accuracy of all components.				SRSS of Calibration Terms in % RP	SRSS of Calibration Terms	NON TESTING UNCERTAINTY
32	FLOW BIASED SCRAM (20-39.1%)			E35/$C$10	LOOP TESTING UNCERTAINTY	LOOP TESTING UNCERTAINTY	0 84*SQRT($E$25^2+$C$26^2+$D$20^2+$O$19+$N$18)
33	CALIBRATION EFFECT (CE)		CALIBRATION TOLERANCE	CALIBRATION TOLERANCE	$C$10*SQRT(A35^2)	SQRT(A35^2)	0 84*-SQRT($E$25^2+$C$26^2+$D$20^2+$O$19+$N$18)-$C$25-$D$19
34	%CS		% RP	%CS	% RP	%CS	% RP
35	1 0000%		0.625	0.50%	1 25	1.00%	2 2273%
36	-1.0000%		-0 625	-0 50%	-1 25	-1.00%	-3 0956%
37	G10						
38	-A35						
39							
40	FLOW BIASED SCRAM (39.1 - 61.7%)						
41	CALIBRATION EFFECT (CE)		CALIBRATION TOLERANCE	CALIBRATION TOLERANCE	LOOP TESTING UNCERTAINTY	LOOP TESTING UNCERTAINTY	NON TESTING ERROR
42	%CS		% RP	%CS	% RP	%CS	% RP
43	1 0000%		0.625	0 50%	1.25	1.00%	2 2938%
44	-1 0000%		-0 625	-0.50%	-1.25	-1.00%	-3.1941%
45							
46							
47	FLOW BIASED SCRAM (61.7 - 119 4%)		CALIBRATION				
48	CALIBRATION EFFECT (CE)		TOLERANCE		LOOP TESTING UNCERTAINTY	LOOP TESTING UNCERTAINTY	NON TESTING ERROR
49	%CS		% RP	%CS	% RP	%CS	% RP
50	1.0000%		0.625	0 50%	1.25	1.00%	2 2387%
51	-1 0000%		-0.625	-0 50%	-1 25	-1.00%	-3 0849%
52							
53							
54	FLOW BIASED SCRAM (>119 4%)		CALIBRATION				
55	CALIBRATION EFFECT (CE)		TOLERANCE		LOOP TESTING UNCERTAINTY	LOOP TESTING UNCERTAINTY	NON TESTING ERROR
56	%CS		% RP	%CS	% RP	%CS	% RP
57	1.0000%		0 50	0 40%	1.25	1.00%	2.2193%
58	-1.0000%		-0 50	-0 40%	-1.25	-1.00%	-3 0393%
59							
60	FIXED SCRAM (REDUCED)		CALIBRATION				
61	CALIBRATION EFFECT (CE)		TOLERANCE		LOOP TESTING UNCERTAINTY	LOOP TESTING UNCERTAINTY	NON TESTING ERROR
62	%CS		% RP	%CS	% RP	%CS	% RP
63	1 0000%		0 50	0.40%	1 25	1.00%	2.2193%
64	-1.0000%		-0 50	-0 40%	-1.25	-1.00%	-3 0393%

	H	I	J	K	L	M	N	O	P	Q	R	S	T
1		includes bias and random errors.					INSTRUMENTS		AV = AL - SQRT($E$25^2+$C$26^2+$D$20^2+$O$19+$O$10)-$C$25-$D$19				
2	REPEATABILITY	DRIFT	LINEARITY	HYSTERESIS	ENVIRON. EFF.	SEISMIC	SUMS SQUARED (+/-)						
3	%CS	%CS	%CS	%CS	%CS	%CS	ACCURACIES	ALL OTHERS		Non Testing Error :			
4							((G5/100*$C$11)^2)	((I5/100*C8)^2)		E25: Primary Element Accuracy Random Error as a percent of Power			
5							0.00000000	0.00000000		C26 : Process Measurement Accuracy Random Error as a percent of RP			
6							0.00000000	0.00000000		D20: Flow Uncertainty Random Effect [includes 0.25% ST] as a percent of Rx POWER			
7		0.2667%					0.00001111	0.00001111		O19: Squared combination of all Drift and other terms for LPRM and APRM Converted to percent of RP			
8		0.5000%				0.00	0.00010000	0.00003906		N16: Squared combination of accuracies for all LPRM and APRM averaging circuits Converted to percent of RP.			
9							0.00000000	0.00000000		C25 : Primary Element Accuracy Bias Error as a percent of Power			
10		0.0000%					0.00015625	0.00000000		D19: Flow Uncertainty Bias Effect as a percent of Rx POWER			
11		0.0000%					0.00015625	0.00000000					
12		0.0000%					0.00015625	0.00000000	LSp = AV - $C$10*SQRT(A35^2))				
13		0.0000%					0.00015625	0.00000000		Testing Error:			
14		0.0000%					0.00015625	0.00000000		A35: Accuracy of the FCTR Card			
15							SUM(N5:N9)	SUM(O5:O9)					
16							0.00011111	0.00005017	Sum of the squares of the APRM/LPRM circuit drift and other errors SUM(P6:P10)				
17								0.00000079	CALIBRATION EQUIPMENT CONVERTED TO % RP AND SQUARED E18^2				
18								(D16/100*C10)^2					
19								0.00005098	Sum of the calibration error and the drift and other circuit errors.				
20								SUM(O16:O17)					
21													
22													
23							Total Loop Uncertainty	Applied Non-Testing Uncertainties					
24				FLOW BIASED SCRAM (20-30.9%)			-4.3456%	-3.0956%					
25				FLOW BIASED SCRAM (30.9 - 66.7%)			-4.4441%	-3.1941%					
26				FLOW BIASED SCRAM (66.7 - 99.0%)			-4.3340%	-3.0840%					
27				FLOW BIASED SCRAM (>99.0%)			-4.2893%	-3.0393%					
28				FIXED SCRAM (REDUCED)			-3.2752%	-3.0393%					
29													
30													
31		Method 1 AV	LIMITING SETPOINT										
32	L35/$C$10*100	ITS: (AV)	LSp	SETPOINT	ALLOWABLE	MARGIN	CTS: AS-FOUND TOLERANCE (FT)			CALIBRATION TOLERANCE			
33		% RP	% RP	(O35/125)*10	VALUE	(M2)	O35/C10+J35	S35*10	O35+G35	O35/$C$10+F35	V35*10	O35+E35	
34	% CS	$E$10+(L36*100)	N35+G36	Vdc	Vdc	% RP	%CS	VDC	% RP	%CS	VDC	% RP	
35	1.782%	54.60	53.35	4.27	4.37	N/A	43.68%	4.37	54.60	43.18%	4.32	53.98	
36	-2.476%	N35-($D$10*$D$22)	O35-($D$10*$D$22)				41.68%	4.17	52.10	42.18%	4.22	52.73	
37		48.00	46.75										
38	Typical AV and Setpoint Curves	0.33*Wd+ 48.00	0.33*Wd+ 46.75										
39													
40		Method 1 AV	LIMITING SETPOINT	SETPOINT	ALLOWABLE	MARGIN	CTS: AS-FOUND TOLERANCE (FT)			CALIBRATION TOLERANCE			
41		ITS: (AV)	LSp		VALUE	(M2)				(CT)			
42	% CS	% RP	% RP	Vdc	Vdc	% RP	%CS	VDC	% RP	%CS	VDC	% RP	
43	1.8350%	60.84	59.59	4.77	4.87	N/A	48.67%	4.87	60.84	48.17%	4.82	60.22	
44	-2.5553%	19.01	17.76				46.67%	4.67	58.34	47.17%	4.72	58.97	
45		1.07*Wd+ 19.01	1.07*Wd+ 17.76										
46													
47		Method 1 AV	LIMITING SETPOINT	SETPOINT	ALLOWABLE	MARGIN	CTS: AS-FOUND TOLERANCE (FT)			CALIBRATION TOLERANCE			
48		ITS: (AV)	LSp		VALUE	(M2)				(CT)			
49	% CS	% RP	% RP	Vdc	Vdc	% RP	%CS	VDC	% RP	%CS	VDC	% RP	
50	1.7910%	85.15	83.90	6.71	6.81	N/A	68.12%	6.81	85.15	67.62%	6.76	84.53	
51	-2.4679%	51.22	49.97				66.12%	6.61	82.65	66.62%	6.66	83.28	
52		0.55*Wd+ 51.22	0.55*Wd+ 49.97										
53													
54		Method 1 AV	LIMITING SETPOINT	SETPOINT	ALLOWABLE	MARGIN	CTS: AS-FOUND TOLERANCE (FT)			CALIBRATION TOLERANCE			
55		ITS: (AV)	LSp		VALUE	(M2)				(CT)			
56	% CS	% RP	% RP	Vdc	Vdc	% RP	%CS	VDC	% RP	%CS	VDC	% RP	
57	1.7755%	116.96	115.71	9.26	9.36	N/A	93.57%	9.36	116.96	92.97%	9.30	116.21	
58	-2.4315%						91.57%	9.16	114.46	92.17%	9.22	115.21	
59													
60		Method 1 AV	LIMITING SETPOINT	SETPOINT	ALLOWABLE	MARGIN	CTS: AS-FOUND TOLERANCE (FT)			CALIBRATION TOLERANCE			
61		ITS: (AV)	LSp		VALUE	(M2)				(CT)			
62	% CS	% RP	% RP	Vdc	Vdc	% RP	%CS	VDC	% RP	%CS	VDC	% RP	
63	1.7755%	12.97	11.72	0.94	1.04	N/A	10.38%	1.04	12.97	9.78%	0.98	12.22	
64	-2.4315%						8.38%	0.84	10.47	8.98%	0.90	11.22	

4.4.2.1. The detector sensitivity shall be such that the output of the signal conditioner corresponds to the required percent power reading associated with the neutron flux level in the vicinity of the detector.

4.4.2.2. The range of neutron flux (operating) shall be as specified on the data sheets.

4.4.2.3. The range of neutron flux at 100 percent reactor power shall be as specified on the data sheets.

4.4.2.4. The range of gamma dose rate at 100 percent reactor power shall be as specified on the data sheets.

4.4.2.5. The detector shall be designed such that the saturation characteristics of the detector do not cause an error in the signal due to power supply variations of greater than ±1 percent of the 100 percent reactor power value over the operating neutron flux range specified in the data sheets.

4.4.2.6. The detector shall be so designed that the true output shall not deviate from the ideal output by more than ±1 percent of the 100 percent reactor power value over the top decade of the operating flux range specified in the data sheets.

4.4.2.7. The detector shall have a minimum lifetime of 2.0 years in the lifetime neutron flux specified in the data sheets. End-of-life is defined as having occurred when the ratio of the output signal resulting from neutrons, to the output signal resulting from gammas, reaches 5 to 1.

4.4.2.8. The detector/cable leakage current shall not exceed ±1.6 percent of the full scale output during the life of the detector. Leakage current is defined as that current presented to the signal conditioning equipment when the detector is at operating conditions but with no neutron or gamma flux present.

4.4.2.9. The detector and detector assembly environment shall be as follows:

a. Neutron and Gamma Flux at Detector as specified on the data sheets.

b. Dose Rates at Detector Assembly Connector:

Gamma: 2.4 R/hr
Neutrons: 10 rem/hr

c. Reactor Pressure:

Operation: 1025 psig at 546°F
Design: 1250 psig at 600°F
Maximum Emergency Pressure: 1375 psig at 583°F

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4.4.5.2. The true output of the signal conditioning equipment shall not deviate from the ideal output by more than ±0.8 percent of full scale at control room design center environmental conditions over the range of flux (operating) specified in the data sheets.

4.4.5.3. At the control room design center environmental conditions specified in the data sheets, the equipment shall not have a long term drift (700 hours) greater than ±0.8 percent of full scale.

4.4.5.4. The signal conditioning equipment shall be designed so that the gain can be set at a desired value within ±0.1 percent of the full scale value over its range of adjustment. The gain shall be adjustable in three steps and each step shall be continuously adjustable by at least a factor of 5.

