QA Record

ORIGINAL

TVAN CALCULATION COVERSHEET

Title DEMONSTRATED ACCURACY CALCULATION 0-RE-90-125/126	Plant SQN Unit 0	Page

Preparing Organization NE-I&C	Key Nouns (For EDM) I&C, INSTR, CALIBRATION, SETPOINT, ACCURACY		
Calculation Identifier 0-RE-90-125/126	Each time these calculations are issued, preparer must ensure that the original (R0) RIMS/EDM accession number is filled in.		
	Rev	(for EDM use)	EDM Accession Number
Applicable Design Document(s) SQN-DC-V-9.0 and SQN-DC-V-13.9.6	R0		B87 000607 018
	R1		
UNID System(s) 90	R2		
	R3		

	R0	R	R	R	
					Quality Related? Yes ☒ No ☐
DCN, EDC, NA	NA				Safety related? If yes, mark Quality Related yes Yes ☒ No ☐
Prepared					
Checked	E.H.Turner				These calculations contain unverified assumption(s) that must be verified later? Yes ☐ No ☒
Design Verified	E.H.Turner				These calculations contain special requirements and/or limiting conditions? Yes ☐ No ☒
Approved	G.R.Bell for J.H.Rinne				These calculations contain a design output attachment? Yes ☐ No ☒
Approval Date	6/7/2000				Calculation Classification E
SAR Affected?	Yes ☐ No ☒	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Microfiche generated Yes ☐ No ☒
Revision applicability	Entire calc ☒	Entire calc ☐ Selected pgs ☐	Entire calc ☐ Selected pgs ☐	Entire calc ☐ Selected pgs ☐	Number

Statement of Problem:
Determine the accuracy of the subject instrument loop(s) and demonstrate that the accuracy is adequate for the intended purpose. Primary elements are located in a Harsh environment. Subject devices are not part of PAM.

Abstract

Calculations were performed to determine the accuracy of the subject instrument loops. The determined accuracies were compared to the required accuracies, setpoints, safety limits an/or operating limits and the accuracy for the loops listed below were demonstrated to be acceptable for their intended function.

0-R-90-125 & 0-R-90-126

☒ Microfilm and return calculation to Calculation Library. Address: OPS-1

☐ Microfilm and return calculation to:

☐ Microfilm and destroy.

TVAN CALCULATION RECORD OF REVISION
Page 1 of 1

TVAN CALCULATION RECORD OF REVISION

Title DEMONSTRATED ACCURACY CALCULATION 0-RE-90-125/126

Revision No.	DESCRIPTION OF REVISION	Date Approved
0	Initial issue. The loops evaluated by this calculation were previously removed from the scope of calculation 0-RE-90-106A. This calculation supports resolution of SQ971511PER and defines an Allowable Value for input to Proposed Tech Spec Change 98-03. for JRBell Legibility Evaluated and Accepted for Issue: J. H. Rinne Date 6/7/2000 This revision contains 176 pages.	

TVAN CALCULATION DESIGN VERIFICATION (INDEPENDENT REVIEW) FORM
Page 1 of 1

TVAN CALCULATION DESIGN VERIFICATION (INDEPENDENT REVIEW) FORM

0-RE-90-125/126	0
Calculation No.	Revision

Method of design verification (independent review) used:

1. Design Review ☒
2. Alternate Calculation ☐
3. Qualification Test ☐

Comments:

All comments between myself and the preparer have been resolved. This calculation revision is found to be in compliance with NEDP-2. The FSAR compliance review has been performed as denoted by incorporation of the appropriate form. Additionally, the methodology utilized in revision 0 of this calculation is commensurate with the guidelines provided in Branch Technical Instruction EEB-TI-28, R4.

Prepared: Date: 6/1/03

FSAR COMPLIANCE REVIEW

This review has been performed to verify FSAR compliance. The following FSAR sections have been reviewed:

5.2.7.1 and 12.2.4

Tech Specs 3/4.3.3.1 and 3/4.4.6

Results of review:

The SAR is not impacted by issuance of this calculation.

Note: Tech Spec Table 3.3-6 specifies a setpoint value of ≤ 400 cpm for control room isolation. This setpoint is conservative with respect to the results of this calculation. Additionally, this calculation also defines an Allowable Value. The existing setpoint of ≤ 400 cpm in Table 3.3-6 could be replaced with the Allowable Value via Tech Spec Change 98-03.

Prepared: ____________ Date: 5/26/00
Checked: E.H. Turner Date: 5/31/00

TABLE OF CONTENTS

SHEET

DESIGN INPUT DATA

COMPUTATIONS/ANALYSES

SUPPORTING GRAPHICS

PURPOSE

The purpose of this calculation is a) to determine the accuracy of the instrumentation covered by this calculation, and b) to demonstrate that the instrumentation is sufficiently accurate to perform its intended function without safety or operational limits being exceeded.

ASSUMPTIONS

✓ This calculation contains no assumptions.

_____ The following assumptions were used in the performance of this calculation. These assumptions require further analysis. This calculation may require revision if the assumptions below are shown to be invalid.

REQUIREMENTS

#1 A Digital Volt Meter shall be used for calibration of the output device.

#2 M & TE accuracy shall be better than or equal to one (1) times the accuracy of the device being calibrated.

#3 The calibration cycle shall not exceed 18 months plus an allowable 25% extension (22.5 months).

SPECIAL REQUIREMENTS

NONE

LIMITING CONDITIONS

NONE

SOURCE OF DESIGN INPUT INFORMATION (REFERENCES)

REF#	ATT#	REFERENCE (RIMS#)
1	-	Calculation SQNAPS3-100 (R12), "Demonstrated range for Sequoyah Nuclear Plant Radiation Monitors"
2	-	Design Criteria SQN-DC-V-21.0 (R13), "Environmental Design"
3	-	TVA Drawings: 1-45N1620-4 (R2), 1,2-47W605-1 (R10), 1,2-47W600-103 (R3)
4	-	Calculation SQN-OSG7-0033 (R13), "Radiation Monitoring System (90) 10CFR50.49 Category and Operating Times"
5	-	General Atomic Manual, E-115-188 for RP-30.
6	-	General Atomic Manual, E-199-313 for RD-32.
7	1	Detectors: Historical Calibration Data
8	2-11	Monitoring Signal Conditioning Components: Historical Calibration data
9	12	Calculation SQNAPS3-053 R3
10	-	Master Equipment List (MEL)
11	-	Branch Technical Instruction EEB-TI-28, R5
12	13	Statistical Analysis
13	14	Letter from Noel Seefeldt Representative for General Atomics/Sorrento 4-16-90 (B26900511900)
14	15	Calibration Report Models RD-32-05 and RD-32-08 Offline Beta Detectors
15	16	Operation and Maintenance Manual for Radiation Analyzer Readout Module RP-30
16	-	SQN TI-18, Radiation Monitoring
17	17	Letter to W. S. Raughley, TVA from Noel A. Seefeldt/Don Peat 3-16-90 (B26900330903)
18	-	General Atomic Manual, E-199-313, Seismic Test Report
19	-	Design Criteria SQN-DC-V-9.0 (R13), "Post Accident Monitoring"

A) DEFINITIONS & ABBREVIATIONS

Desired Value: The value of the process variable which is considered desirable for the optimum performance of the instrument loop.

As Found Value: The value of the process variable as read and recorded by the field technician when he went to the device to perform check/calibration of the device.

As Left Value: The value of the process variable read and recorded by the technician at the time when he has completed his check/calibration of the device.

As Found Deviation Percent: The percentage of deviation of the "as found value" and "the desired value".

As Left Deviation Percent: The percentage of deviation of the "as left value" and "the desired value".

As Left As Found Deviation Percent: The deviation in percent between the last calibration "as left deviation percent value" and the next calibration "as found deviation percent value".

Aa	ACCIDENT ACCURACY-ACCURACY OF A DEVICE IN A HARSH ENVIRONMENT CAUSED BY AN ACCIDENT
Aas	COMBINED ACCIDENT AND SEISMIC ACCURACY
Ab	ACCEPTANCE BAND - THE RANGE OF VALUES AROUND THE CORRECT VALUE DETERMINED TO BE ACCEPTABLE WITHOUT RECALIBRATION
AB	AUXILIARY BOILER LINE BREAK
AF	AFW PUMP TURBINE STEAM SUPPLY LINE BREAK
An	NORMAL ACCURACY - ACCURACY OF A DEVICE LOCATED IN AN ENVIRONMENT NOT AFFECTED BY AN ACCIDENT OR PRIOR TO AN ACCIDENT
Anf	CALIBRATION ACCURACY (MEASURABLE INSTRUMENT ERRORS AT TIME OF CALIBRATION)
As	POST SEISMIC ACCURACY
AV	ALLOWABLE VALUE=SAFETY LIMIT/REQUIRED ACCURACY MINUS NON-MEASUREABLES; USED FOR THE PURPOSE OF DETERMINING REPORTABILITY ONLY.
CFM	CUBIC FEET PER MINUTE