4.4.5.5. The signal conditioning equipment shall provide a 0 to 160 mV for zero to full scale output for the computer.

4.4.5.6. The signal conditioning equipment shall provide a 0 to 10 volt signal to the Average Power Range Monitoring system. Assignment of the various signal conditioning outputs to the APRM's is made on the Instrument Engineering Diagram (IED) listed in Paragraph 2 of the data sheets. The signal conditioner shall be designed such that two APRM's may be driven from each LPRM signal conditioner output.

4.4.5.7. The signal conditioning equipment shall provide a 0 to 10 volt signal to the Rod Block Monitor (RBM) System specified in Paragraph 4.8.8. The required "A" core level and "C" core level conditioned detector signals shall be connected through a switching matrix to the RBM associated with Reactor Protection System Trip System A. The required "B" core level and "D" core level conditioned detector signals shall be connected through the switching matrix to the RBM associated with Reactor Protection System Trip System B. The appropriate inputs shall be automatically switched upon selection of a rod. Selection details are found on the Instrument Engineering Diagram (IED) listed in Paragraph 2 of the data sheets.

4.4.5.8. Signal Output to LPRM Meter Group Display - The equipment shall be designed such that a group of conditioned outputs are provided to the LPRM Group Display upon selection of a control rod. Particular selection and routing details are as specified on the Instrument Engineering Diagram (IED) listed in Paragraph 2 of the data sheets.

4.4.6. <u>Trip and Alarm Functions</u>. The following trip and alarms are required:

a. Upscale Level Alarm

b. Downscale Level Alarm

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4.4.1. (continued)

These sources are placed axially in the core as shown on Figure 1, and radially as shown on the instrument engineering diagram listed in Paragraph 2 of these data sheets. The sources shall be irradiated in a manner described on the irradiation specification listed on the Neutron Source Drawing listed in Paragraph 2 of these data sheets.

b. Penetrations shall be designed and installed such that special coaxial cables can be used for connection of detectors to signal conditioning equipment.

4.4.2. Intermediate Range Monitoring System. Penetrations - same as Paragraph 4.4.1 above.

4.4.3. Power Range Monitoring Systems

a. Detector and Detector Assembly shall be placed within the core in the manner shown in Figure 2 of these data sheets.

b. Range of Operating Neutron Flux shall be from 1.2×10^{12} nv to 2.8×10^{14} nv.

c. The Neutron Flux at 100 percent Reactor Power in the vicinity of the detector shall be within the range of 9.4×10^{13} nv to 2.8×10^{14} nv. The peak neutron flux at 120 percent of rated power will be 3.4×10^{14} nv. The detector signal resulting from this flux shall not deviate from the ideal output by more than (later) percent of the 100 percent rated power value.

d. The Gamma Flux at 100 percent Reactor Power in the vicinity of the detector shall be within the range of 4.2×10^{8} R/hr to 1.2×10^{9} R/hr.

e. Detector Lifetime Neutron Flux shall be 1.84×10^{21} nv maximum at the maximum gamma flux specified.

4.4.4. Local Power Range Monitoring. When the reactor power is distributed with octant symmetry, the equivalent positions shall be as shown in Table I of these data sheets.

4.4.5. Average Power Range Monitoring. The number of LPRM outputs used as input to an APRM that may be bypassed at any one time shall not exceed one* for APRMs that have ten LPRM inputs (not counting LPRMs powered from another bus) and seven for an APRM that has twenty unshared LPRM inputs.

*Under conditions where all LPRM signals from and associated with the companion LPRM are missing.

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GENERAL ELECTRIC

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REV NO. 01

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TITLE DESIGN & PERFORMANCE SPEC.
A P R M
FIRST MADE FOR DESIGN STANDARDS 212.7.3

REVISIONS
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1.0 TEMPERATURE AND HUMIDITY	
1.1 Restricted	175A9680 para. 1.1
1.2 Full	175A9680 para. 1.2
2.0 POWER	
2.1 +5 volts DC	175A9683
2.2 ±15 volts DC	175A9698
3.0 INPUTS	
3.1 LPRM	
3.1.1 Polarity and Range	0 to +10 volts DC
3.1.2 Maximum number to operate	24
3.1.3 Minimum number to operate in spec.	10
3.1.4 Minimum number to operate	6
3.2 LPRM Bypass	1 for each LPRM
3.3 LPRM Count	
3.3.1 Number	1
3.3.2 Polarity and Range	-0.5 ma per LPRM
3.4 Calibrator Power	
3.4.1 Number	1 for each LPRM
3.4.2 Value	-14 volts DC nominal
3.5 Flow	2 to 10 volts DC nominal
4.0 OUTPUTS	
4.1 Recorder	0 to -1 volt
Output Impedance	1.2K ohms
4.2 Computer	0 to -160 mv
Output Impedance	215 ohms
4.3 Meter	0 to -10 volts DC
4.4 RBM Reference Signal (Isolated)	0 to -10 volts DC

5.0 CONTROLS AND INDICATORS

5.1 Mode Switch

5.1.1 Operate

5.1.2 Standby. Same as 5.1.1 except inoperative trip is tripped.

5.1.3 Zero. LPRM's disconnected, DC amp can be adjusted to zero.

5.1.4 Power Test. Operator may apply and adjustable simulated power signal while still connected to the actual flow signal.

5.1.5 Power and Flow Test. Operator may apply adjustable simulated signals for both Power and Flow.

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TITLE DESIGN & PERFORMANCE SPEC.
A P R M
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REVISIONS
1 Ted Bush 10-4 REVISED FIRST MADE FOR

5.2 Meter Function Switches

5.2.1 Average. Average output of LPRM's not bypassed.
5.2.2 Flow. Output from Flow Converter in percent Flow.
5.2.3 Count. Number of LPRM's being Averaged. Meter reading is 5 times the number.
5.2.4 A1-A6, B1-B6, C1-C6, D1-D6. Meter reads output of each LPRM. Selects calibrator power from observed LPRM.

5.3 Meter Reverse, Expand Switch

5.3.1	Reverse	1 volt f.s.
5.3.2	Normal	10 volts f.s.
5.3.3	X10 expand	1 volt f.s.

5.4 Power Test Potentiometer. Adjustable simulated Power signal; Range-zero to greater than full scale.
5.5 Flow Test Potentiometer. Adjustable simulated Flow signal; Range-less than zero to greater than 100% Flow.
5.6 Calibration Adjust Potentiometer. Controls voltage to precision resistors of Calibrator Range-0 to greater than -10 volts DC.
5.7 Calibration Monitor Switch. Allows Calibrator voltage to be viewed on meter.
5.8 LPRM Bypassed Light. Indicates when LPRM being monitored is in the Calibrate or Bypassed condition.
5.9 Meter Expand Light. Indicates when the meter Reverse, Expand Switch is in a position other than Normal.
5.10 Trip Reset Switch. Resets all latching trips in the APRM and associated LPRM's.

6.0 PERFORMANCE

6.1 Averaging Circuitry

6.1.1	Accuracy (includes Linearity and Stability)	
	Restricted Conditions	±0.8%
	Full Conditions	±2.4%
6.1.2	Drift	±0.5%/2 weeks
6.1.3	Response Time	<5 ms
6.1.4	Gain	2.5 ±40%

6.2 Trip Circuits (Non-Flow Biased)
Specs. apply when using Quad Trip Unit 136B1322 and Trip Reference Unit 136B1321.

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GENERAL ELECTRIC

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TITLE DESIGN & PERFORMANCE SPEC.
APRM
FIRST MADE FOR DESIGN STANDARDS 212.7.3

175A1259.
CONT ON SHEET F SH NO. 3

REVISIONS
1 : REVISED FIRST MADE FOR

6.2.1 Accuracy
Restricted Conditions ±1% f.s
Full Conditions ±2% f.s
6.2.2 Drift ±0.5%/2 weeks

6.3. Trip Circuits (Flow Biased) specs. apply when using Quad Trip Unit 136B1322, Trip Reference Unit 136B1321, and Trip Bias Unit 216X541.

6.3.1 Accuracy

6.3.1.1 Restricted Conditions
50 to 100% flow ±1%
0 to 50% flow ±2%
6.3.1.2 Full Conditions
50 to 100% flow ±2%
0 to 50% flow ±3%

6.4 Count Trip Reference

6.4.1 Linearity
Restricted Conditions ±1%
Full Conditions ±2%
6.4.2 Stability
Restricted Conditions ±1%
Full Conditions ±2%
6.4.3 Drift ±0.5%2 weeks

7.0 CONSTRUCTION

7.1 Cards
7.2 Modules
7.3 Mechanical Keying

8.0 TEST REQUIREMENTS 175A1299

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REVISION STATUS SHEET

DOC TITLE FLOW CONTROL TRIP REFERENCE CARD

LEGEND OR DESCRIPTION OF GROUPS
| - DENOTES CHANGE

TYPE: DSGN SPEC.

FMF: OPTION 1A

MPL ITEM.: NA

IEEE CLASS 1E
THIS ITEM IS OR CONTAINS A SAFETY RELATED ITEM YES [X] NO [ ] EQUIP CLASS CODE A

REVISION			C
0	RM-01079 JUN 20, 1994		
1	R.A. SEARLES FEB 08, 1995	RJA	
	CN02137 CHK BY: R.A. SEARLES ENGR: C.J. MILLER		
2	R.A. SEARLES DEC 09 1996	RJA	
	CN04842 CHK BY: R.A. SEARLES ENGR: S.D. SAWYER		

PRINTS TO

MADE BY	APPROVALS	GENERAL ELECTRIC COMPANY 175 CURTNER AVENUE SAN JOSE CALIFORNIA 95125
C.J. MILLER FEB 09, 1994	P.J. KINDER JUN 10, 1994	
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1. DOCUMENT DESCRIPTION

1.1 DOCUMENT PURPOSE AND USE

This Design Specification describes in quantitative terms the characteristics of the FLOW CONTROL TRIP REFERENCE CARD.

These characteristics are grouped as follows:

- Inputs to the card - their information content and electrical characteristics
- Outputs from the card - their information content and electrical characteristics
- The functions of the card - its information processing, transfer functions, and the interrelationships between the inputs and the outputs
- The physical environment under which the card will function properly
- The card's physical parameters - size, shape, type and placement of connectors
- Application information - potential safety hazards

1.2 DOCUMENT SCOPE

This document describes the performance of the FLOW CONTROL TRIP REFERENCE CARD with respect to its use as a component part.

2. RELATED DOCUMENTS

2.1 REQUIREMENTS

a) BWROG Hardware-Related Task Authorization for Stability LTS Enhanced Option I-A: 94.159.0, .5, 95.159.0, .5, .7, 96.159.0

b) NUMAC Requirements Specification: 23A5082

c) NUMAC Software Configuration Management Plan 23A5161 (meets requirements of ANSI/IEEE 7-4.3.2-1982)

d) NEDO-32339-A Class 1, December 1996 - Licensing Topical Report, Reactor Stability Long-Term Solution Enhanced Option I-A

e) NEDO-32339-P Supplement 2, Enhanced Option I-A Solution Design, April 1995, with errata 8/1/95, 9/15/95, 1/31/96, 3/27/96, and 11/27/96

f) NEDO-32339 Supplement 5, Enhanced Option I-A Solution Closure, September 1996

2.2 APPLICABLE STANDARDS

a. MIL HDBK-217F Reliability Prediction of Electronic Equipment

b. GE 265A1148 Specification for Printed Circuit Boards

c. IEEE 323-1974 Qualifying Class 1E Equipment for Nuclear Power

d. IEEE 344-1975 Seismic Qualification of Class 1E Equipment for Nuclear Power

e. GE 100 Series Electromagnetic, Interference and Susceptibility

3. DESCRIPTION

3.1 GENERAL

The FLOW CONTROL TRIP REFERENCE CARD is a Class 1E component. This card provides all of the functions required by the original equipment and section 2.2, and will not deter from the current mechanical parameters or electrical connections in order to implement new features, unless otherwise requested. Logic common, if not present at the connector, will be connected to present unused pins. In addition, this card provides input flow signal validation to ensure fail safe operation. This card may be inserted and removed under power without danger and will automatically reinitiate after completion of an internal self-test (approx. 5 sec.). This card provides for the following interface between the input flow and the output references:

- Provides flow signal output following noise & EMI filtering.
- Provides a Scram Trip Reference based on a derived core flow function residing in memory for the recirculation Two Loop Operation, Two Loop Setup Operation, Single Loop Operation and Single Loop Setup Operation settings.
- Provides a control rod block Trip Reference based on a derived core flow function residing in memory for the recirculation Two Loop Operation (TLO), TLO Setup, Single Loop Operation (SLO), and SLO Setup settings with slope and offset adjustment.
- DIP switches provide selection of alignment constants for the Recirculation Drive/Core Flow transfer function.
- DIP switches provide selection of an alternate set of trip reference function tables.
- DIP switches provide constants for the Power Based Adjustment transfer function.
- Provides a recorder output of the control rod block Trip Reference with offset adjustment.
- Provides validation of incoming flow signal (out-of-range high or low).
- Provides an INOP output contact that is actuated if the card is not operable or fails self test.
- Status LED provides visual latched confirmation of status (INOP).
- Status pushbutton provides reset of status (INOP).
- Setup LED provides visual latched confirmation of setpoint Setup condition.
- Setup pushbutton alternately changes between SETUP and NORMAL setpoint arrays.
- Provides for automatic reset of trip reference setpoints to normal based on a preset control rod block trip reference value.
- Provides a factory test output.

3.2 PHYSICAL

The FLOW CONTROL TRIP REFERENCE CARD is designed in two different size configurations. The FLOW CONTROL TRIP REFERENCE CARD is designed as a pin-compatible replacement for the existing FCTR Card in the APRM page. See Section 7, Specified Mechanical Characteristics, for details.

3.3 FIRMWARE

This card contains firmware for providing recirculation drive flow based setpoints associated with the input-output interface.

4. OPERATIONAL PERFORMANCE

4.1 ACCURACY

The FLOW CONTROL TRIP REFERENCE CARD will be designed to operate with an accuracy of ±1.0 % over 36 months due to environmental, initial calibration and accuracy drift.

4.2 SERVICE LIFE

The target service life for the FLOW CONTROL TRIP REFERENCE CARD is to operate continuously (within the specified environmental limits, and allowing for replacement of failed components) for at least 40 years.

4.3 POWER REQUIREMENTS

This card will require +15 VDC, -15 VDC, Analog Common & Digital Common for normal operation. Digital Common will be required for EMI grounding purposes even though +5 VDC is not being used. The +5 VDC will be generated on board from the +15 VDC. The card connections will be compatible with the present pin-out configuration in the APRM page connector with the Digital Common if connected, taken from the present logic common pin-out. If not connected, then the logic common will be connected to present unused pins. The power requirements of this card will not adversely affect the APRM page's power supply capability. Application and tolerances are listed below.

4.3.1 POSITIVE LOGIC CIRCUIT SUPPLY VOLTAGE
(Generated on board from the +15 VDC & Analog Common)

Application: +5 Volt DC power used for internal logic.

PARAMETER	SYMBOL	MIN LIMIT	OPERATING MAX	OPERATING MAX	MAX LIMIT	UNITS
Logic Supply Voltage	Vcc	0	4.5	5.5	5.5	VDC
Logic Supply Ripple Voltage	Vccr	0	0.00	0.05	0.10	VRMS

4.3.2 POSITIVE ANALOG CIRCUIT SUPPLY VOLTAGE

Application +15 Volt DC power used for internal ADC's, DAC's, amplifiers, etc.

PARAMETER	SYMBOL	MIN LIMIT	OPERATING MAX	OPERATING MAX	MAX LIMIT	UNITS
Positive Analog Supply Voltage	Vdd	0	14	16	16	VDC
Analog Supply Ripple Voltage	Vddr	0	0.00	0.01	0.10	VRMS

4.3.3 NEGATIVE ANALOG CIRCUIT SUPPLY VOLTAGE

Application: -15 Volt DC power used for internal ADC's, DAC's, amplifiers, etc.,

PARAMETER	SYMBOL	MIN LIMIT	OPERATING MAX	OPERATING MAX	MAX LIMIT	UNITS
Negative Analog Supply Voltage	Vss	0	-14	-16	-16	VDC
Analog Supply Ripple Voltage	Vssr	0	0.00	0.01	0.10	VRMS

4.4 SAMPLE TIME

The minimum time for sampling the flow input is 4 msec. The interval for updating the trip references is 28 msec.

4.5 ANTI-ALIASING FILTER

The flow input anti-aliasing filter is set at <20 Hz.

4.6 RESPONSE TIME

The maximum response time from input to output is 250 msec,

4.7 AUTOMATIC TRIP REFERENCE SELECTION

Trip reference functions are identified as setup and non-setup. When the control rod block setpoint exceeds a specified Automatic Setdown Setpoint, the trip reference functions are taken from the non-setup tables, even if the setup selection has been made with the pushbutton selector switch provided.

4.8 RECIRCULATION DRIVE CORE FLOW TRANSFER FUNCTION

The Recirculation Drive/Core Flow transfer function will be adjustable to accommodate variations in this relationship. Two four-position DIP switches, operating in binary, are used to select the appropriate alignment constants used in the transfer function. There will be a maximum of sixteen choices for each of two alignment constants.

4.9 POWER BASED ADJUSTMENT ADDER

The Power Based Adjustment Adder provides an adjustment to the output trip reference setpoints. The same adjustment adder is applied to both output trip references. Three of four switches are used to provide eight choices for the adjustment adder. Selection of an adjustment adder of zero results in no adjustment to the output trip references.

4.10 ALTERNATE TRIP REFERENCE SELECTION

Two complete sets of trip reference arrays are stored in memory. One switch of a four DIP switch is used to select between SET1 (primary) and SET2 (alternate).

5. PROGRAMMING INFORMATION

5.1 TRIP REFERENCE ARRAYS

At least 512 points (9-bit resolution) composing an array of each specified function (plant specific) will be held in memory. There will be up to a maximum of two sets, each consisting of eight (8) transfer functions. These functions are programmed into the memory component (installed on a EPROM) and can only be changed by component replacement .

5.2 TRIP REFERENCE FUNCTION SPECIFICATIONS

The 512 point, (9-bit resolution) tables for each plant-specific trip reference function are specifies as:

1. Single Loop Operation (SLO) NORMAL
   a. Scram
   b. Control rod block

2. Two Loop Operation (TLO) NORMAL
   a. Scram
   b. Control rod block

3. SLO Setup
   a. Scram
   b. Control rod block

4. TLO Setup
   a. Scram
   b. Control rod block

These functions are programmed into the memory component (installed on a socket) and can only be changed by component replacement.

5.3 SIGNAL VALIDATION

The input recirculation drive flow will be validated to confirm that it is not out-of-range (high >130 or low < -15%).

5.4 AUTOMATIC SETDOWN SETPOINT

The Automatic Setdown Setpoint is provided for each pair of TLO (NORMAL/SETUP) and SLO (NORMAL/SETUP) trip references. The setpoint is programmed into EPROM.

6. SPECIFIED I/O CHARACTERISTICS

6.1 INPUTS

6.1.1 ELECTRICAL INPUTS

1. Input Flow: 0 to 10 volts DC (relates to 0 to 125 % flow)
   Input impedance, Z_{in}, is 100 KΩ.

6.1.2 LOCAL OPERATOR'S INPUTS

1. Recirc TLO/SLO (switch allows choice)
2. INOP Reset (pushbutton)
3. Recorder offset adjustment
4. SETUP (pushbutton - alternate action)
5. DIP switches for drive flow alignment constants, power-based adjustment constant, and Alternate trip reference selection

a) Manual Reset:
   1. Pushbutton
   2. Change in switch status (TLO/SLO)

b) Automatic Reset:
   1. From SETUP to NORMAL of a specified rod block setpoint corresponding to 5% recirculation drive flow above A'nom [1]
   2. Power failure
   3. Exiting INOP

Upon reset of SETUP, current recirculation TLO/SLO switch setting will determine the applicable arrays applied

6.2 OUTPUTS

6.2.1 ELECTRICAL OUTPUTS

1. Output Recirc Drive Flow: 0 to +10 volts DC
2. Scram Trip Reference: 0 to -10 volts DC
3. Control rod block Trip Reference: 0 to -10 volts DC
4. Control rod block Recorder, 0 to -1 volt DC with an offset of ± 100 mV
5. INOP: normally open (N.O.) contact, non-latched. Open, non-energized, on INOP.

[1] A'nom - the highest flow in operating domain associated with Restricted Region of recirculation drive flow transfer function (plant specific),

[2] A critical Self-test fault zeroes the Scram and Rod Block trip references (forces APRM scram and rod block)

6.2.1.1 FACTORY TEST OUTPUT

Single digital fiber-optic communication output, transmitter only, at a data rate of 19.2 kHz. Hewlett-Packard HFBR-1414T fiber-optic transmitter.

6.2.2 LOCAL OPERATOR'S INDICATION

1. A non-latched two color LED to indicate trip reference setup condition. LED color indications are:

• GREEN:	Normal boundaries
• YELLOW:	Setup boundaries
• YELLOW (slow blink):	Flow validation inhibit (normal boundaries)
• YELLOW (double blink):	Flow validation inhibit (setup boundaries)

2. A latched two color LED to indicate card INOP Status. LED color indications are:

• GREEN:	Operating Normal
• RED (steady):	Current INOP (self-test fault)
• RED (slow blink):	Previous INOP, cleared, but not reset (Initial power-up or previous self-test fault) *
• RED (fast blink):	Flow validation fault
• RED/GREEN (fast blink):	Previous Flow validation fault *
• OFF:	No power to card

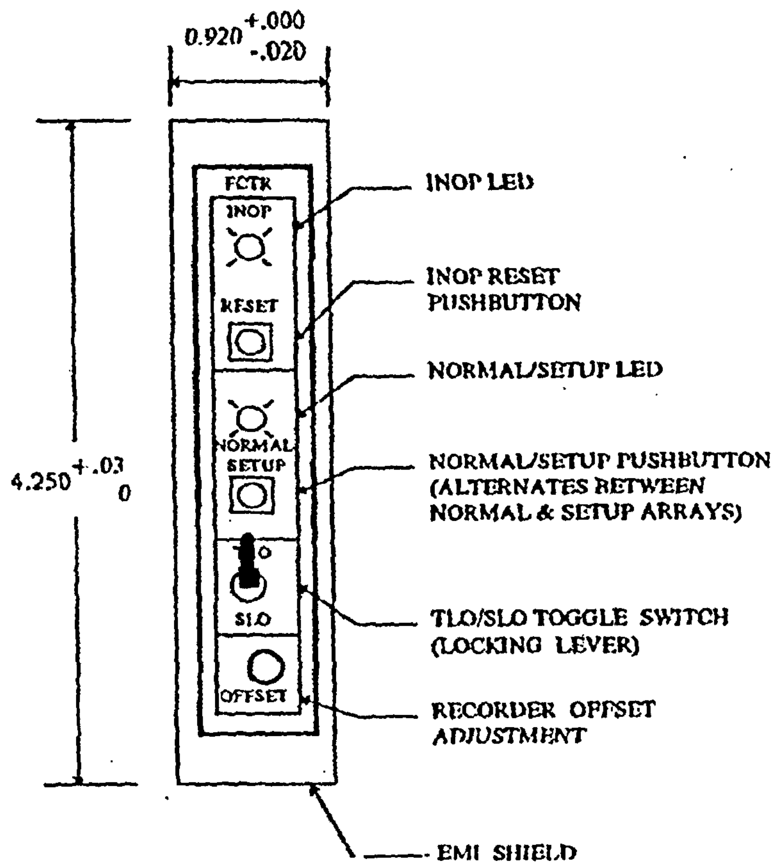
* Previous INOP or flow validation fault is reported and reset in the order of occurrence.