A) DEFINITIONS & ABBREVIATIONS

CPM	COUNTS PER MINUTE
CV	CVCS LETDOWN LINE BREAK
De	DRIFT ACCURACY
Ebs	ERROR DUE TO BI-STABLE SET POINT VOLTAGE INACCURACY
Ebsc	ERROR DUE TO BI-STABLE CALIBRATION INACCURACY
Ect	ERROR DUE TO CURRENT TRANSMISSION
Eed	ERROR DUE TO ENERGY DEPENDENCE INACCURACY
Efa	FIELD ALIGNMENT ERROR
Efr	ERROR DUE TO FLOW RATE INACCURACY
Eip	ERROR DUE TO IMPRECISION INACCURACY
Encr	NET COUNT RATE ERROR
Epc	PRIMARY CALIBRATION ERROR
Epo	ERROR DUE TO SAMPLE LINE PLATE OUT LOSSES
Ese	SEISMIC ERROR
HELB	HIGH ENERGY LINE BREAK
IAD	INTEGRATED ACCIDENT DOSE
ICRe	INPUT TEST INSTRUMENT READING INACCURACY
ICTe	INPUT TEST INSTRUMENT CALIBRATION INACCURACY
INDRe	INDICATOR READING ERROR
IRe	INACCURACY DUE TO CABLE LEAKAGE
L	LOSS OF COOLANT ACCIDENT
M	MARGIN - THE DIFFERENCE BETWEEN THE SAFETY LIMIT/OPERATING LIMIT AND THE NORMAL/ACCIDENT ACCURACY (Mn = NORAL MARGIN Ma = ACCIDENT MARGIN
mR/Hr	MILLIREM PER HOUR

A) DEFINITIONS & ABBREVIATIONS

N/A	NOT APPLICABLE
NCR	NET COUNT RATE
OCRe	OUTPUT TEST EQUIPMENT READING INACCURACY
OCTe	OUTPUT TEST INSTRUMENT CALIBRATION INACCURACY
PRCSe	PROCESS UNCERTAINTY
PSEe	INACCURACY DUE TO POWER SUPPLY VARIATIONS
PV	PROCESS VALUE (ACTUAL)
RADe	INACCURACY TO DUE TO RADIATION EXPOSURE
Re	REPEATABILITY INACCURACY
RH	RHR LINE BREAK
RNDe	NORMAL RADIATION DOSE BETWEEN CALIBRATION
RPT	RESPONSE TIME
Se	INACCURACY FOLLOWING A SEISMIC EVENT
SECu	SPAN ERROR CORRECTION UNCERTAINTY
SL	SAFETY LIMIT
SP	SETPOINT
SPEe	ZERO ERROR DUE TO EFFECTS OF OPERATING PRESSURE
TAe	TEMPERATURE EFFECT AT ACCIDENT CONDITIONS
TID	TOTAL 40 TEARS INTEGRATED DOSE
TNe	TEMPERATURE EFFECT IN THE MAXIMUM/NINIMUM ABNORMAL TEMPERATURE RANGES
TPRe	TEST POINT RESISTOR ERROR
WLe	WATERLEG UNCERTAINTY
WLHP	WATERLEG HIGH POINT
WLLP	WATERLEG LOW POINT

DESIGN INPUT DATA

B) LOOP COMPONENT LIST

LOOP ID#	COMPONENT ID#
0-R-90-125	0-RE-90-125 0-RM-90-125 0-RI-90-125
0-R-90-126	0-RE-90-126 0-RM-90-126 0-RI-90-126

REV	0	PREP	LMB	DATE	1/12/00	CHECK	ENT	DATE	5/31/00	SHEET	7	C/O	8 .
REV		PREP		DATE		CHECK		DATE		SHEET		C/O	.
REV		PREP		DATE		CHECK		DATE		SHEET		C/O	.

DESIGN INPUT DATA

C) LOOP FUNCTION

MAIN CONTROL ROOM INTAKE MONITORS (0-R-90-125 & 126)

These loops are used to monitor gross radioactivity of the air in the normal intake ventilation duct to the MCR. These monitors are provided to satisfy the requirements of 10CFR50, Appendix A for providing radiation protection to permit occupancy of the MCR. Detection of a high radioactivity level in the intake air being introduced into the MCR from outside shall automatically cause the transfer from normal to emergency mode (reference 19).

C) LOOP REQUIREMENTS AND LIMITS

RESPONSE TIME: The electronic field equipment (RE & RM) responds rapidly to Radioactivity level changes, therefore, in comparison to Operator interface the response time for this loop is negligible. This loop performs both an indicating function (RI) and a control function (transfer to emergency ventilation). Therefore, the response time of the entire radiation loop is not a concern.

SAFETY LIMIT (TRANSFER FROM NORMAL TO EMERGENCY MODE):

6.82×10^4 CPM (REFERENCE 9)

INDICATED RANGE: 10^1 to 10^7 CPM.

SETPOINT (BISTABLE):

Radiation monitoring setpoints will vary over the fuel cycle of the plant, however the error values will be given as constant and will not vary based on the setpoint. The setpoint for this loop is controlled by Chemistry but must be maintained ≤ 400 cpm for compliance with the Tech Spec. This is conservative based on the results of this calculation which identifies that a setpoint of $\leq 1.94 \times 10^4$ cpm is adequate for compliance with the above safety limit.

However, this calculation defines an Allowable Value that could replace the setpoint of ≤ 400 cpm defined in Tech Spec table 3.3-6 via Tech Spec Change 98-03.

DESIGN INPUT DATA

D) COMPONENT DATA

VALID FOR DEVICES IDENTIFIED ON SHEET(S):8

COMPONENT: 0-RE-90-125&126 CONTRACT#: 92759 REFERENCE#: 6

MANUFACTURER/MODEL: General Atomic RD-32 Detector/Pre-Amp REFERENCE#: 6

INPUT RANGE & UNITS: * NOTE#: * REFERENCE#: 1

OUTPUT RANGE & UNITS: 10^1 TO 10^7 CPM NOTE#: - REFERENCE#: 6

OVERRANGE LIMIT: N/A NOTE#: - REFERENCE#: -

CALIBRATED SPAN: 10^1 TO 10^7 CPM NOTE#: - REFERENCE#: 6

ROOM#/ PANEL#: C01 NOTE#: - REFERENCE#: 2

ELEVATION/COORDINATE: 732/PC1 NOTE#: - REFERENCE#: 3

MIN/MAX ABNORMAL TEMP: 60°F / 104°F NOTE#: - REFERENCE#: 2

ACCIDENT TEMPERATURE: 104°F NOTE#: - REFERENCE#: 2

RADIATION TID (RAD): 3.5×10^2 NOTE#: - REFERENCE#: 2

RADIATION IAD (RAD): $< 2.2 \times 10^3$ NOTE#: - REFERENCE#: 2

INSTRUMENT TAP INFORMATION REFERENCE #: N/A

WLHP TAP ELEVATION: N/A WLHP CONDENSING POT ELEVATION: N/A

WLLP TAP ELEVATION: N/A WLLP CONDENSING POT ELEVATION: N/A

EVENT/CATEGORY/OPERATING TIME: Mild Environment NOTE#: - REFERENCE#: 4

N/A / N/A / N/A

* Range in µCi/cc depends on the specific isotope being monitored (See Reference 1).

REV	10	PREP	LMB	DATE	5/23/00	CHECK	EHT	DATE	5/31/00	SHEET	9	C/O	10 .
REV		PREP		DATE		CHECK		DATE		SHEET		C/O	.
REV		PREP		DATE		CHECK		DATE		SHEET		C/O	.

DESIGN INPUT DATA

D) COMPONENT DATA

VALID FOR DEVICES IDENTIFIED ON SHEET(S):10

COMPONENT: 0-RM-90-125&126
0-RI-90-125&126 CONTRACT#: 92759 REFERENCE#: 5

MANUFACTURER/MODEL: General Atomic RP-30 REFERENCE#: 10

INPUT RANGE & UNITS: 10^1 to 10^7 CPM NOTE#: - REFERENCE#: 5

OUTPUT RANGE & UNITS: 10^1 to 10^7 CPM NOTE#: - REFERENCE#: 5

OVERRANGE LIMIT: N/A NOTE#: - REFERENCE#: -

CALIBRATED SPAN: 10^1 to 10^7 CPM NOTE#: - REFERENCE#: 5

ROOM#/ PANEL#: Mechanical Equip Rm C01 / 732′ NOTE#: - REFERENCE#: 2

ELEVATION/COORDINATE: 732' / PC1 NOTE#: - REFERENCE#: 3

MIN/MAX ABNORMAL TEMP: 60°F / 104°F NOTE#: - REFERENCE#: 2

ACCIDENT TEMPERATURE: 104°F NOTE#: - REFERENCE#: 2

RADIATION TID (RAD): 3.5×10^2 NOTE#: - REFERENCE#: 2

RADIATION IAD (RAD): $< 2.2 \times 10^3$ NOTE#: - REFERENCE#: 2

INSTRUMENT TAP INFORMATION REFERENCE #: N/A

WLHP TAP ELEVATION: N/A WLHP CONDENSING POT ELEVATION: N/A

WLLP TAP ELEVATION: N/A WLLP CONDENSING POT ELEVATION: N/A

EVENT/CATEGORY/OPERATING TIME: Mild Environment NOTE#: - REFERENCE#: 4

N/A / N/A / N/A
/ /
/ /
/ /

BRANCH/PROJECT IDENTIFIER 0-RE-90-125/126
DEMONSTRATED ACCURACY CALCULATION

DESIGN INPUT DATA

D) COMPONENT DATA (CONTINUED)

COMPONENT: 0-RE/RM-90-125&126

PARAMETER	VALUE/UNITS	NOTE#	REFERENCE#
Eed	Negligible	1,3	9,17
Encr	Negligible	1	9,17
Eimp	± 20.0% of reading	1,2	15,16
Ebs	± 1.0% of reading	4	13
Ect	Not Required	5	--
Epc	± 20.0% of reading	1,6	14,17
Ese	Not Required	7	18
ICTe	± 0.1% of FS (bistable) ± 4.0% of reading (ratemeter)	8,9	8
ICRe	± 4.0% of reading	8	8
OCTe	± 0.1% of FS (ratemeter & indicator)	9	--
OCRe	Not Required	9	--
Ab	± 3.0% of span	10	15,17
Se	Not Required	7	18
RNDe	Not Required	11	2
RADe	Not Required	11	2
TNe	Included in Re	12	15,17
TAe	Not Required	12	15,17
PRCSe	+ 24.48% of reading - 13.82% of reading	13	--
PRCSe$_{BIAS}$	+ 16.03% of reading	13	--
INDRe	+ 1.62% of span - 1.32% of span	14	--
IRe	Not Required	15	2
TPRe	Not Required	16	--
INDMe	± 2.0% of span	17	17
Re	± 3.0% of span	12	15,17
Ebd	± 2.2% of span	18	8
Efac	± 5.1% of reading	19	17

REV 0 PREP LMB DATE 5/24/00 CHECK EHT DATE 5/31/00 SHEET 11 C/O 12 .
REV __ PREP __ DATE __ CHECK __ DATE __ SHEET __ C/O __ .
REV __ PREP __ DATE __ CHECK __ DATE __ SHEET __ C/O __ .

DESIGN INPUT DATA

E) COMPONENT DATA NOTES (CONTINUED)

COMPONENT: 0-RE/RM-90-125&126

#	NOTE
1	Reference 17 identifies typical uncertainties associated with this equipment. Each uncertainty term is addressed by this calculation.

The uncertainty terms are:

A) Calibration: (Epc) This term accounts for the uncertainty of the primary calibration of the prototype detector. A known gaseous, liquid or solid source which is NBS traceable is routed through a prototype detector sample chamber or mock-up of the process stream to be monitor is used to calibrate the prototype detector assembly. The error associated with the output measurement of the prototype detector under calibration combine to yield primary calibration error. This error cannot be seen during plant calibration.

B) Factory Alignment Error: (Efac) This term accounts for the uncertainty associated with obtaining acceptable reference readings with the factory calibration source. This uncertainty is the difference between the prototype detector and the detector supplied to TVA using the factory calibration source. Mounting variation of the source is a contributor to this uncertainty. This uncertainty also accounts for the additional error in duplicating the same discriminator and gain (high voltage) levels used during the primary calibration with the prototype detector. This error cannot be seen during plant calibration.

C) Field Alignment: (Efa) After completion of factory test, monitors are delivered for installation at the site. The shipping, storage and installation process along with differences between the factory and site power, cable runs, noise, noise and general environment causes drifts in monitor response between the factory and the site. These monitors have adjustable discriminators and power supplies, and can be successfully realigned at the sites. The uncertainty associated with calibration or realignment of the monitor in the field is accomplished by calibrating to the plant calibration source. This uncertainty of calibration is accounted for via the M&TE uncertainties included in this calculation, i.e., ICTe, ICRe, OCTe, OCRe, and Ab. Thus field alignment error is not required to be included as a separate term.

D) Energy Dependence: (Eed) The difference in response of the detector to varying energy. The detector has a different sensitivity for each isotope it observes, the spread of these sensitivities is the error due to energy dependence. Normally the expected isotopes will be predominantly Xe-133. Plant procedures use the specific calibration factor analyzed by Engineering. Therefore, the energy dependence is accounted for and need not be considered as an uncertainty in this calculation.

DESIGN INPUT DATA

E) COMPONENT DATA NOTES (CONTINUED)

COMPONENT: 0-RE/RM-90-125&126

#	NOTE
1	(Continued)

E) Net Count Rate: (Encr) The Net Count Rate error is also referred to as Detector Environment error. Sorrento Electronics addresses detector environment as four types of uncertainties; Energy Dependence (discussed in D above), Temperature Effect, Response Time (Dead Time), and Sample Flow errors. Per Sorrento, changes in temperature can affect photomultiplier tubes, however on their RD-52, RD-53, AND RD-56 detectors no change in response was seen for changes in temperature from 40 to 130°F. Photomultiplier tubes are effectively linear for count rates from 10 cpm to 10^6 cpm. Above 10^6 cpm, PM tubes are affected by dead time with up to 30% foldover at count rates above 10^7 cpm. At a true count rate of 10^7 cpm, the actual reading would be about 7 X 10^6 cpm. The sample process error is accounted for separately inside this calculation under PRCSe. The count rate of concern is much smaller than 10^6 cpm, therefore, the Net Count Rate error is accounted for and need not be considered as an uncertainty in this calculation.

F) Electronics: (An, An of the rate meter) The uncertainty in measuring and processing the signals generated by the detector.

2 Statistical uncertainty associated with counting the nuclear events will be greatest for the lowest countrate assuming equal time for counting (same count rate). Imprecision is determined by calculating the standard deviation:

$$\sigma = \sqrt{R/T}$$

where R = countrate in cpm
T = 2RC (RC = time constant of readout module)
(RC varies with countrate)

The maximum setpoint for these monitors defined by this calculation is 1.94 x 10^4 CPM. The time constants used in the calculation are given in reference 15.

$$\sigma = \sqrt{\frac{1.94x10^4}{2(0.00717)}}$$

$$\sigma = 1163.12$$

$$2\sigma = 2326.25$$

$$SP \pm 2\sigma = 1.94 \text{ x } 10^4 \text{ CPM} \pm 2326.25 \text{ CPM}$$

Therefore %Error = ± { ± 2326.25 / 1.94 x 10^4 } X 100
= ± 11.99% at setpoint at the 95% confidence level

DESIGN INPUT DATA

E) COMPONENT DATA NOTES (CONTINUED)
COMPONENT: 0-RE/RM-90-125&126

#	NOTE
2	(Continued)

	Setpoint	RC	Sigma (cpm)	2 Sigma (cpm)	% Error
	100	0.434	10.73	21.47	21.47
	200	0.434	15.18	30.36	15.18
	400	0.434	21.47	42.93	10.73
	600	0.434	26.29	52.58	8.76
	800	0.434	30.36	60.72	7.59
	1200	0.0589	100.93	201.86	16.82
	1600	0.0589	116.54	233.09	14.57
	2200	0.0589	136.66	273.32	12.42
	2800	0.0589	154.17	308.34	11.01
	3400	0.0589	169.89	339.78	9.99
	4200	0.0589	188.82	377.64	8.99
	4900	0.0589	203.95	407.90	8.32
	5600	0.0589	218.03	436.07	7.79
	6200	0.0589	229.42	458.83	7.40
	7200	0.0589	247.23	494.45	6.87
	7800	0.0589	257.32	514.64	6.60
	8800	0.0589	273.32	546.64	6.21
	9800	0.0589	288.43	576.86	5.89
	10800	0.00717	867.84	1735.67	16.07
	11800	0.00717	907.12	1814.25	15.37
	12800	0.00717	944.78	1889.56	14.76
	13800	0.00717	980.99	1961.98	14.22
	14800	0.00717	1015.91	2031.82	13.73
	15800	0.00717	1049.67	2099.35	13.29
	16800	0.00717	1082.38	2164.76	12.89
	17800	0.00717	1114.13	2228.26	12.52
	18300	0.00717	1129.67	2259.34	12.35
	18800	0.00717	1145.00	2289.99	12.18
	19300	0.00717	1160.12	2320.25	12.02
	19350	0.00717	1161.62	2323.25	12.01
Setpoint	**19400**	**0.00717**	**1163.12**	**2326.25**	**11.99**
	19450	0.00717	1164.62	2329.25	11.98
	19500	0.00717	1166.12	2332.24	11.96
	19550	0.00717	1167.61	2335.23	11.94
	20050	0.00717	1182.45	2364.90	11.80
	20550	0.00717	1197.10	2394.20	11.65
	21050	0.00717	1211.58	2423.16	11.51

DESIGN INPUT DATA

E) COMPONENT DATA NOTES (CONTINUED)

COMPONENT: 0-RE/RM-90-125&126

\# NOTE

2 (Continued)

Based on the preceding tabular data, the Error varies with setpoints from 200 to 19,400 cpm with a maximum value of ±16.82% at a setpoint of 1200 cpm. Therefore, the % Error of ±16.82% for a maximum setpoint of 19,400 cpm would be acceptable for Eimp. However, for conservatism, a rounded up value of ±20% of reading will be used for Eimp.

3 The detectors have a different sensitivity for each isotope they observe, the spread of these sensitivities is the error due to energy dependence. For these monitors, the isotope concentrations used for the analysis to set the safety limit which can be considered the worst-case analysis are given in reference 15. This mixture will determine the CPM output at the setpoint. Therefore, the energy dependence is accounted for and need not be considered as an uncertainty in this calculation..

4 Per reference 13, the trip circuit is highly stable and accurate with an absolute accuracy much better than 1% of reading. For conservatism, bistable error will be set equal to ±1% of reading.

5 The signal from the noble gas channel detector is coupled to the respective readout module via coaxial cable. The signal from the detector is first amplified in a preamplifier which is a part of each detector assembly. The coaxial cable is terminated in its characteristic impedance at the input of the readout module. The attenuation of the signal in the cable is "compensated" as follows:

A) A calibration source is used which has a dominant β energy low compared to that of nuclides to be detected.

B) In the calibration procedure, using the source described in A. above, the discriminator levels in the readout module are adjusted to give a countrate within a specified band which agrees with the activity of the source.

C) The signal pulses from the expected nuclides in the expected spectra of nuclides will then be larger than those which were used to set the discriminator levels, and will be counted.

Therefore it is not necessary to consider errors due to current transmission.

DESIGN INPUT DATA

E) COMPONENT DATA NOTES (CONTINUED)

COMPONENT: 0-RE/RM-90-125&126

#	NOTE

6 Primary calibration is a procedure in which an NBS traceable source is routed through a sample chamber and the response is noted. The error associated with this calibration is ± 20% of reading, reference 14 & 17.

7 Per reference 18, GA Seismic report, a seismic event will have no effect on the system. Therefore, Ese and Se are not required.

8 The calibration of the readout module uses a pulse generator, counter and timer. Instrument maintenance records (reference 8) have shown that a 4% variance in the desired pulse rate is achievable. A 45 variance in pulse rate can be equated to a 4% variance in reading Therefore, ICTe and ICRe = ± 4% of reading.