[1] Non-latched

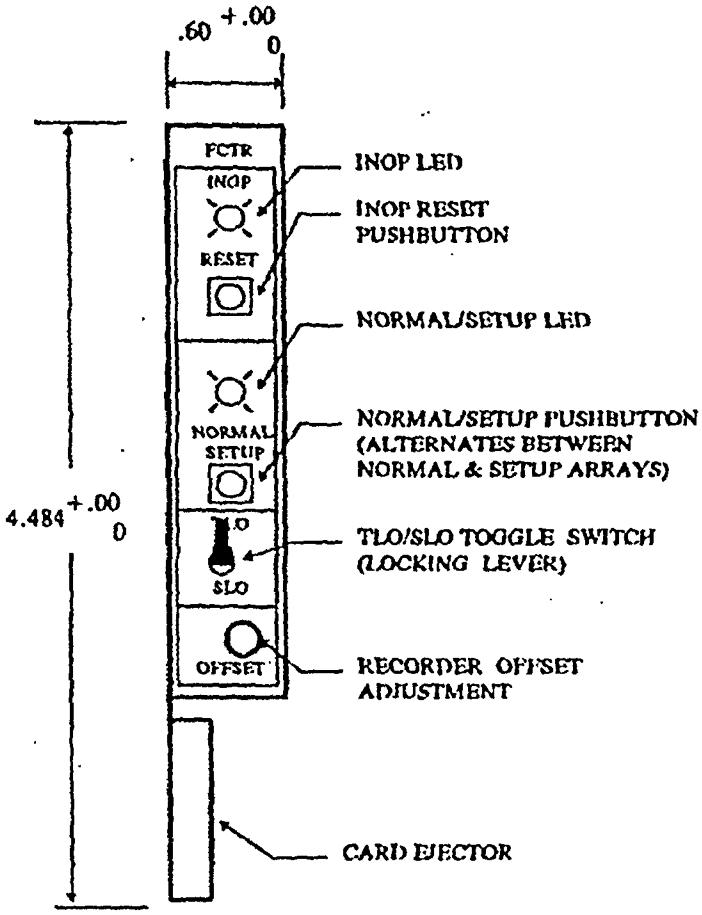
[2] If an INOP occurs (RED) and then clears automatically, this indication will be latched RED-blinking) which indicates normal operation but with a past INOP. This can be reset by the INOP Reset pushbutton.

7. SPECIFIED MECHANICAL CHARACTERISTICS

7.1 METAL CASE: (BWR 3 - early BWR 4)

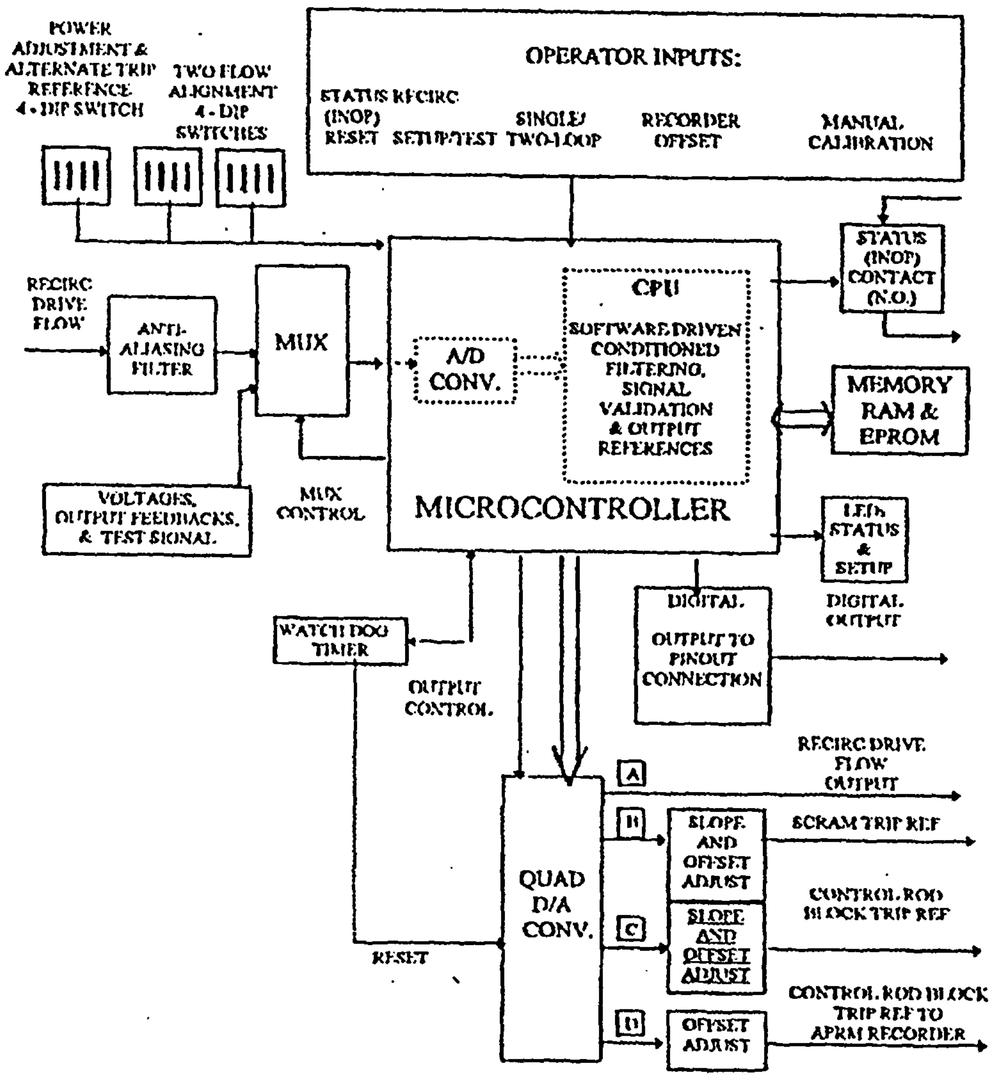


7.2 SMALL - 44 PIN: (late BWR 4 - BWR 6)



8. BLOCK DIAGRAM

-- BLOCK DIAGRAM --



9. SPECIFIED OPERATING ENVIRONMENT

The FLOW CONTROL TRIP REFERENCE CARD will not adversely affect or be affected by the operation of any other components or equipment operating within the same environment.

9.1 TEMPERATURE AND HUMIDITY LIMITATIONS

This card will perform all specified functions correctly when operated within the specified temperature range illustrated in Figure 9-1 and the, specified relative humidity range illustrated in Figure 9-2 (Applicable Standard 2.2 c).

Figure 9-1, Temperature Limitations

(0 °C < Ta < 70 °C)

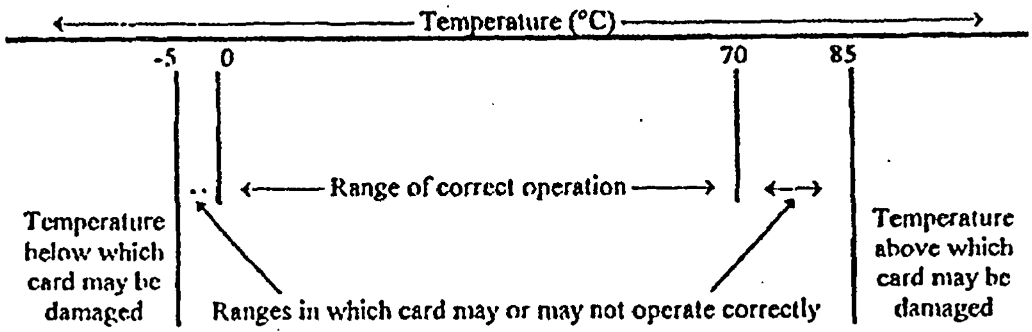
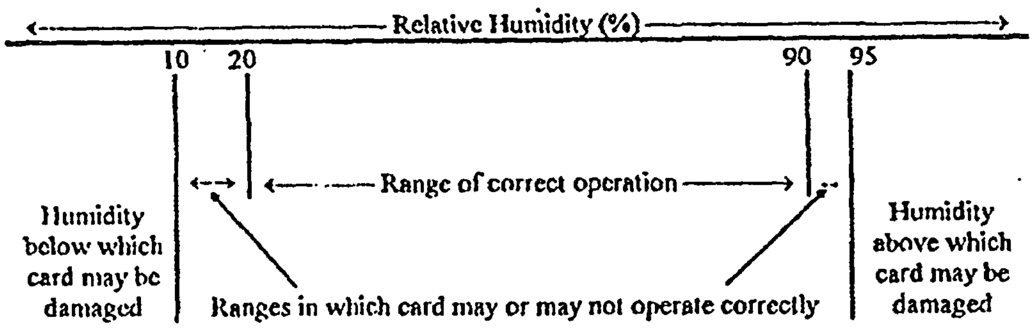


Figure 9-2, Humidity Limitations

(20% < Rel Humidity < 90%)



9.2 ELECTROMAGNETIC INTERFERENCE

The FCTR card is qualified for electromagnetic compatibility (EMC) by type testing and analysis. The EMC testing performed eliminates the need for utilities to perform in-plant electromagnetic environment surveys in accordance with EPRI guidelines (Reference 7).

9.2.1 SUSCEPTIBILITY

The FCTR card is mounted within the existing cabinets of the NMS and derives power from NMS power supplies. Therefore, power and signal conducted noise immunity are not significantly affected by the replacement or addition of these cards. The existing power supply immunity to conducted noise and power surges remains unchanged. Thus, the only EMC susceptibility tests performed on the FCTR card are:

- Electrostatic Discharge (ESD) - IEC-801-2
- Simulated Lightning Strike Conducted Immunity Test (using pulse measurements provided by Entergy Operations, Inc.)
- Radiated Electric Field Test (demonstrate that adequate margins exist for proper FCTR operation when installed into an existing NMS page under electromagnetic near-field emissions from adjacent cards)

9.2.2 EMISSIONS

The radiated emissions test confirm that the FCTR card has sufficiently low near-field emissions as to not affect the existing NMS pages. Similar to 9.2.1 above, there is no accepted test level for this application; therefore, it must be established as follows:

- Radiated Electric Field Test (demonstrate that adequate margins exist for adjacent cards to operate without electromagnetic near-field interference from the FCTR card installed into an existing NMS page)

9.3 AMBIENT PRESSURE LIMITATIONS

This card will perform to specification for any absolute pressure in the range of 13 psi to 16 psi.

9.4 RADIATION EXPOSURE LIMITATIONS

9.4.1 DOSE RATE

The card will perform to specification over its design life in a gamma field of 3 mR/hr or less.

9.4.2 TOTAL DOSE

This card will perform to specification over its service life for a total integrated gamma dose of 1×10^3 Rads.

9.5 SEISMIC DISTURBANCE LIMITATIONS

The FCTR Card will be qualified based on applicable areas described in IEEE 344-1975 (Applicable Standard 2.2-d). The APRM page environment will be established through analysis, and it will be determined that the addition of the FCTR into the APRM page will not significantly degrade existing system performance when subjected to seismic events. Documentation will show that qualified tests and levels (or analysis) cover APRM page environment for this application.

10. SAFETY PRECAUTIONS

10.1 PERSONNEL SAFETY

- ELECTRICAL

No voltage greater than 28 volts ± tolerance (for Status INOP contact) is present on this card. This card may be removed under power without danger.

- MECHANICAL

No moving parts will cause personal danger.

- THERMAL

None; no high temperatures are present on this card.

- RADIOLOGICAL

None- no radioactive materials are incorporated into this card.

- CHEMICAL

None - no corrosive or toxic substances are incorporated into this card,

11. TEST REQUIREMENTS

11.1 AUTOMATIC SELF-TEST

An automatic self-test feature will be used on this card. This feature will automatically test at least once per minute. If an error or occurs an INOP will be initiated.

- A known internal reference is used, with its outputs, Scram & Control Rod Block Trip References, internally checked against the expected outputs to verify correct system operation.
- The voltages; power, logic. & reference are monitored to verify they are within tolerance.
- The CPU monitors power failures to ensure fail-safe operation.
- Watch dog supervisory circuit is used to ensure correct software operation, cycle timing and logic power failure.
- Voltages from the DAC are fed back through the ADC to ensure correct hardware conversion operation
- Self-test diagnostic testing ensures correct DAC operation and sets its output to "0" if the signal is not updated (frozen).

11.2 MANUAL SURVEILLANCE/CALIBRATION

Manual surveillance will be required at least every 36 months. This will consist of inputting an existing externally known simulated recirc drive flow signal to verify correct system operation.

Test points are provided for measuring the power voltages (+5 VDC, +15 VDC & -15 VDC) and the system clock (16 MHz).