9 As a requirement of this calculation, a digital voltmeter shall be used to read the output of the calibrated device. Therefore, OCRe is not required. Instrument maintenance has used a Keithley 197 DVM which has a stated accuracy of 0.018% input + 0.00024 V over a range of 0-20 V dc. It is reasonable that any new DVMs will have an accuracy at least equal to the current DVMs. Therefore to be conservative an error of ±0.1% full scale will be used for OCTe for the ratemeter and indicator, and ICTe for the bistable.

10 Per reference 15 and 17, the ratemeter reference accuracy is ±3% of equivalent linear full scale. All of the ratemeter errors are encompassed by this 3% error (Reference 15). This includes calibration inaccuracies, temperature effect, environmental effects and inherent equipment inaccuracies. Reference 15 states that temperature effect is ±0.1% of equivalent linear full scale / °C. The ratemeter is located in the Control Building, where the maximum temperature excursion is 16°C to 40°C (reference 2). This would yield a temperature effect of:

$$\begin{aligned}\text{Temp. Effect} &= \pm(40 - 16\text{C}) \times 0.1\% \times 10\text{V} \\ &= \pm 0.24\ \text{V}\end{aligned}$$

Excluding this temperature effect would result in an inaccuracy of (0.3V - 0.24V = 0.06V). This 0.06V would still include other inaccuracies in addition to the reference accuracy. Per TI-28 (Reference 11), the acceptance band (Ab) should be at least equal to the reference accuracy. If the entire 0.06V were attributed to reference accuracy, Ab would equal 0.6% of equivalent full scale. However, to add more conservatism and minimize impact to existing plant procedures, Ab for the ratemeter and ratemeter/detector will be set equal to ±3.0% of equivalent full scale, while the Ab for the bistable and the indicator will also be set equal to ±3.0% of equivalent full scale.

DESIGN INPUT DATA

E) COMPONENT DATA NOTES (CONTINUED)

COMPONENT: 0-RE/RM-90-125&126

\# NOTE

11 The detector, preamplifier and readout module are located in a mild environment where the maximum radiation is ≤2.2 X 10^3 RADs(reference 2).

12 Per reference 15 and 17, the vendor stated accuracy is ± 3% of equivalent linear full scale. This ± 3% includes calibration inaccuracies, temperature effect, environmental effects and inherent equipment accuracies.

13 Process uncertainty is applicable to the gas monitors. Process uncertainty is discussed in Computation/Analyses Section A.

14 The indicator reading error is 1/2 the largest division on the scale. The indicator scale is logarithmic which means that the reading error will vary depending on which part of the decade the reading is taken. To obtain the reading in percentage of span. The maximum reading error in the positive direction = Log(1.5) - Log(1.0) = 0.176 decades, while the maximum reading error in the negative direction = Log(2.0) - Log(1.5) = 0.124 decades. These rate meters have a scale of 6 decades, therefore, % span error equals:

$$\text{INDRe}(+) = 0.0293 \text{ error}$$
$$= 2.93\% \text{ of span}$$

$$\text{INDRe}(-) = \frac{0.124 \dfrac{\text{decades}}{\text{error}}}{6 \text{ decades}}$$

$$\text{INDRe}(-) = -\ 0.0206 \text{ error}$$
$$= -\ 2.06\% \text{ of span}$$

$$\text{INDRe}(+) = \frac{0.176 \dfrac{\text{decades}}{\text{error}}}{6 \text{ decades}}$$

DESIGN INPUT DATA

E) COMPONENT DATA NOTES (CONTINUED)

COMPONENT: 0-RE/RM-90-125/126

#	NOTE

14 (continued)

However, as shown by this table the positive and negative reading errors will vary throughout the readings on the decade.

Reading on Decade	% Span Error
2.0 - 3.0	+1.62% -1.32%
5.0 - 6.0	+0.69% -0.63%
7.0 - 8.0	+0.50% -0.47%
8.0 - 9.0	+0.44% -0.41%

The readability between the 1 and 2 divisions is approximately 10 times better than between 9 and 10 due to the physical size of the scale markings. Therefore, the operator is less likely to make a 1/2 division reading error on the larger scale divisions. Using this reasoning the reading error for the first scale division (between 1.0 and 2.0) will be taken as 1/4 divisions. Therefore positive reading will = Log(1.25) - Log(1.0) = 0.0969 decades, and the negative reading error = Log(1.25) - Log(1.5) = -0.0792 decades. Therefore % span reading error equals:

$$\text{INDRe}(+) = \frac{0.0969 \frac{\text{decades}}{\text{error}}}{6 \text{ decades}}$$

$$\text{INDRe}(+) = 0.0162 \text{ error}$$
$$= 1.62\% \text{ of span}$$

$$\text{INDRe}(-) = \frac{0.0792 \frac{\text{decades}}{\text{error}}}{6 \text{ decades}}$$

$$\text{INDRe}(-) = -\ 0.0132 \text{ error}$$

$$= -\ 1.32\% \text{ of span}$$

It should be noted that these values for 1/4 division reading error between the 1 and 2 scale divisions are still more conservative than 1/2 division reading errors for the remainder of the decade scale division.

DESIGN INPUT DATA

E) COMPONENT DATA NOTES (CONTINUED)

COMPONENT: 0-RE/RM-90-125&126

#	NOTE
15	Per reference 2, the detector, preamplifier and readout module are in a mild environment, therefore insulation resistance effects will be negligible.
16	The test point resistor used for the calibration of this equipment is internal to the readout module and is accounted for in the accuracy of the module. Therefore, no additional error is needed for TPRe.
17	Per reference 17, the movement error of the indicator is ±2%. Therefore INDMe = ±2% of equivalent full scale. The front panel indicator is not used for calibration of the bistable or ICS point, a DVM is used for these devices, therefore INDMe is not required for these devices.
18	Using the calibration data from these devices, a statistical analysis shows the bistable and the drift associated with it was determined to be 2.2% of full scale (See reference 12 statistical analysis).
19	Per reference 17 the error associated with factory alignment of the detectors, as given by the vendor, is 5.1% of reading.

COMPUTATIONS/ANALYSES

A) PROCESS UNCERTAINTY DISCUSSION/CALCULATION

_____ NO PROCESS UNCERTAINTY EXISTS FOR THIS CALCULATION BECAUSE:

_____ THE MEASURED PARAMETER IS THE PARAMETER OF CONCERN; THEREFORE, PROCESS VARIATIONS ARE ACCOUNTED FOR IN THE DETERMINATION OF SAFETY AND/OR OPERATIONAL LIMITS.

_____ OTHER: SEE DISCUSSION BELOW.

__X__ PROCESS UNCERTAINTY DOES EXIST AND IS DETAILED IN THE FOLLOWING DISCUSSION/CALCULATION.

A.1 Radiation Monitor 0-R-90-125 and 126 Density Correction

A.1.1 Temperature

A difference in temperature between the process and the detector infers a difference in density between the process and the detector. A change in density will bias the concentration per unit volume measurement.

Due to a high velocity transit through the sample line, approximately 30 fps based on 10 CFM through a 1" O.D. sample line, the measurement will be considered isothermal. At 30 fps it will only take a few seconds for the sample to reach the detector location. Any slight cooling will result in higher densities at the detector which will produce slightly higher count rates than at the process.

A.1.2 Pressure

The radiation detector sample pumps are low volumetric flow pumps set to 10 SCFM based on the flow correction curves supplied in the technical manuals. A representative sample from the process line is set up using the flow pump, manual ball valves, the monitor flow indicator, pressure indicator, and M&TE flow instrumentation. Considering this setup procedure and that the gas detector is located on the suction side of the pump, the pressure at the detector location will be less than at the process.

A difference in pressure between the process and the detector infers a difference in density between the process and the detector. A difference in density will bias the concentration per unit volume measurement. If the density at the detector is lower than process density then the detector will undercount the activity, which is not conservative with respect to MCR intake concentration. Thus pressure difference must be accounted for between the process and the detector.

COMPUTATIONS/ANALYSES

A) PROCESS UNCERTAINTY DISCUSSION/CALCULATION

A.1 Radiation Monitor Density Correction (Continued)

A.1.2 Pressure (Continued)

The optimum means with which to compensate for this phenomena is to quantify the difference in pressure between the detector and the process and to then establish the setpoint/indication allowing for the difference. Thus a pressure compensation factor must be calculated. The compensation factor is to be used in conjunction with the sensitivity curve supplied with the detectors to account for the difference between the measured pressure at the detector location and the process. The compensation factor can also be used to compensate indicated activity readings used in determining containment concentration.

Since the plant chemistry group will establish these setpoints, a correction factor formula based on observed detector pressure will be developed for inclusion in the Design Engineering Setpoint Scaling Document (the output document for this calculation). Uncertainty in the pressure measurement associated with the correction factor will be included in this calculation.

The vendor has developed an empirical formula to be used for pressure compensation. (Reference 19 "GA Manual E-115-647", Rev. 6). This equation will be used to calculate a correction factor to be used in calculating setpoints and to compensate for errors in indications used to calculate offsite releases.

The equation is

$$\text{Correction Factor (CF)} = \frac{P_P}{(P_P - P_n) * (1 + P_n * A_n)}$$

Where: P_P = Process pressure In. Hg. Absolute

P_n = Detector pressure In. Hg. Vac.

A_n = Self absorption factor

A_n = .013 for Xe-133

A_n = .004 for Kr-85

A_{nxe} = .013 will be used to calculate the correction factor. The dominant isotope is Xe-133 and yields a worst case error. Table A.2 gives the correction factors for detector pressures from 0 - 12 Inches of Hg. Vacuum.