9.2.2 EMISSIONS

Again, there is no accepted test level for this application, therefore, it must be established. The test levels for emissions for the APRM page will be established by the following:

- Qualify new FCTR CARD per emission test at derived susceptibility qualification level above
- Document how qualified tests and levels cover APRM page environment for this application

9.3 AMBIENT PRESSURE LIMITATIONS

This card will perform to specification for any absolute pressure in the range of 13 psi to 16 psi.

9.4 RADIATION EXPOSURE LIMITATIONS

9.4.1 DOSE RATE

This card will perform to specification over its service life in a gamma field of 1x10E-5 rads /sec or less.

9.4.2 TOTAL DOSE

This card will perform to specification over its service life for a total integrated gamma dose of 1x10E4 rads.

9.5 SEISMIC DISTURBANCE LIMITATIONS

The FCTR Card will be qualified based on applicable areas described in IEEE 344-1975 (Applicable Standard 2.2 d). The APRM page environment will be established through analysis, and it will be determined that the addition of the new FCTR into the APRM page will not significantly degrade existing system performance when subjected to seismic events. Documentation will show that qualified tests and levels (or analysis) cover APRM page environment for this application.

10. SAFETY PRECAUTIONS

10.1 PERSONNEL SAFETY

- ELECTRICAL
  No voltage greater than 28 volts ± tolerance (for Status/INOP contact) is present on this card. This card may be removed under power without danger.

- MECHANICAL
  No moving parts will cause personal danger.

- THERMAL
  None; no high temperatures are present on this card.

- RADIOLOGICAL
  None; no radioactive materials are incorporated into this card.

- CHEMICAL
  None; no corrosive or toxic substances are incorporated into this card.

11. TEST REQUIREMENTS

11.1 AUTOMATIC SELF-TEST

An automatic self-test feature will be used on this card. This feature will automatically test at least once per minute. If an error occurs an INOP will be initiated.

- A known internal reference is used, with its outputs, Scram & Alarm References, internally checked against the expected outputs to verify correct system operation.

- The voltages; power, logic & reference are monitored to verify they are within tolerance.

- The CPU monitors power failures to ensure fail-safe operation.

- Watch dog supervisory circuit is used to ensure correct software operation, cycle timing and logic power failure.

11.1 AUTOMATIC SELF-TEST (con't)

- Voltages from the DAC are fedback through the ADC to ensure correct hardware conversion operation.
- Self-test diagnostic testing ensures correct DAC operation and sets its output to "0" if the signal is not updated (frozen).

11.2 MANUAL SURVEILLANCE / CALIBRATION

Manual surveillance will be required at least every 36 months. This will consist of inputting an existing externally known simulated recirc drive flow signal to verify correct system operation.

Test points are provided for measuring the power voltages (+5 VDC, +15 VDC & -15 VDC) and the system clock (16 MHz).

FCTR Accuracy & Drift

The 148C6411 Digital FCTR card (schematic 105E1374) has an analog front-end consisting of an analog mux (233A3701 based on the ADG516A), quad op amp (233A3709 based on the AD713), and 10-bit A/D (2-bit precision within the 233A3692P001 microcontroller based on the 80C517A). The major contributor to accuracy over the calibrated range of Drive Flow (0 to 10V) is the resolution of the microcontroller's A/D. This provides 844 counts or ± 0.47% resolution with the 2-bit precision. The analog mux, input op amps, and precision feedback resistors provide ± 0.12% accuracy. This yields (SRSS) an accuracy of ± 0.5% (all analog front-end components). The Digital FCTR performs all other operations digitally and therefore has no accuracy errors after the A/D and D/A conversions. The analog outputs of the FCTR are calibrated during the system-level calibration which includes the Quad Trip card and other components of the flow loop. In addition, the accuracy error introduced from the output 12-bit D/A converters is negligible when compared with other FCTR components. Therefore, the Digital FCTR card provides an accuracy of ± 0.5%.

The temperature drift effects are not shown above because the FCTR application provides stable temperature operation. However, the combined effects of accuracy and temperature drift (over the rated 0-70°C range of operation) are better than ± 1%.

Steve Sawyer
GE Electronics & Technology
Steve D Sawyer
11/24/2003

Leonid Sheikman
GE Electronics & Technology
L. Sheikman
11/24/2003

VERMONT YANKEE SETPOINT CONTROL PROGRAM
INTERDEPARTMENTAL REVIEW OF CALCULATION:

VYC- 693A Revision 2 has been prepared and independently reviewed. The Departments impacted by this calculation are requested to review the results of this calculation, concur with the results and/or recommendations, and document the department's acceptance prior to the calculation being approved.

1. Summary: This calculation evaluates the uncertainty & setpoint for the APRM/RBM Neutron Monitoring Trip Loops.

2. Calculation Open Items: AP-0028 to be Assigned

   2.1. *None* NA

3. Department Review - contact the Setpoint Program Manager (Joe Garozzo) if not in agreement with the conclusions/statements.

   3.1. Vermont Yankee I&C

   3.1.a. Procedure *OP-4308* will require the following:

   1. Add the following in the procedure discussion:

      Allowable Values:

Allowable Values			
Output Instrument	**% RxP**	**mV**	**Curve % RxP**
APRM A, B, C, D, E, F Scram Trips			
ARTS/MELLLA Flow Biased			
APRM High Flux Scram (Two Loop Ops)			
Core Flow 0 to ≤31.1 % (point based on 25% flow)	71.1	5.6880	< 0.4W+61.10%
Core Flow 31.1 to ≤54.0 % (point based on 50 % flow)	97.31	7.7848	< 1.28W+33.31%
Core Flow 54.0 to ≤75 % (point based on 70% flow)	113.48	9.0784	< 0.66W+67.28%
Core Flow > 75%	116.96	9.3568	N/A
APRM High Flux Scram (Single Loop Ops)			
Core Flow 0 to ≤39.1 % (point based on 25% flow)	68.09	5.4472	< 0.4W+58.09%
Core Flow 39.1 to ≤61.9 % (point based on 50% flow)	87.56	7.0048	< 1.28W+23.56%
Core Flow 61.9 to ≤83.0 % (point based on 70% flow)	108.3	8.6640	< 0.66W+62.10%
Core Flow > 83.0%	116.96	9.3568	N/A
EPU Flow Biased			
APRM High Flux Scram (Two Loop Ops)			
Core Flow 0 to ≤30.9 % (point based on 25% flow)	58.7	4.6960	< 0.33W+50.45%
Core Flow 30.9 to ≤66.7 % (point based on 50% flow)	80.73	6.4584	< 1.07W+27.23%
Core Flow 66.7 to ≤99.0 % (point based on 75% flow)	103.59	8.2872	< 0.55W+62.34%
Core Flow > 99.0%	116.96	9.3568	N/A
APRM High Flux Scram (Single Loop Ops)			
Core Flow 0 to ≤39.1 % (point based on 25% flow)	56.25	4.5000	< 0.33W+48.00%
Core Flow 39.1 to ≤61.7 % (point based on 50% flow)	72.51	5.8008	< 1.07W+19.01%
Core Flow 61.7 to ≤119.4 % (point based on 75% flow)	92.47	7.3976	< 0.55W+51.22%
Core Flow > 119.4%	116.96	9.3568	N/A

a. As-Left and As-Found values:

Calibration Points, As-Left and As-Found					
Output Instrument	Setting Vdc	As-Left Min	As-Left Max	VYDC As-Found Min	VYDC As-Found Max
APRM A, B, C, D, E, F Scram Trips					
ARTS/MELLLA Flow Biased					
APRM High Flux Scram (Two Loop Ops)					
Core Flow 0 to ≤ 31.1 % (point based on 25% flow)	5.5880	5.538	5.638	5.488	5.688
Core Flow 31.1 to ≤54.0 % (point based on 50 % flow)	7.6848	7.635	7.735	7.585	7.785
Core Flow 54.0 to ≤75 % (point based on 70% flow)	8.9784	8.928	9.028	8.878	9.078
Core Flow > 75%	9.2568	9.207	9.307	9.157	9.357
APRM High Flux Scram (Single Loop Ops)					
Core Flow 0 to ≤39.1 % (point based on 25% flow)	5.3472	5.297	5.397	5.247	5.447
Core Flow 39.1 to ≤61.9 % (point based on 50% flow)	6.9048	6.855	6.955	6.805	7.005
Core Flow 61.9 to ≤83.0 % (point based on 70% flow)	8.5640	8.514	8.614	8.464	8.664
Core Flow > 83.0%	9.2568	9.207	9.307	9.157	9.357
EPU Flow Biased					
APRM High Flux Scram (Two Loop Ops)					
ow 0 to ≤30.9 % (point based on 25% flow)	4.5960	4.546	4.646	4.496	4.696
Core Flow 30.9 to ≤66.7 % (point based on 50% flow)	6.3584	6.308	6.408	6.258	6.458
Core Flow 66.7 to ≤99.0 % (point based on 75% flow)	8.1872	8.137	8.237	8.087	8.287
Core Flow > 99.0%	9.2568	9.207	9.307	9.157	9.357
APRM High Flux Scram (Single Loop Ops)					
Core Flow 0 to ≤39.1 % (point based on 25% flow)	4.4000	4.350	4.450	4.300	4.500
Core Flow 39.1 to ≤61.7 % (point based on 50% flow)	5.7008	5.651	5.751	5.601	5.801
Core Flow 61.7 to ≤119.4 % (point based on 75% flow)	7.2976	7.248	7.348	7.198	7.398
Core Flow > 119.4%	9.2568	9.207	9.307	9.157	9.357

Note: Adjustment of the As Left Calibration Tolerance in the conservative direction is acceptable

c. Revise Head to reflect: NA

d. Insert the following M&TE requirements:
DMM's with total device error of better than ±0.05% CS (10 VDC Range)
HP 3466A or the HP 34401A are acceptable devices to support this accuracy Requirements. VYC-1758

2. In the body of the procedure and the data sheet revise as follows:

b. Trip Setpoint:

Limiting Setpoints and Calibration Cardinal Points			
Output Instrument	% RxP	mV	Curve % RxP
APRM A, B, C, D, E, F Scram Trips			
ARTS/MELLLA Flow Biased			
APRM High Flux Scram (Two Loop Ops)			
Core Flow 0 to ≤ 31.1 % (point based on 25% flow)	69.85	5.5880	< 0.4W+59.85%
Core Flow 31.1 to ≤54.0 % (point based on 50 % flow)	96.06	7.6848	< 1.28W+32.06%
Core Flow 54.0 to ≤75 % (point based on 70% flow)	112.23	8.9784	< 0.66W+66.03%
Core Flow > 75%	115.71	9.2568	N/A
APRM High Flux Scram (Single Loop Ops)			
Core Flow 0 to ≤39.1 % (point based on 25% flow)	66.84	5.3472	< 0.4W+56.84%
Core Flow 39.1 to ≤61.9 % (point based on 50% flow)	86.31	6.9048	< 1.28W+22.31%
Core Flow 61.9 to ≤83.0 % (point based on 70% flow)	107.05	8.5640	< 0.66W+60.85%
Core Flow > 83.0%	115.71	9.2568	N/A
EPU Flow Biased			
APRM High Flux Scram (Two Loop Ops)			
Core Flow 0 to ≤30.9 % (point based on 25% flow)	57.45	4.5960	< 0.33W+49.20%
Core Flow 30.9 to ≤66.7 % (point based on 50% flow)	79.48	6.3584	< 1.07W+25.98%
Core Flow 66.7 to ≤99.0 % (point based on 75% flow)	102.34	8.1872	< 0.55W+61.09%
Core Flow > 99.0%	115.71	9.2568	N/A.
APRM High Flux Scram (Single Loop Ops)			
Core Flow 0 to ≤39.1 % (point based on 25% flow)	55	4.4000	< 0.33W+46.75%
Core Flow 39.1 to ≤61.7 % (point based on 50% flow)	71.26	5.7008	< 1.07W+17.76%
Core Flow 61.7 to ≤119.4 % (point based on 75% flow)	91.22	7.2976	< 0.55W+49.97%
Core Flow > 119.4%	115.71	9.2568	N/A

c. Revise calibration data to reflect head correction of: *NA*

d. Insert a 9-point calibration for all analog instruments: *NA for Neutron Monitoring*

3.1.b. The following comments/recommendations apply:

1. Change Setpoints as identified above, Concur ☑

Sign & Date [signature], 12/1/03 *
Vermont Yankee I&C Representative

* Exact Data points may be adjusted. Final tolerance may require reevaluation / change, based on field performance.

VERMONT YANKEE SETPOINT CONTROL PROGRAM
INTERDEPARTMENTAL REVIEW OF CALCULATION:

VYC- 693A Revision 2 has been prepared and independently reviewed. The Departments impacted by this calculation are requested to review the results of this calculation, concur with the results and/or recommendations, and document the department's acceptance prior to the calculation being approved.

1. Summary: This calculation evaluates the uncertainty & setpoint for the APRM/RBM Neutron Monitoring Trip Loops.

2. Calculation Open Items: AP-0028 to be Assigned

   2.1. *None* NA

3. Department Review - contact the Setpoint Program Manager (Joe Garozzo) if not in agreement with the conclusions/statements.

3.2. Vermont Yankee Reactor Engineering

3.2.a. *None*

Concur ☑

① VERIFY SLO value @ CF 39.1 to ≤ 61.7 (≤1.07W + 22.2% or 26.8%)
① 22.2% PER PC-263
② Correct CTP limit. (159 to 1912 ; LPSP from 20% to LPSP.
② WORDING REVISED JG 12/1/03

1. Improved Technical Specifications

Analytical Limits APRM High Flux Scram (Two Loop Ops)	
Core Flow 0 to ≤ 31.1 %	< 0.4W+64.4%
Core Flow 31.1 to ≤ 54.0 %	< 1.28W+37.0%
Core Flow 54.0 to ≤ 75 %	< 0.66W+70.5%
Core Flow > 75%	Maximum of 120%
APRM High Flux Scram (Single Loop Ops)	
Core Flow 0 to ≤ 39.1 %	< 0.4W+61.2%
Core Flow 39.1 to ≤ 61.9 %	< 1.28W+26.8%
Core Flow 61.9 to ≤ 83.0 % Core Flow >83%	< 0.66W+65.2% Maximum of 120%
APRM High Flux Scram (Two Loop Ops)	
Core Flow 0 to ≤ 30.9 %	< 0.33W+53.7%
Core Flow 30.9 to ≤ 66.7 %	< 1.07W+30.8%
Core Flow 66.7 to ≤ 99 % Core Flow > 99%	< 0.55W+65.5% Maximum of 120%
APRM High Flux Scram (Single Loop Ops)	
Core Flow 0 to ≤ 39.1 %	< 0.33W+51.1%
Core Flow 39.1 to ≤ 61.7 %	< 1.07W+22.2%
Core Flow 61.7 to ≤ 119.4 % Core Flow >119.4	< 0.55W+54.3% Maximum of 120%

Sign & Date Bob Vita [signature] / 12-1-03
Vermont Yankee RE Representative

VERMONT YANKEE SETPOINT CONTROL PROGRAM
INTERDEPARTMENTAL REVIEW OF CALCULATION:

VYC- 693A_ Revision _2_has been prepared and independently reviewed. The Departments impacted by this calculation are requested to review the results of this calculation, concur with the results and/or recommendations, and document the department's acceptance prior to the calculation being approved.

1. Summary: This calculation evaluates the uncertainty & setpoint for the APRM/RBM Neutron Monitoring Trip Loops.

2. Calculation Open Items: AP-0028 to be Assigned

   2.1. *None* NA

3. Department Review - contact the Setpoint Program Manager (Joe Garozzo) if not in agreement with the conclusions/statements.

3.3. Vermont Yankee Operations

Concur

3.3.a. Recalibrate APRMs, LPRMs etc after seismic event ☒
Sign & Date Lonnie J. Cantrell / 12/01/2003
Vermont Yankee Operations Representative

VERMONT YANKEE SETPOINT CONTROL PROGRAM
INTERDEPARTMENTAL REVIEW OF CALCULATION:

VYC- 693A Revision 2 has been prepared and independently reviewed. The Departments impacted by this calculation are requested to review the results of this calculation, concur with the results and/or recommendations, and document the department's acceptance prior to the calculation being approved.

1. Summary: This calculation evaluates the uncertainty & setpoint for the APRM/RBM Neutron Monitoring Trip Loops.

2. Calculation Open Items: AP-0028 to be Assigned

   2.1. *None* NA

3. Department Review - contact the Setpoint Program Manager (Joe Garozzo) if not in agreement with the conclusions/statements.

3.4. Vermont Yankee Systems Manager

	Concur	Comments
3.4.a. This analysis supports the design bases for the APRM/RBM Neutron Monitoring Trip System	☑	NONE

Sign & Date [signature] / 12-1-2003
Vermont Yankee System Engineering Representative

Comments:

None

DOCUMENTATION OF COMPUTER RESOURCE USE

CALCULATION NO.: VYC-0693A REVISION NO.: 2 CCN No.: N/A

Computer Used (include manufacturer, CPU Type, and operating system version and level):
Dell Dimension 8200 Pentium 4 2.4 MHz; Windows XP Professional version 5.1 service pack 1 Microsoft Excel version 2002 Service Pack 2.

Computer Input Attached*? ☐ Yes ☒ No

Location/Identifier: _____

Computer Output Attached*? ☐ Yes ☒ No

Location/Identifier: _____

* Large volume input/output should be provided on CD. See Appendix E for format requirements.

List the computer codes used, and complete the following:

	Approved per PP 7800		Appropriateness Verified		Outstanding SPRs or Code Errors[1]	
Code Name/Version and/or Script File	Yes[3]	No	Yes	No	Yes[2]	No
Calculation Detail and Charts (Attachments B1 through B4) Microsoft Excel Version 2002 SR 2		✓	✓			✓

[1] Software Problem Report (SPR), does not exist as a reporting method in PP 7800 and AP 6030. Contact the Code sponsor and review any outstanding SPRs or Code errors. [ER2000805]
[2] If yes, fill out information below.
[3] If yes, include the Code name on the Computer Code line of the title page, VYAPF 0017.01.

If a computer code was not verified in accordance with PP 7800 and AP 6030, or if there are outstanding SPRs, state below why it is appropriate.

Code Name/Script File	Appropriateness
Calculation Detail and Charts (Attachments B1 through B4) Microsoft Excel Version 2002 SR 2	Appropriateness was verified through hand calculation

JG 12/1/03

VY CALCULATION REVIEW FORM

Calculation Number: VYC-693A Revision Number: 2 CCN Number: N/A

Title: APRM/RBM Neutron Monitoring Trip Loops

Reviewer Assigned: Kirk Melson Required Date:

☐ INTERDISCIPLINE REVIEW ☑ INDEPENDENT REVIEW

COMMENTS*	RESOLUTION
1. Excel Sheets – For TLU terms, the inputs to the equation are mixed with some being listed in terms of a decimal value and labeled as percent of span, and others formatted as percent of span. Need to express input terms the same.	1. Made all input terms in values which format to percent of span.
2. Excel Sheets – For TLU terms, the inputs to the equation are mixed, in that some terms are actually in percent of span, and others are in percent Reactor Power. Need input terms to be consistent.	2. Changed input values to percent of Reactor Power.
3. Either remove flow noise as a PMA term or provide specific reference.	3. All uncertainties for flow are covered by VYC-690. Removed flow noise as an uncertainty parameter with PMA.
4. Calibration tolerances for Fixed Hi Scram and Reduced Fixed Scram are different than for Flow Bias. Please revise, based on. procedure.	4. Corrected Cal Tolerances, based on OP-4308 and OP-43108.
5. Add input tables for Flow Values to Word Document.	5. Added Tables 8 and 9.

Kirk R. Melson / 09/21/03
Reviewer Signature Date

[signature] / 09/21/03
Calculation Preparer (Comments Resolved) Date

Method of Review: ☒ Calculation/Analysis Review
☐ Alternative Calculation
☐ Qualification Testing

Kirk R. Melson / 09/21/03
Reviewer Signature (Comments Resolved) Date

*Comments shall be specific, not general. Do not list questions or suggestions unless suggesting wording to ensure the correct interpretation of issues. Questions should be asked of the preparer directly.

JG 12/1/03 Page ~~8~~ 10 of ~~1~~ 10

VY CALCULATION REVIEW FORM

Calculation Number: VYC-693A Revision Number: 2 CCN Number: N/A

Title: APRM/RBM Neutron Monitoring Trip Loops

Reviewer Assigned: Kirk Melson Required Date: ______

☑ INTERDISCIPLINE REVIEW ☐ INDEPENDENT REVIEW

COMMENTS*	RESOLUTION
6. Correct Flow Break Points for ARTS/MELLLA Single Loop Ops in Table 3 of Word document.	6. Corrected.
7. Change AL from 13.5 to 15 in spreadsheets.	7. Corrected to 15.
8. Correct cross references in Cells A25, A26, and E16 to reflect	8. Corrected cross references.
9. LPRM drift term is extrapolated from 700 hours to 1250 hours, which is no longer necessary. Please remove the extrapolation.	9. Extrapolation no longer performed. Drift for 700 hours is used.
10. Remove APRM Avg Circuit and LPRM items from testing error.	10. Moved these errors to non-tested uncertainties.
11. Remove Scientific notations in the spreadsheets.	11. Corrected formatting to decimal.
12. Remove all equations, values for other than Method 1.	12. Removed.
13. Set Cal Effect equal to Accuracy, as it is larger than CT.	13. Set equal to accuracy term.
14. Biases are negative, and the negative error is to be used for AV.	14. Showed bias in negative uncert comp and changed to use neg for AV.

Kirby R. Melson / 09/21/03
Reviewer Signature Date

[signature] / 09/21/03
Calculation Preparer (Comments Resolved) Date

Method of Review: ☒ Calculation/Analysis Review
☐ Alternative Calculation
☐ Qualification Testing

Kirby R. Melson / 09/21/03
Reviewer Signature (Comments Resolved) Date

*Comments shall be specific, not general. Do not list questions or suggestions unless suggesting wording to ensure the correct interpretation of issues. Questions should be asked of the preparer directly.

Docket No. 50-271
BVY 03-115

Attachment 3

Vermont Yankee Nuclear Power Station

Technical Specification Proposed Change No. 257

Discussion of Changes for Revised Technical Specifications

DISCUSSION OF CHANGES TO REVISED TECHNICAL SPECIFICATIONS

TS 2.1.A.1.a (current page 6)

The heading of this section is changed from "APRM Flux Scram Trip Setting (Run Mode)" to "APRM Flux Scram Allowable Value (Run Mode)."

The Standard Technical Specifications nomenclature of "Allowable Value" is adopted for this trip function of the reactor protection system. This change is made to clarify that the specification is an Allowable Value that corresponds to the limiting value that the instrument may have for operability. This change is made to draw a distinction from other TS that may specify trip settings that differ from the definition of an Allowable Value. This change is acceptable because it represents the appropriate operability limitation for the parameter (Neutron Flux Trip Settings).

TS 2.1.A.1.a (current page 6)

The specification for this limiting safety system setting is changed from "When the mode switch is in the RUN position, the APRM flux scram trip setting shall be as shown on Figure 2.1.1 and shall be: $S \leq 0.66(W-\Delta W)+54\%$" to "When the mode switch is in the RUN position, the APRM flux scram Allowable Value shall be:

Two loop operation:

$S \leq$	0.4 W	+	61.10%	for	0%	$< W \leq$	31.1%
$S \leq$	1.28 W	+	33.31%	for	31.1%	$< W \leq$	54.0%
$S \leq$	0.66 W	+	67.28%	for	54.0%	$< W \leq$	75.0%

with a maximum of 117.0% power for W > 75.0%

Single loop operation:

$S \leq$	0.4 W	+	58.09%	for	0%	$< W \leq$	39.1%
$S \leq$	1.28 W	+	23.56%	for	39.1%	$< W \leq$	61.9%
$S \leq$	0.66 W	+	62.10%	for	61.9%	$< W \leq$	83.0%

with a maximum of 117.0% power for W > 83.0%"

The change in the neutron flux trip setting algorithm is supported by the ARTS/MELLLA analysis provided as part of Proposed Change No. 257. The deletion of reference to TS Figure 2.1.1 is discussed below.