COMPUTATIONS/ANALYSES

A) PROCESS UNCERTAINTY DISCUSSION/CALCULATION

TABLE A.2
DETECTOR PRESSURE CORRECTION FACTOR

PRESSURE CORRECTION FACTORS		
PROCESS PRESSURE	DETECTOR PRESSURE	CORRECTION FACTOR
29.92 In. Hg. Ab.	12.00 In. Hg. Vac.	1.4443
29.92 In. Hg. Ab.	11.50 In. Hg. Vac.	1.4131
29.92 In. Hg. Ab.	11.00 In. Hg. Vac.	1.3835
29.92 In. Hg. Ab.	10.50 In. Hg. Vac.	1.3556
29.92 In. Hg. Ab.	10.00 In. Hg. Vac.	1.3292
29.92 In. Hg. Ab.	9.50 In. Hg. Vac.	1.3042
29.92 In. Hg. Ab.	9.00 In. Hg. Vac.	1.2804
29.92 In. Hg. Ab.	8.50 In. Hg. Vac.	1.2578
29.92 In. Hg. Ab.	8.00 In. Hg. Vac.	1.2364
29.92 In. Hg. Ab.	7.50 In. Hg. Vac.	1.2160
29.92 In. Hg. Ab.	7.00 In. Hg. Vac.	1.1965
29.92 In. Hg. Ab.	6.50 In. Hg. Vac.	1.1780
29.92 In. Hg. Ab.	6.00 In. Hg. Vac.	1.1603
29.92 In. Hg. Ab.	5.50 In. Hg. Vac.	1.1435
29.92 In. Hg. Ab.	5.00 In. Hg. Vac.	1.1274
29.92 In. Hg. Ab.	4.50 In. Hg. Vac.	1.1120
29.92 In. Hg. Ab.	4.00 In. Hg. Vac.	1.0973
29.92 In. Hg. Ab.	3.50 In. Hg. Vac.	1.0832
29.92 In. Hg. Ab.	3.00 In. Hg. Vac.	1.0697
29.92 In. Hg. Ab.	2.50 In. Hg. Vac.	1.0568
29.92 In. Hg. Ab.	2.00 In. Hg. Vac.	1.0445
29.92 In. Hg. Ab.	1.50 In. Hg. Vac.	1.0326
29.92 In. Hg. Ab.	1.00 In. Hg. Vac.	1.0213
29.92 In. Hg. Ab.	0.50 In. Hg. Vac.	1.0104
29.92 In. Hg. Ab.	0.00 In. Hg. Vac.	1.0000

REV 0 PREP LMB DATE 5/23/00 CHECK EHT DATE 5/31/00 SHEET 22 C/O 23 .
REV ___ PREP ___ DATE ___ CHECK ___ DATE ___ SHEET ___ C/O ___ .
REV ___ PREP ___ DATE ___ CHECK ___ DATE ___ SHEET ___ C/O ___ .

COMPUTATIONS/ANALYSES

A) PROCESS UNCERTAINTY DISCUSSION/CALCULATION

A.1 Radiation Monitor Density Correction (Continued)

A.1.2 Pressure (Continued)

Normal vacuum is between 5 and 7 In. Hg. A maximum detector baseline pressure of 6 In. Hg. Vacuum will be used to calculate a pressure correction factor to define PRCSe. Additionally, a bias error ($PRCSe_{BIAS}$) will also be defined for this baseline pressure of 6 In. Hg. Vacuum. The correction factor does not need to be used for TI-30 "Radiological Gaseous Effluent" calculations because these monitors are not used to calculate offsite releases. Since a bias term is being considered for the maximum detector baseline pressure of 6 In. Hg. Vacuum, this correction factor does not need to be input to the ICS for compensating setpoints or ICS indications.

From Table A.2 CF = 1.1603 for 6 In. of Hg. Vacuum

Table A.2 can be used to determine a correction factor for the indicator and recorder based on actual detector pressure reading by the plant if a situation arises that requires specific data.

As stated above, the uncertainties in the correction factor included in this calculation will be based on 6 In. Hg. Vacuum, ± 6 In. Hg. Vacuum. The ± 6 In. Hg. Vacuum accounts for a span of 0 to 12 In. Hg. Vacuum range. The only way for the 0 In. Hg. Vacuum to occur would be for the vacuum pump to stop. If the vacuum pump stops the flow would also stop, resulting in a malfunction alarm due to a flow rate of less than 4 scfm flow. The +6 In. Hg. Vacuum uncertainty in the correction factor will give a +12 In. Hg. Which will cause the vacuum switch to initiate a malfunction alarm. Therefore, a , ± 6 In. Hg. Vacuum uncertainties in the correction factor will be conservative. The uncertainties are calculated as follows:

$+CF = (CF_{12} - CF_6)/CF_6 * 100 = ((1.4443 - 1.1603)/ 1.1603) * 100$
$+CF = +24.48\%$ of reading

$-CF = (CF_0 - CF_6)/CF_6 * 100 = ((1.0000 - 1.1603)/ 1.1603) * 100$
$-CF = -13.82\%$ of reading

Therefore, **PRCSe = +24.48 / -13.82% of reading**

An additional bias term $PRCSe_{BIAS}$ will be considered based on utilizing the 6 In. Hg. Vacuum defined in the above discussion. From Table A.2, the error is 16.03%. The sign convention for this error term is positive. As previously stated, if the density (i.e., pressure) at the detector is lower than process density the detector will undercount the activity. Therefore, decreasing pressure (i.e.,increasing vacuum) will result in an indicating value that is lower than the true value. From reference 11 (EEB Branch Instruction TI-28), Error = True Value - Indicated Value.

Therefore, **$PRCSe_{BIAS}$ = +16.03% of reading**

COMPUTATIONS/ANALYSES

B) WATERLEG UNCERTAINTY DISCUSSION/CALCULATION

X APPLICABLE TO ALL LOOPS LISTED ON SHEET 8

____ APPLICABLE ONLY TO LOOPS:

X WATERLEG UNCERTAINTY IS NOT CONSIDERED FOR THE CALCULATION BECAUSE:

- X NO WATERLEG EXISTS FOR THIS CALCULATION.
- ____ THE EFFECTS OF WATERLEG CHANGES ARE INSIGNIFICANT. SEE DISCUSSION/CALCULATION BELOW.
- ____ OTHER. SEE DISCUSSION/CALCULATION BELOW.

____ A WATERLEG UNCERTAINTY DOES EXIST FOR THIS LOOP. SEE CALCULATION/DISCUSSION BELOW.

____ SEE SENSING LINE DIAGRAM ON SHEET ____ OF THIS CALCULATION.

COMPUTATIONS/ANALYSES

C) ACCURACY DISCUSSION

X The accuracy of this instrument for normal, post seismic and accident conditions will be determined by considering the parameters tabulated in the design input section of this calculation.

The accuracy calculation for seismic (As) is bounding for all seismic events.

X The square root of the sum of the squares method shall be used in this calculation for the calculating accuracy since the factors affecting accuracy are independent variables.

X Bi-directional errors and uni-directional errors will be combined in a manner such that the sum of the positive uni-directional errors will be added to the positive portion of the bi-directional error (obtained from the square root of the sum of the squares method), and the sum of the negative portion of the bi-directional error.

This method is conservative. Therefore, it will be used in this calculation.

Example: (+/-)10 = bi-directional error
+ 5 = first uni-directional error
- 2 = second uni-directional error

Total Error = (+10 +5) to (-10 -2) = +15 to -12

_____ Other:

For the purposes of this calculation, accuracy is defined as the range of actual process values that may exist for a given indicated or bistable trip value, e.g. an accuracy of +15 psig to -12 psig means that for a indicated or bistable trip value of 100 psig, the actual process pressure may be anywhere between 88 and 115 psig.

All system analysis based on or using accuracy values from this calculation should take into account the fact that operator action and/or automatic initiations may occur at a process value differing from the indicated or setpoint values by the amount of the calculated inaccuracies.

COMPUTATIONS / ANALYSES

D) ACCURACY CALCULATION INDEX

1.1.0 READOUT MODULE ERROR (MODIFIERS) (0-R-90-125,-126)

1.1.1	Reference Accuracy	Re
1.1.2	Output Calibration Test Error	OCTe
1.1.3	Acceptance Band	Ab
1.1.4	Input Calibration Test and Reading Errors	ICTe/ICRe
1.1.5	Normal Measurable/Normal Accuracy	Anf_{RM}/An_{RM}

1.2.0 READOUT MODULE - DETECTOR ERROR (0-R-90-125,-126)

1.2.1	Primary Calibration Accuracy	Epc
1.2.2	Factory Alignment Error	Efac
1.2.3	Imprecision Error	Eimp
1.2.4	Process Uncertainty Error	PRCSe
1.2.5	Normal Measurable Accuracy	$Anf_{RM/RD}$
1.2.6	Normal Loop Accuracy	$An_{RM/RD}$

1.3.0 BISTABLE ACCURACY (0-R-90-125,-126)

1.3.1	Bistable Error	Ebs
1.3.2	Input Calibration Test Error	ICTe
1.3.3	Acceptance Band	Ab
1.3.4	Bistable Drift	Ebd
1.3.5	Normal Measurable Accuracy	Anf_{BS}
1.3.6	Normal Measurable Loop Accuracy	$LAnf_{BS}$
1.3.7	Normal Loop Accuracy	LAn_{BS}
1.3.8	Accident Loop Accuracy	LAa_{BS}
1.3.9	Allowable Value	AV
1.3.10	Setpoint Determination	$Setpoint_{MAX}$