TS Figure 2.1.1 (current page 11)

TS Figure 2.1.1 does not provide any requirement not included in the stated algorithms for this function. Because the figure is redundant, it can be eliminated from TS without any change in technical requirements. In addition, elimination of this figure is consistent with Standard Technical Specifications.

TS Table 3.1.1 (current page 21)

Trip function no. 4, "APRM (APRM A-F) High Flux (flow bias)," is changed consistent with the algorithm change described above for TS 2.1.A.1.a. The algorithm specified in the "Trip Settings" column is changed to the Allowable Value algorithms resulting from the adoption of ARTS/MELLLA. In addition, Footnote (4) to Table 3.1.1 is changed to add a clarifying statement: "The specified APRM High Flux scram (flow bias) Trip Setting is an Allowable Value, which is the limiting value that the trip setpoint may have when tested periodically. The actual scram trip setting is conservatively set in relation to the Allowable Value." The change is made to emphasize that the specification is an Allowable Value that corresponds to the limiting value trip setpoint that the instrument have for operability. This change is made to draw a distinction from other TS that may specify trip settings that differ from the definition of an Allowable Value.

In addition, Footnote (4) is also modified to eliminate the statement: "ΔW is the difference between the two loop and single loop drive flow at the same core flow. This difference must be accounted for during single loop operation. $\Delta W = 0$ for two recirculation loop operation." This statement can be eliminated because separate algorithm specifications are now provided for two loop and single recirculation loop operation, and the term "ΔW" has been eliminated from TS.

Bases Changes

The TS Bases provide explanation and rationale for associated TS requirements, and in some cases, how they are to be implemented. Associated changes to the TS Bases are being made to conform to the changed TS and to add clarity to existing requirements. Bases do not establish actual requirements, and as such do not change technical requirements of the TS. The Bases changes are therefore acceptable, since they administratively document the reasons and provide additional understanding for the associated TS requirements.

Docket No. 50-271
BVY 03-115

Attachment 4

Vermont Yankee Nuclear Power Station

Technical Specification Proposed Change No. 257

Replacement Mark-Ups of the Current Technical Specifications

1.1 SAFETY LIMIT

1.1 FUEL CLADDING INTEGRITY

Applicability:

Applies to the interrelated variable associated with fuel thermal behavior.

Objective:

To establish limits below which the integrity of the fuel cladding is preserved.

Specification:

A. Bundle Safety Limit (Reactor Pressure >800 psia and Core Flow >10% of Rated)

When the reactor pressure is >800 psia and the core flow is greater than 10% of rated:

1. A Minimum Critical Power Ratio (MCPR) of less than 1.10 (1.12 for Single Loop Operation) shall constitute violation of the Fuel Cladding Integrity Safety Limit (FCISL).

Allowable Value

<INSERT #1>

2.1 LIMITING SAFETY SYSTEM SETTING

2.1 FUEL CLADDING INTEGRITY

Applicability:

Applies to trip setting of the instruments and devices which are provided to prevent the nuclear system safety limits from being exceeded.

Objective:

To define the level of the process variable at which automatic protective action is initiated.

Specification:

A. Trip Settings

The limiting safety system trip settings shall be as specified below:

1. Neutron Flux Trip Settings

a. APRM Flux Scram ~~Trip Setting~~ (Run Mode)

When the mode switch is in the RUN position, the APRM flux scram ~~trip setting shall be as shown on Figure 2.1.1 and~~ shall be:

~~S≤0.66(W-ΔW)+54%~~

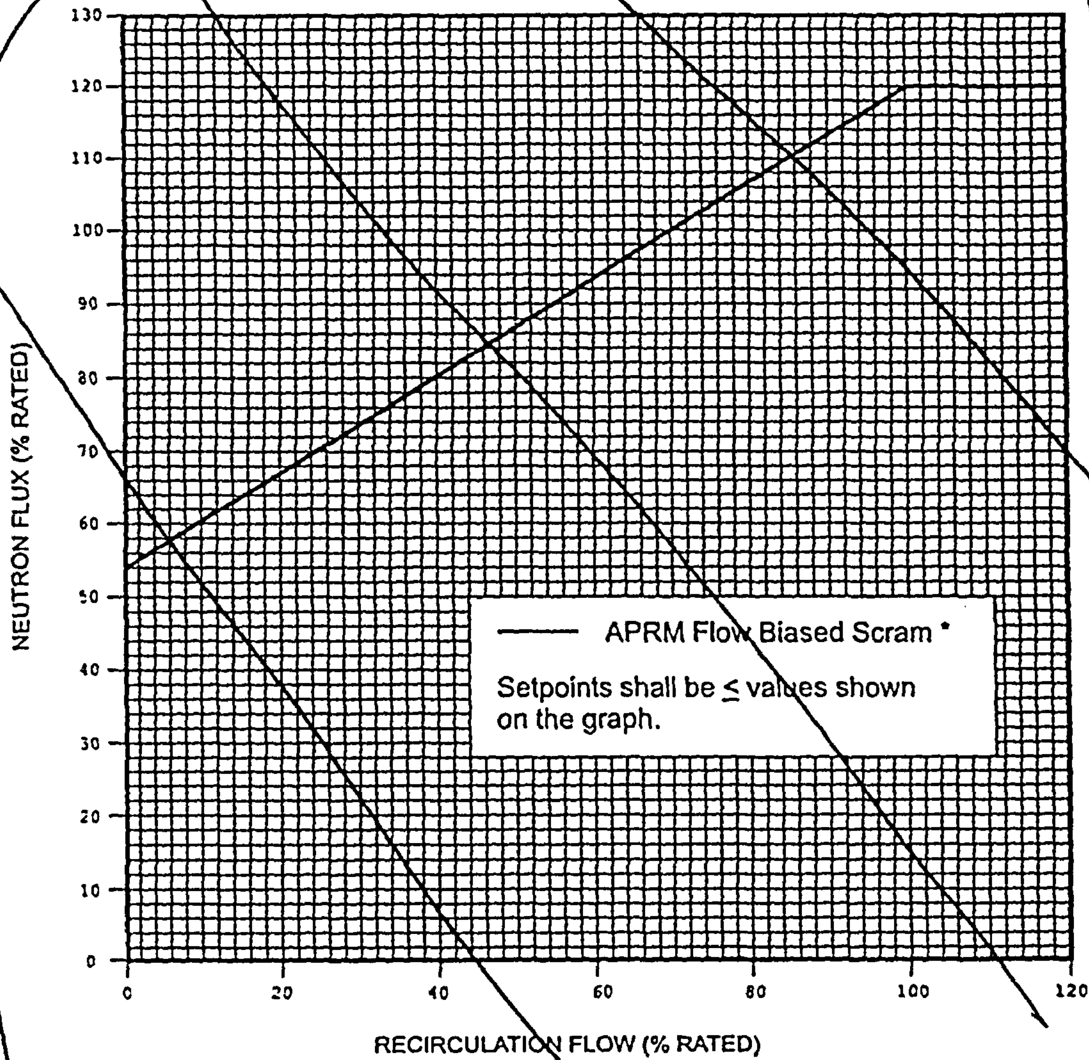
where:

S = setting in percent of rated thermal power (1593 MWt)

W = percent rated two loop drive flow where 100% rated drive flow is that flow equivalent to 48 x 10^6 lbs/hr core flow

FIGURE 2.1-1

APRM FLOW REFERENCE SCRAM SETTING



* ***For single loop operation, the APRM Scram setting is adjusted according to Technical Specification 2.1.A.1.a***

INSERT 7

This page has intentionally been deleted.

BASES:

2.1 FUEL CLADDING INTEGRITY

A. Trip Settings

The bases for individual trip settings are discussed in the following paragraphs.

1. Neutron Flux Trip Settings

a. APRM Flux Scram ~~Trip Setting~~ Allowable Value (Run Mode)

The average power range monitoring (APRM) system, which is calibrated using heat balance data taken during steady state conditions, reads in percent of rated thermal power (1593 MWt). Because fission chambers provide the basic input signals, the APRM system responds directly to average neutron flux. During transients, the instantaneous rate of heat transfer from the fuel (reactor thermal power) is less than the instantaneous neutron flux due to the time constant of the fuel. Therefore, during abnormal operational transients, the thermal power of the fuel will be less than that indicated by the neutron flux at the scram setting. Analyses are performed to demonstrate that the APRM flux scram over the range of settings from a maximum of 120% to the minimum flow biased ~~setpoint of 54%~~ setting provide protection from the fuel safety limit for all abnormal operational transients including those that may result in a thermal hydraulic instability.

An increase in the APRM scram trip setting would decrease the margin present before the fuel cladding integrity Safety Limit is reached. The APRM scram trip setting was determined by an analysis of margins required to provide a reasonable range for maneuvering during operation. Reducing this operating margin would increase the frequency of spurious scrams which have an adverse effect on reactor safety because of the resulting thermal stresses. Thus, the APRM scram trip setting was selected because it provides adequate margin for the fuel cladding integrity Safety Limit yet allows operating margin that reduces the possibility of unnecessary scrams. <INSERT #2>

~~APRM Flux Scram Trip Setting (Run Mode)~~

<INSERT #3> ~~The scram trip setting must be adjusted to ensure that the LHGR transient peak is not increased for any combination of MFLPD and reactor core thermal power. If the scram requires a change due to an abnormal peaking condition, it will be accomplished by increasing the APRM gain by the ratio in Specification 2.1.A.1.a, thus assuring a reactor scram at lower than design overpower conditions.~~ For single recirculation loop operation, the APRM flux scram trip setting is reduced in accordance with the analysis presented in NEDO-30060, February 1983. This adjustment accounts for the difference between the single loop and two loop drive flow at the same core flow, and ensures that the margin of safety is not reduced during single loop operation. <INSERT #4>

Analyses of the limiting transients show that no scram adjustment is required to assure fuel cladding integrity when the transient is initiated from the operating limit MCPR defined in the Core Operating Limits Report.

TABLE 3.1.1

REACTOR PROTECTION SYSTEM (SCRAM) INSTRUMENT REQUIREMENTS

	Trip Function	Trip Settings	Modes in Which Functions Must be Operating: Refuel (1)	Startup (12)	Run	Minimum Number Operating Instrument Channels Per Trip System (2)	Required ACTIONS When Minimum Conditions For Operation Are Not Satisfied (3)
1.	Mode Switch in Shutdown (5A-S1)		X	X	X	1	A
2.	Manual Scram (5A-S3A/B)		X	X	X	1	A
3.	IRM (7-41(A-F))						
	High Flux	≤120/125	X	X		2	A
	INOP		X	X		2	A
4.	APRM (APRM A-F)						
	High Flux (flow bias)	~~≤0.66 (W-ΔW)+54% with a maximum of 120% (4)~~ <INSERT #5>			X	2	A or B
	High Flux (reduced)	≤15%	X	X		2	A
	INOP			X	X	2(5)	A or B
5.	High Reactor Pressure (PT-2-3-55(A-D)(M))	≤1055 psig	X	X	X	2	A
6.	High Drywell Pressure (PT-5-12(A-D)(M))	≤2.5 psig	X	X	X	2	A
7.	Reactor Low (6) Water Level (LT-2-3-57A/B(M)) (LT-2-3-58A/B(M))	≥127.0 inches	X	X	X	2	A
8.	Scram Discharge Volume High Level (LT-3-231(A-H)(M))	≤21 gallons	X	X	X	2 (per volume)	A

TABLE 3.1.1 NOTES (Cont'd)

3. When the requirements in the column "Minimum Number of Operating Instrument Channels Per Trip System" cannot be met for one system, that system shall be tripped. If the requirements cannot be met for both trip systems, the appropriate ACTIONS listed below shall be taken:

<INSERT #6>

...tiate insertion of operable rods and complete insertion of all ...able rods within four hours.

...duce power level to IRM range and place mode switch in the "Startup/Hot Standby" position within eight hours.

c) Reduce turbine load and close main steam line isolation valves within 8 hours.

d) Reduce reactor power to less than 30% of rated within 8 hours.

4. "W" is percent rated two loop drive flow where 100% rated drive flow is that flow equivalent to 48 x 10^6 lbs/hr core flow. ΔW is the difference between the two loop and single loop drive flow at the same core flow. This difference must be accounted for during single loop operation. ΔW = 0 for two recirculation loop operation.

5. To be considered operable an APRM must have at least 2 LPRM inputs per level and at least a total of 13 LPRM inputs, except that channels A, C, D, and F may lose all LPRM inputs from the companion APRM Cabinet plus one additional LPRM input and still be considered operable.

6. The top of the enriched fuel has been designated as 0 inches and provides common reference level for all vessel water level instrumentation.

7. Deleted.

8. Deleted.

9. Channel signals for the turbine control valve fast closure trip shall be derived from the same event or events which cause the control valve fast closure.

10. Turbine stop valve closure and turbine control valve fast closure scram signals may be bypassed at ≤30% of reactor Rated Thermal Power.

11. Not used.

12. While performing refuel interlock checks which require the mode switch to be in Startup, the reduced APRM high flux scram need not be operable provided:

   a. The following trip functions are operable:

      1. Mode switch in shutdown,
      2. Manual scram,
      3. High flux IRM scram
      4. High flux SRM scram in noncoincidence,
      5. Scram discharge volume high water level, and;

   b. No more than two (2) control rods withdrawn. The two (2) control rods that can be withdrawn cannot be face adjacent or diagonally adjacent.

INSERT #1

Two loop operation:

$S \leq$	0.4 W	+	61.10%	for	0%	$< W \leq$	31.1%
$S \leq$	1.28 W	+	33.31%	for	31.1%	$< W \leq$	54.0%
$S \leq$	0.66 W	+	67.28%	for	54.0%	$< W \leq$	75.0%

with a maximum of 117.0% power for W > 75.0%

Single loop operation:

$S \leq$	0.4 W	+	58.09%	for	0%	$< W \leq$	39.1%
$S \leq$	1.28 W	+	23.56%	for	39.1%	$< W \leq$	61.9%
$S \leq$	0.66 W	+	62.10%	for	61.9%	$< W \leq$	83.0%

with a maximum of 117.0% power for W > 83.0%

INSERT #2

The relationship between recirculation drive flow and reactor core flow is non-linear at low core flows. Due to stability concerns, separate APRM flow biased scram trip setting equations are provided for low core flows.

INSERT #3

The APRM flow biased flux scram Allowable Value is the limiting value that the trip setpoint may have when tested periodically, beyond which appropriate action shall be taken. For Vermont Yankee, the periodic testing is defined as the calibration. The actual scram trip is conservatively set in relation to the Allowable Value to ensure operability between periodic testing.

INSERT #4

The single loop operation equations are based on a bounding (maximum) difference between two loop and single loop drive flow at the same core flow of 8%.

INSERT #5

Two loop operation: (4)

$S \leq$	$0.4\ W$	+	61.10%	for	0%	$< W \leq$	31.1%
$S \leq$	$1.28\ W$	+	33.31%	for	31.1%	$< W \leq$	54.0%
$S \leq$	$0.66\ W$	+	67.28%	for	54.0%	$< W \leq$	75.0%

with a maximum of 117.0% power for $W > 75.0\%$

Single loop operation: (4)

$S \leq$	$0.4\ W$	+	58.09%	for	0%	$< W \leq$	39.1%
$S \leq$	$1.28\ W$	+	23.56%	for	39.1%	$< W \leq$	61.9%
$S \leq$	$0.66\ W$	+	62.10%	for	61.9%	$< W \leq$	83.0%

with a maximum of 117.0% power for $W > 83.0\%$

INSERT #6

The specified APRM High Flux scram (flow bias) Trip Setting is an Allowable Value, which is the limiting value that the trip setpoint may have when tested periodically. The actual scram trip setting is conservatively set in relation to the Allowable Value.

Docket No. 50-271
BVY 03-115

Attachment 5

Vermont Yankee Nuclear Power Station

Technical Specification Proposed Change No. 257

Replacement Re-typed Technical Specifications Pages

1.1 SAFETY LIMIT

1.1 FUEL CLADDING INTEGRITY

Applicability:

Applies to the interrelated variable associated with fuel thermal behavior.

Objective:

To establish limits below which the integrity of the fuel cladding is preserved.

Specification:

A. Bundle Safety Limit (Reactor Pressure >800 psia and Core Flow >10% of Rated)

When the reactor pressure is >800 psia and the core flow is greater than 10% of rated:

1. A Minimum Critical Power Ratio (MCPR) of less than 1.10 (1.12 for Single Loop Operation) shall constitute violation of the Fuel Cladding Integrity Safety Limit (FCISL).

2.1 LIMITING SAFETY SYSTEM SETTING

2.1 FUEL CLADDING INTEGRITY

Applicability:

Applies to trip setting of the instruments and devices which are provided to prevent the nuclear system safety limits from being exceeded.

Objective:

To define the level of the process variable at which automatic protective action is initiated.

Specification:

A. Trip Settings

The limiting safety system trip settings shall be as specified below:

1. Neutron Flux Trip Settings

a. APRM Flux Scram Allowable Value (Run Mode)

When the mode switch is in the RUN position, the APRM flux scram Allowable Value shall be:

Two loop operation:

$S \leq 0.4W + 61.10\%$ for $0\% < W \leq 31.1\%$

$S \leq 1.28W + 33.31\%$ for $31.1\% < W \leq 54.0\%$

$S \leq 0.66W + 67.28\%$ for $54.0\% < W \leq 75.0\%$

With a maximum of 117.0% power for W > 75.0%

Single loop operation:

$S \leq 0.4W + 58.09\%$ for $0\% < W \leq 39.1\%$

$S \leq 1.28W + 23.56\%$ for $39.1\% < W \leq 61.9\%$

$S \leq 0.66W + 62.10\%$ for $61.9\% < W \leq 83.0\%$

With a maximum of 117.0% power for W > 83.0%

where:

S = setting in percent of rated thermal power (1593 MWt)

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BASES:

2.1 FUEL CLADDING INTEGRITY

A. Trip Settings

The bases for individual trip settings are discussed in the following paragraphs.

1. Neutron Flux Trip Settings

a. APRM Flux Scram Allowable Value (Run Mode)

The average power range monitoring (APRM) system, which is calibrated using heat balance data taken during steady state conditions, reads in percent of rated thermal power (1593 MWt). Because fission chambers provide the basic input signals, the APRM system responds directly to average neutron flux. During transients, the instantaneous rate of heat transfer from the fuel (reactor thermal power) is less than the instantaneous neutron flux due to the time constant of the fuel. Therefore, during abnormal operational transients, the thermal power of the fuel will be less than that indicated by the neutron flux at the scram setting. Analyses are performed to demonstrate that the APRM flux scram over the range of settings from a maximum of 120% to the minimum flow biased setting provide protection from the fuel safety limit for all abnormal operational transients including those that may result in a thermal hydraulic instability.

An increase in the APRM scram trip setting would decrease the margin present before the fuel cladding integrity Safety Limit is reached. The APRM scram trip setting was determined by an analysis of margins required to provide a reasonable range for maneuvering during operation. Reducing this operating margin would increase the frequency of spurious scrams which have an adverse effect on reactor safety because of the resulting thermal stresses. Thus, the APRM scram trip setting was selected because it provides adequate margin for the fuel cladding integrity Safety Limit yet allows operating margin that reduces the possibility of unnecessary scrams. The relationship between recirculation drive flow and reactor core flow is non-linear at low core flows. Due to stability concerns, separate APRM flow biased scram trip setting equations are provided for low core flows.

The APRM flow biased flux scram Allowable Value is the limiting value that the trip setpoint may have when tested periodically, beyond which appropriate action shall be taken. For Vermont Yankee, the periodic testing is defined as the calibration. The actual scram trip is conservatively set in relation to the Allowable Value to ensure operability between periodic testing. For single recirculation loop operation, the APRM flux scram trip setting is reduced in accordance with the analysis presented in NEDO-30060, February 1983. This adjustment accounts for the difference between the single loop and two loop drive flow at the same core flow, and ensures that the margin of safety is not reduced during single loop operation. The single loop

BASES: 2.1 (Cont'd)

operation equations are based on a bounding (maximum) difference between two loop and single loop drive flow at the same core flow of 8%.

Analyses of the limiting transients show that no scram adjustment is required to assure fuel cladding integrity when the transient is initiated from the operating limit MCPR defined in the Core Operating Limits Report.

TABLE 3.1.1

REACTOR PROTECTION SYSTEM (SCRAM) INSTRUMENT REQUIREMENTS

	Trip Function	Trip Settings	Modes in Which Functions Must be Operating Refuel (1)	 Startup(12)	 Run	Minimum Number Operating Instrument Channels Per Trip System (2)	Required ACTIONS When Minimum Conditions For Operation Are Not Satisfied (3)
1.	Mode Switch in Shutdown (5A-S1)		X	X	X	1	A
2.	Manual Scram (5A-S3A/B)		X	X	X	1	A
3.	IRM (7-41(A-F))						
	High Flux	≤120/125	X	X		2	A
	INOP		X	X		2	A
4.	APRM (APRM A-F)						
	High Flux (flow bias)	Two loop operation: (4) S≤ 0.4W+ 61.10% for 0% < W ≤ 31.1% S≤ 1.28W+ 33.31% for 31.1% < W ≤ 54.0% S≤ 0.66W+ 67.28% for 54.0% < W ≤ 75.0% With a maximum of 117.0% power for W > 75.0% Single loop operation: (4) S≤ 0.4W+ 58.09% for 0% < W ≤ 39.1% S≤ 1.28W+ 23.56% for 39.1% < W ≤ 61.9% S≤ 0.66W+ 62.10% for 61.9% < W ≤ 83.0% With a maximum of 117.0% power for W > 83.0%			X	2	A or B
	High Flux (reduced)	≤15%	X	X		2	A
	INOP			X	X	2(5)	A or B
5.	High Reactor Pressure (PT-2-3-55(A-D) (M)	≤1055 psig	X	X	X	2	A

TABLE 3.1.1 NOTES (Cont'd)

3. When the requirements in the column "Minimum Number of Operating Instrument Channels Per Trip System" cannot be met for one system, that system shall be tripped. If the requirements cannot be met for both trip systems, the appropriate ACTIONS listed below shall be taken:

   a) Initiate insertion of operable rods and complete insertion of all operable rods within four hours.
   b) Reduce power level to IRM range and place mode switch in the "Startup/Hot Standby" position within eight hours.
   c) Reduce turbine load and close main steam line isolation valves within 8 hours.
   d) Reduce reactor power to less than 30% of rated within 8 hours.

4. The specified APRM High Flux scram (flow bias) Trip Setting is an Allowable Value, which is the limiting value that the trip setpoint may have when tested periodically. The actual scram trip setting is conservatively set in relation to the Allowable Value. "W" is percent rated two loop drive flow where 100% rated drive flow is that flow equivalent to 48 x 10^6 lbs/hr core flow.

5. To be considered operable an APRM must have at least 2 LPRM inputs per level and at least a total of 13 LPRM inputs, except that channels A, C, D, and F may lose all LPRM inputs from the companion APRM Cabinet plus one additional LPRM input and still be considered operable.

6. The top of the enriched fuel has been designated as 0 inches and provides common reference level for all vessel water level instrumentation.

7. Deleted.

8. Deleted.

9. Channel signals for the turbine control valve fast closure trip shall be derived from the same event or events which cause the control valve fast closure.

10. Turbine stop valve closure and turbine control valve fast closure scram signals may be bypassed at $\leq$30% of reactor Rated Thermal Power.

11. Not used.

12. While performing refuel interlock checks which require the mode switch to be in Startup, the reduced APRM high flux scram need not be operable provided:

    a. The following trip functions are operable:

       1. Mode switch in shutdown,
       2. Manual scram,
       3. High flux IRM scram
       4. High flux SRM scram in noncoincidence,
       5. Scram discharge volume high water level, and;

    b. No more than two (2) control rods withdrawn. The two (2) control rods that can be withdrawn cannot be face adjacent or diagonally adjacent.