1.4.0 INDICATOR ACCURACY (0-R-90-125,-126)

1.4.1	Output Calibration Test Error	OCTe
1.4.2	Acceptance Band	Ab
1.4.3	Indicator Movement Error	INDMe
1.4.4	Indicator Reading Error	INDRe
1.4.5	Normal Measurable Accuracy	Anf_I
1.4.6	Normal Measurable Loop Accuracy	$LAnf_I$
1.4.7	Normal Loop Accuracy	LAn_I
1.4.8	Accident Loop Accuracy	LAa_I

COMPUTATIONS / ANALYSES

D) ACCURACY CALCULATIONS

1.1 READOUT MODULE ERROR (RM)

1.1.1 Reference Accuracy (Re)

$$\begin{aligned} Re &= \pm 3.0\% \text{ of FS} \\ &= \pm 0.03 * 10 \text{ V} \\ &= \pm 0.3 \text{ V} \\ &= \pm 0.3 \text{ V} \end{aligned}$$

1.1.2 Output Calibration Test Error (OCTe)

$$\begin{aligned} OCTe &= \pm 0.1\% \text{ of FS} \\ &= \pm 0.001 * 10 \text{ V} \\ &= \pm 0.01 \text{ V} \end{aligned}$$

1.1.3 Acceptance Band (Ab)

$$\begin{aligned} Ab &= \pm 3.0\% \text{ of FS} \\ &= \pm 0.03 * 10 \text{ V} \\ &= \pm 0.3 \text{ V} \end{aligned}$$

1.1.4 Input Calibration: Test Error (ICTe) & Reading Error (ICRe)

$ICTe = ICRe = \pm 4.0\%$ of reading

Per Reference 14, the transfer function to equate a reading error into an equivalent linear full scale error is:

$$\%\text{ Reading Error} = -[1 - 10^{\pm B(A)}] * 100$$

Where B = No. of decades/span
A = Eq. linear full scale error in volts

Therefore, by arranging terms the reading error can be expressed in volts by the following equation:

$$\text{Volts}(+) = [\text{Log}(1 + (\%\text{ Reading}/100))] / (\text{No. Decades/Span})$$

$$\text{Volts}(-) = [\text{Log}(1 - (\%\text{ Reading}/100))] / (\text{No. Decades/Span})$$

Therefore, ICTe expressed in volts is calculated as follows:

$$\begin{aligned} +ICTe &= [\text{Log}(1 + (4.0\%/100))] / (6/10) \\ &= (\text{Log}(1.04)) / 0.6 \\ &= +0.028 \text{ V} \end{aligned}$$

$$\begin{aligned} -ICTe &= [\text{Log}(1 - (4.0\%/100))] / (6/10) \\ &= (\text{Log}(0.96)) / 0.6 \\ &= -0.029 \text{ V} \end{aligned}$$

And;

$+ICRe = +0.028$ V

$-ICRe = -0.029$ V

COMPUTATIONS / ANALYSES

D) ACCURACY CALCULATIONS

1.1.5 Normal Measurable/Normal Accuracy Anf_{RM}/An_{RM}

$$\pm Anf_{RM} = \pm\sqrt{(Re^2+OCTe^2+Ab^2+ICTe^2+ICRe^2)}$$

$$+Anf_{RM} = +\sqrt{(0.3^2+0.01^2+0.3^2+0.028^2+0.028^2)} = +0.426\text{ V}$$

$$-Anf_{RM} = -\sqrt{(0.3^2+0.01^2+0.3^2+0.029^2+0.029^2)} = -0.426\text{ V}$$

From the equation above, these values may be converted to % of reading as follows:

$$+Anf_{RM} = -[1 - 10^{(0.426)(0.6)}] * 100 = -[1 - 10^{(0.256)}] * 100 = +80.30\%\text{ of reading}$$

$$-Anf_{RM} = -[1 - 10^{(-0.426)(0.6)}] * 100 = -[1 - 10^{(-0.256)}] * 100 = -44.53\%\text{ of reading}$$

Since all parameters are measurable, the Normal Accuracy is equal the normal measurable accuracy.

$$\pm An_{RM} = \pm Anf_{RM} = \pm 0.426\text{ V}$$

1.2 READOUT MODULE - DETECTOR ERROR (RM/RD)

1.2.1 Primary Calibration Accuracy (Epc)

$\pm Epc$ = ±20% of reading
$+Epc$ = +0.132 V
$-Epc$ = -0.162 V

1.2.2 Factory Alignment Error (Efac)

$\pm Efac$ = ±5.1% of reading
$+Efac$ = +0.036 V
$-Efac$ = -0.038 V

1.2.3 Imprecision Error (Eimp)

$\pm Eimp$ = ±20% of reading
$+Eimp$ = +0.132 V
$-Eimp$ = -0.162 V

1.2.4 Process Uncertainty Error (PRCSe)

$\pm PRCSe$ = +24.48% / -13.82% of reading
$+PRCSe$ = +0.158 V
$-PRCSe$ = -0.108 V

$PRCSe_{BIAS}$ = +16.03% of reading
$PRCSe_{BIAS}$ = +0.108 V

COMPUTATIONS / ANALYSES

D) ACCURACY CALCULATIONS

1.2.5 Normal Measurable Accuracy ($Anf_{RM/RD}$)

$$\pm Anf_{RM/RD} = \pm\sqrt{(Anf_{RM}^2+Eimp^2)}$$

$$\begin{aligned} +Anf_{RM/RD} &= +\sqrt{(0.426^2+0.132^2)} \\ &= +0.446 \text{ V} \end{aligned}$$

$$\begin{aligned} -Anf_{RM/RD} &= -\sqrt{(0.426^2+0.162^2)} \\ &= -0.456 \text{ V} \end{aligned}$$

1.2.6 Normal Loop Accuracy ($An_{RM/RD}$)

$$\pm An_{RM/RD} = \pm\sqrt{(Anf_{RM}^2+Epc^2+Efac^2+Eimp^2+PRCSe^2)} + PRCSe_{BIAS}$$

$$\begin{aligned} +An_{RM/RD} &= +\sqrt{(0.426^2+0.132^2+0.036^2+0.132^2+0.158^2)} + 0.108 \\ &= +0.493 + 0.108 \text{ V} \\ &= +0.601 \end{aligned}$$

$$\begin{aligned} -An_{RM/RD} &= -\sqrt{(0.426^2+0.162^2+0.038^2+0.162^2+0.108^2)} \\ &= -0.497 \text{ V} \end{aligned}$$

1.3 BISTABLE ACCURACY (BS)

1.3.1 Bistable Error (Ebs)

±Ebs = ±1.0% of reading

+Ebs = +0.007 V
-Ebs = -0.007 V

1.3.2 Input Calibration Test Error (ICTe)

±OCTe = ±0.1% of FS
= ±0.001 * 10 V
= ±0.01 V

1.3.3 Acceptance Band (Ab)

±Ab = ±3.0% of FS
= ±0.03 * 10 V
= ±0.3 V

1.3.4 Bistable Drift (Ebd)

±Ebd = ±2.2% of FS
= ±0.022 * 10 V
= ±0.22 V

COMPUTATIONS / ANALYSES

D) ACCURACY CALCULATIONS

1.3.5 Normal Measurable Accuracy (Anf_{BS})

$$\pm Anf_{BS} = \pm\sqrt{(Ebs^2+ICTe^2+Ab^2+Ebd^2)}$$

$$\pm Anf_{BS} = \pm\sqrt{(0.007^2+0.01^2+0.3^2+0.22^2)}$$
$$= \pm 0.372 \text{ V}$$

1.3.6 Normal Measurable Loop Accuracy ($LAnf_{BS}$)

$$\pm LAnf_{BS} = \pm\sqrt{(Anf_{RM/RD}{}^2+Anf_{BS}{}^2)}$$

$$+LAnf_{BS} = +\sqrt{(0.446^2+0.372^2)}$$
$$= +0.581 \text{ V} \quad (+123.2\% \text{ of reading})$$

$$-LAnf_{BS} = -\sqrt{(0.456^2+0.372^2)}$$
$$= -0.588\text{V} \quad (-55.6\% \text{ of reading})$$

1.3.7 Normal Loop Accuracy (LAn_{BS})

$$\pm LAn_{BS} = \pm\sqrt{(Anf_{BS}{}^2+ An_{RM/RD}{}^2)} + PRCSe_{BIAS}$$

$$+LAn_{BS} = +\sqrt{(0.372^2+0.493^2)} + 0.108$$
$$= +0.726 \text{ V} \quad (+172.6\% \text{ of reading})$$

$$-LAn_{BS} = -\sqrt{(0.372^2+0.497^2)}$$
$$= -0.621\text{V} \quad (-57.6\% \text{ of reading})$$

1.3.8 Accident Loop Accuracy (LAa_{BS})

There are no additional inaccuracies during an accident. Therefore, $LAa_{BS} = LAn_{BS}$

$$+LAa_{BS} = +0.726 \text{ V} \quad (+172.6\% \text{ of reading})$$

$$-LAa_{BS} = -0.621 \text{ V} \quad (-57.6\% \text{ of reading})$$

COMPUTATIONS / ANALYSES
D) ACCURACY CALCULATIONS

1.3.9 Allowable Value (AV)

The safety limit for the bistable control function (transfer from normal to emergency mode) is 6.82×10^4 cpm. The loop bistable errors defined in sections 1.3.6 and 1.3.7 are:

$+LAnf_{BS} = +0.581$ V (+123.2% of reading)

$+LAn_{BS} = +0.726$ V (+172.6% of reading)

+AV is defined as follows:

$+AV = \text{Safety Limit} - (Adbe - LAnf_{BS} + \text{Margin})$

Where $Adbe = +LAn_{BS}$, and Margin is defined as 0.182 V or 25% of $+LAn_{BS}$ for conservatism.

Converting the Safety Limit to volts:

$$\text{Safety Limit(volts)} = \frac{Log[Input(cpm)] - 1}{\left[\dfrac{\#of\ Decades}{Voltage\ Span}\right]}$$

$$\text{Safety Limit(volts)} = \frac{Log[6.82 x 10^4] - 1}{\left[\dfrac{6}{10}\right]}$$

Safety Limit(volts) = 6.390 volts

Therefore;

$+AV(volts) = 6.390 - (0.726 - 0.581 + 0.182)$
$+AV(volts) = 6.063$ V

Converting to cpm;

$$+AV(cpm) = 10^{\left[\frac{Output(volts)\ X\ \#of\ Decades}{Voltage\ Span} + 1\right]}$$

$$+AV(cpm) = 10^{\left[\frac{6.063\ X\ 6}{10} + 1\right]}$$

$+AV(cpm) = 4.34 \times 10^4$ (rounded down for conservatism)

1.3.10 Setpoint Determination

A maximum setpoint value will be determined based on the value defined for +AV in the previous section:

$$\text{Setpoint}_{MAX}(\text{volts}) = +AV - (+LAnf_{BS})$$
$$\text{Setpoint}_{MAX}(\text{volts}) = 6.063 - 0.581$$
$$\text{Setpoint}_{MAX}(\text{volts}) = 5.482$$

Converting to cpm;

$$\text{Setpoint}_{MAX}(\text{cpm}) = 10^{\left[\frac{\text{Output(volts)} \times \text{\#of Decades}}{\text{Voltage Span}} + 1\right]}$$

$$\text{Setpoint}_{MAX}(\text{cpm}) = 10^{\left[\frac{5.482 \times 6}{10} + 1\right]}$$

$\text{Setpoint}_{MAX}(\text{cpm}) = 1.94 \times 10^4$ (rounded down for conservatism)

Note: $\text{Setpoint}_{MAX} + LAn_{BS} = 5.482 + 0.726 = 6.208$ volts or 5.31×10^4 cpm and $\text{Setpoint}_{MAX} - LAn_{BS} = 5.482 - 0.621 = 4.861$ volts or 8.25×10^3 cpm.

1.4 INDICATOR ACCURACY (I)

1.4.1 Output Calibration Test Error (OCTe)

$$\pm OCTe = \pm 0.1\% \text{ of FS}$$
$$= \pm 0.001 * 10 \text{ V}$$
$$= \pm 0.01 \text{ V}$$

1.4.2 Acceptance Band (Ab)

$$\pm Ab = \pm 3.0\% \text{ of FS}$$
$$= \pm 0.03 * 10 \text{ V}$$
$$= \pm 0.3 \text{ V}$$

1.4.3 Indicator Movement Error (INDMe)

$$\pm INDMe = \pm 2.0\% \text{ of FS}$$
$$= \pm 0.02 * 10 \text{ V}$$
$$= \pm 0.2 \text{ V}$$

1.4.4 Indicator Reading Error (INDRe)

$$+INDRe = +1.61\% \text{ of span}$$
$$= +0.0161 * 10 \text{ V}$$
$$= +0.161 \text{ V}$$

$$-INDRe = -1.32\% \text{ of span}$$
$$= -0.0132 * 10 \text{ V}$$
$$= -0.132 \text{ V}$$

COMPUTATIONS / ANALYSES

D) ACCURACY CALCULATIONS

1.4.5 Normal Measurable Accuracy (Anf_I)

$$\pm Anf_I = \pm\sqrt{(OCTe^2 + Ab^2 INDMe^2)}$$

$$\pm Anf_I = \pm\sqrt{(0.01^2 + 0.3^2 + 0.2^2)}$$
$$= \pm 0.361 \text{ V}$$

1.4.6 Normal Measurable Loop Accuracy ($LAnf_I$)

$$\pm LAnf_I = \pm\sqrt{(Anf_{RM/RD}{}^2 + Anf_I{}^2)}$$

$$+LAnf_I = +\sqrt{(0.446^2 + 0.361^2)}$$
$$= +0.574 \text{ V} \quad (+121.0\% \text{ of reading})$$

$$-LAnf_I = -\sqrt{(0.456^2 + 0.361^2)}$$
$$= -0.582 \text{ V} \quad (-55.2\% \text{ of reading})$$

1.4.7 Normal Loop Accuracy (LAn_I)

$$\pm LAn_I = \pm\sqrt{(Anf_I{}^2 + INDRe^2 + An_{RM/RD}{}^2)} + PRCSe_{BIAS}$$

$$+LAn_I = +\sqrt{(0.361^2 + 0.161^2 + 0.493^2)} + 0.108$$
$$= +0.740 \text{ V} \quad (+178.0\% \text{ of reading})$$

$$-LAn_I = -\sqrt{(0.361^2 + 0.132^2 + 0.497^2)}$$
$$= -0.628 \text{ V} \quad (-58.0\% \text{ of reading})$$

1.4.8 Accident Loop Accuracy (LAa_I)

There are no additional inaccuracies during an accident. Therefore, $LAa_I = LAn_I$

$$+LAa_I = +0.740 \text{ V} \quad (+178.0\% \text{ of reading})$$

$$-LAa_I = -0.628 \text{ V} \quad (-58.0\% \text{ of reading})$$

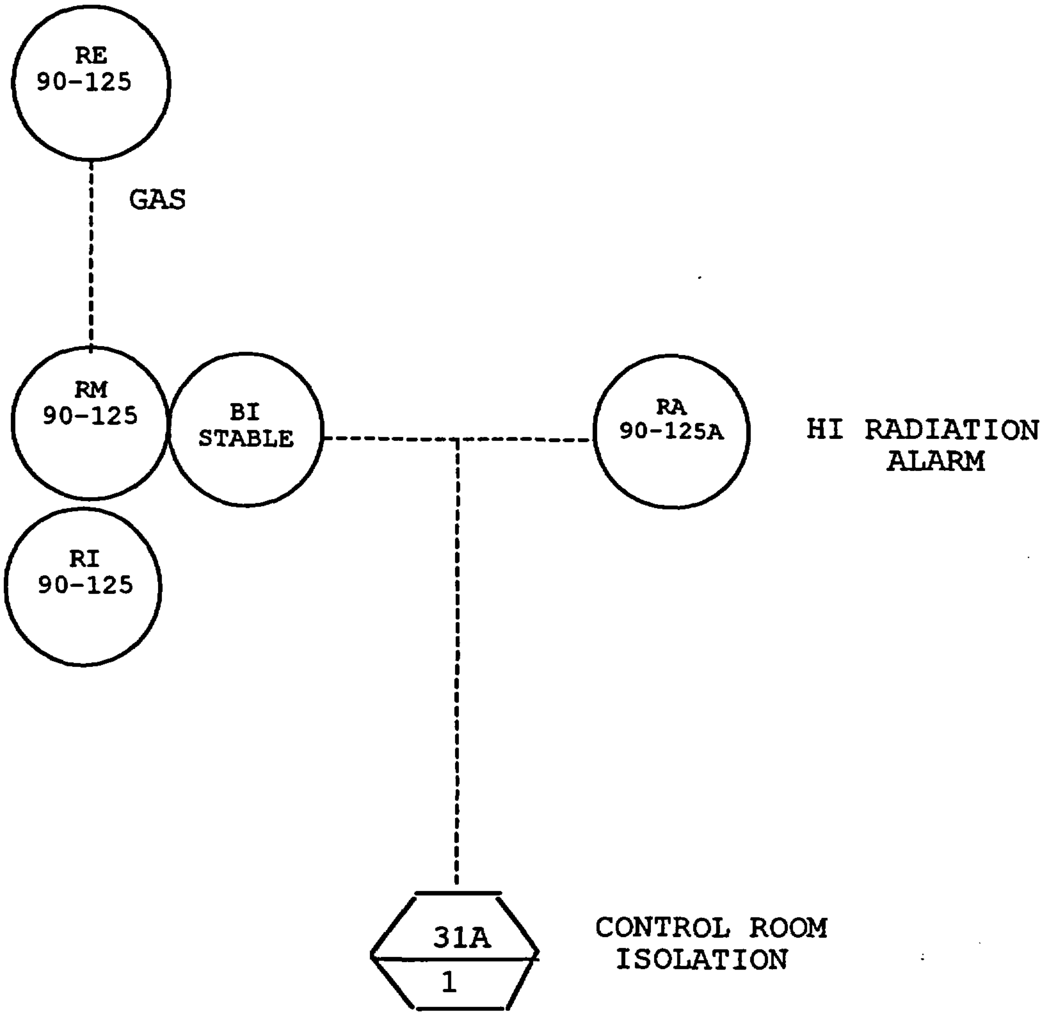
Per reference 9, there is no required accuracy for the indicator.

REV	0	PREP	LMB	DATE	1/12/00	CHECK	EHT	DATE	6/1/00	SHEET	33	C/O	34
REV		PREP		DATE		CHECK		DATE		SHEET		C/O	
REV		PREP		DATE		CHECK		DATE		SHEET		C/O	

BRANCH/PROJECT IDENTIFIER 0-RE-90-125/126
DEMONSTRATED ACCURACY CALCULATION

A) LOOP DIAGRAM

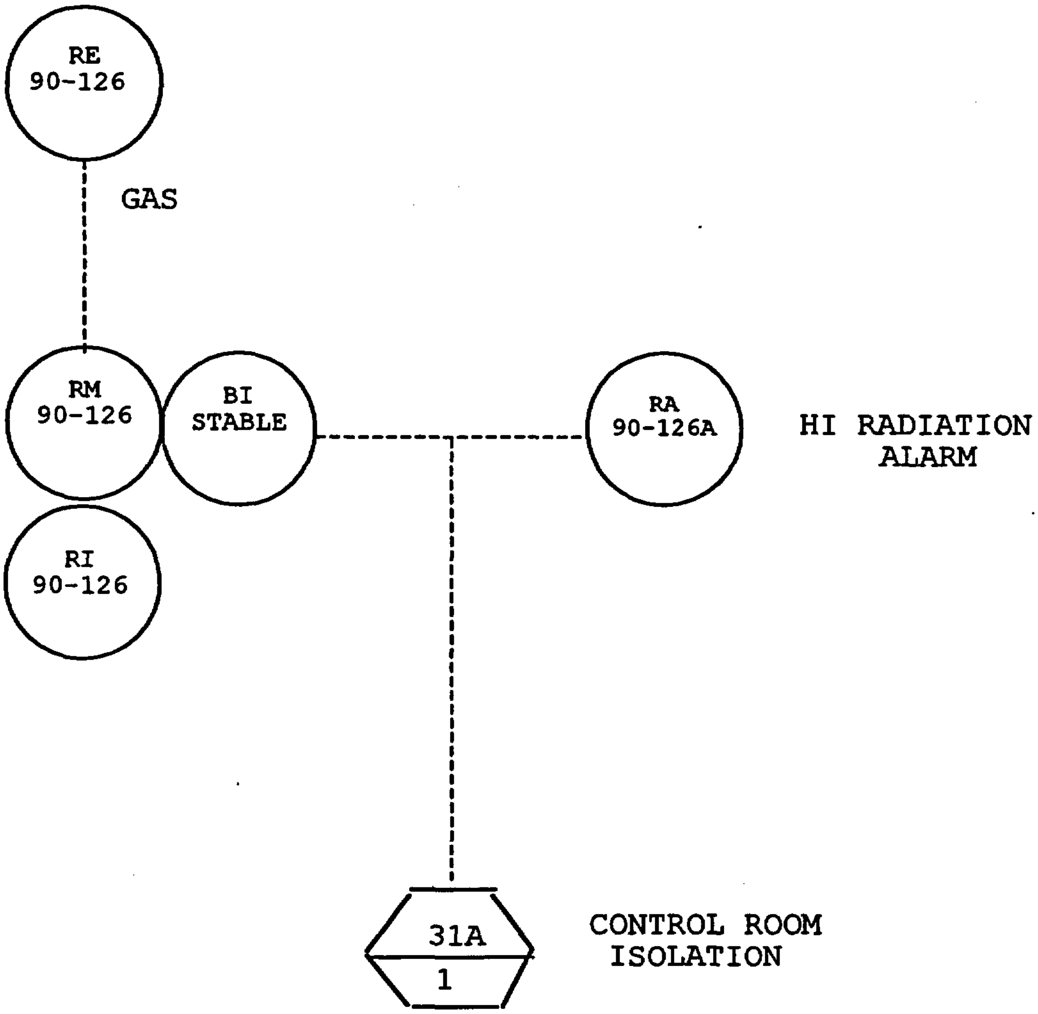
APPLICABLE ONLY TO LOOPS: 0-R-90-125



REV	0	PREP	LMB	DATE	1/13/00	CHECK	EHT	DATE	6/1/00	SHEET	34	C/O	35
REV		PREP		DATE		CHECK		DATE		SHEET		C/O	
REV		PREP		DATE		CHECK		DATE		SHEET		C/O	

A) LOOP DIAGRAM

APPLICABLE ONLY TO LOOPS: 0-R-90-126



REV 0 PREP LMB DATE 1/13/00 CHECK ENT DATE 6/1/00 SHEET 35 C/O 36 .
REV PREP DATE CHECK DATE SHEET C/O .
REV PREP DATE CHECK DATE SHEET C/O .

SUMMARY OF RESULTS (BISTABLE)

APPLICABLE ONLY TO LOOPS: 0-R-90-125
0-R-90-126

SAFETY LIMIT	6.82×10^4 cpm
PV = Accident	5.31×10^4 cpm
PV = Seismic	5.31×10^4 cpm
PV = Normal	5.31×10^4 cpm
Max Setpoint	1.94×10^4 cpm
PV = Normal	8.25×10^3 cpm
PV = Seismic	8.25×10^3 cpm
PV = Accident	8.25×10^3 cpm

Margin 1.51×10^4 cpm

All values shown are in cpm

(Refer to accuracy discussion, sheets 29-32 for clarification of above)

+Av = 4.34×10^4 cpm

-Av = N/A

+Aas = N/A

-Aas = N/A

SUMMARY OF RESULTS (INDICATION)

APPLICABLE ONLY TO LOOPS: 0-R-90-125
0-R-90-126

SAFETY LIMIT N/A

Margin N/A

PV = Accident +178.0

PV = Seismic +178.0

PV = Normal +178.0

Indication

PV = Normal -58.0

PV = Seismic -58.0

PV = Accident -58.0

All values shown are in % of reading

* The maximum setpoint was determined with no margin from the upper range of the channel.

(Refer to accuracy discussion, sheet 32-33 for clarification of above)

+Av = N/A

-Av = N/A

+Aas = N/A

-Aas = N/A

CONCLUSIONS

X APPLICABLE TO ALL LOOPS LISTED ON SHEETS 8

____ APPLICABLE ONLY TO LOOPS: ________________

In conclusion, the demonstrated accuracy of +0.726 volts ($+LAn_{BS}$) and -0.621 volts ($-LAn_{BS}$)for bistable loops 0-R-90-125 and 126 will not result in challenging the upper safety limit of 6.82×10^4 cpm based on maintaining a bistable setpoint of $\leq 1.94 \times 10^4$ cpm. However, the current setpoint for this loop is controlled by Chemistry and must be maintained ≤ 400 cpm for compliance with the value listed in Tech Spec table 3.3-6.

This calculation defines an Allowable Value of 4.34×10^4 cpm that could replace the setpoint of ≤ 400 cpm defined in Tech Spec table 3.3-6 via Tech Spec Change 98-03. Loop Indication for 0-R-90-125 and 126 does not have a required accuracy and is therefore determined to be acceptable.

TVAN CALCULATION COVERSHEET

Title **Determination of Main Control Room Intake Monitor (0-RM-90-125,-126) Setpoint**	Plant SQN Unit 1/2	Page 1

Preparing Organization Mechanical Design	Key Nouns (For EDM) Radiation Monitor, MHA LOCA, FHA, Control Room
Calculation Identifier SQNAPS3-053	Each time these calculations are issued, preparer must ensure that the original (R0) RIMS/EDM accession number is filled in.

	Rev	(for EDM use)	EDM Accession Number
Applicable Design Document(s) NA	R0	870727F0013	B45 870530 238
	R1	930602G0002	B87 930601 002
UNID System(s) 90	R2		B87 960816 003
	R3		

	R0	R1	R2	R3		Yes	No
					Quality Related?	■	☐
DCN, EDC, NA	NA	NA	NA	NA	Safety related? If yes, mark Quality Related yes	■	☐
Prepared	Marc C. Berg	Regis M. Nicoll	Peter G. Studer	Marc C. Berg			
Checked	William M. Bennett	Marc C. Berg	Marc C. Berg		These calculations contain unverified assumption(s) that must be verified later?	☐	■
Design Verified	Kenneth D. Keith, Jr.	Marc C. Berg	Marc C. Berg		These calculations contain special requirements and/or limiting conditions?	☐	■
Approved	Frank A. Koontz, Jr.	William A. Eberly	Michael J. Lorek	for WM Justice	These calculations contain a design output attachment?	☐	■
Approval Date	5/30/87	6/1/93	8/13/96	8/17/99	Calculation Classification	Essential	
SAR Affected?	Yes ☐ No ■	Yes ☐ No ■	Yes ☐ No ■	Yes ☐ No ■	Microfiche generated	■	☐
Revision applicability	Entire calc ☐	Entire calc ■ Selected pgs ☐	Entire calc ■ Selected pgs ☐	Entire calc ■ Selected pgs ☐	Number R3: TVA-F-B000073		

Statement of Problem:

Determine if the 400 cpm setpoint for the Main Control Room air intake monitor (0-RM-90-125, -126) is acceptable, exclusive of instrument and sampling inaccuracies. Further, determine the safety limit for the subject monitors.

Abstract

The purpose of this calculation is to determine if the current setpoint value of 400 cpm or less, exclusive of instrument and sampling inaccuracies, for the main control room air intake monitors is acceptable. Revision 3 is to update the calculation to the latest calibration factors as part of the corrective action of SQPER981301 (ref.4). This calculation was initiated because no documentation had been found to support the setpoint value given in the SQNP Tech Spec 3.3.3.1 for the main control room air intake monitors (0-RM-90-125, 126) which consist of monitor type RD-32-01. These detectors were installed to protect the operators by isolating the control room in the event an accident released significant amounts of radioactivity.

The first part of this calculation determines the count rate to be expected at the beginning of a LOCA to see if this value is greater than the setpoint. The second part of the calculation determines the count rate for the beginning of a Fuel Handling Accident (FHA). The third part of this calculation determines the control room operator doses for the entire duration of a MHA-LOCA as if the main control room never isolates. The ratio of the 10CFR50 Appendix A GDC 19 limit of 30 rem inhalation to this dose will become a normalization factor. This normalization factor will then multiplied by the release during the 30-46 sec interval to obtain the normalized activity for which the count rate could be determined. The count rate determined in this way will give the initial average count rate at which the operators would receive 30 rem inhalation for the duration of the accident if the MCR never isolates.

The current TS maximum setpoint of 400 cpm for the RM-90-125, -126 control room intake monitor is more than adequate to assure that the GDC-19 limits are not exceeded. The safety limits for these monitors was determined to be 6.82E4 cpm with an intake concentration of 1.28E-3 uCi/cc .

■ Microfilm and return calculation to Calculation Library: Address: ☐ Microfilm and return calculation to: -	☐ Microfilm and destroy.

Attachment No. 12 Sheet 1 of 1
Identifier 0-RE-90-125/126