GE-NE-533-020-0492
DRF: D11-00017

REACTOR BUILDING VENTS RADIATION MONITORING SYSTEM

(RBVRM)

DRIFT RATE CALCULATION

FOR

TENNESSEE VALLEY AUTHORITY

BROWNS FERRY NUCLEAR PLANT

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CALIBRATION FREQUENCY EXTENSION

1. INTRODUCTION

The Reactor Building Vents Radiation Monitoring Subsystem channels presently utilize a 90 day calibration frequency. The retrofit of the instrumentation with NUMAC based equipment provides an opportunity to extend the calibration interval to once per cycle. A cycle is defined as 18 months ± 25%.

A previous investigation (Attachment 1) examined the drift associated with the NUMAC RBVRM instrument loop and provided conclusions and recommendations pertaining to a once per cycle calibration.

This calculation, in conjunction with the aforementioned investigation, will demonstrate that the overall drift rate of the NUMAC RBVRM is within specified limits.

2. COMPONENTS AFFECTING DRIFT

Potential drift sources for the RBVRM instrument loop include the sensor and converter's Geiger Mueller (GM) tube, the sensor and converter's discriminator, the RBVRM's High Voltage Power Supply (HVPS), and the digital circuits located in the RBVRM chassis (Attachment 1). The discriminator and the digital circuits have been considered to add a negligible amount to the channel drift due to the characteristics of the digital design of the instrument (Attachment 1).

The remaining two items have had the following drift values assigned to them: a 2% of point drift per plant cycle for the Geiger Mueller tube, and a maximum 15 volt per month drift for the HVPS (Attachment 1).

The 2% of point value for the GM tube was derived by assigning a constant linear degradation of sensitivity over the manufacturer's stated lifetime for the tubes. This value was determined to be 2% (Attachment 1). Because the manufacturer was unable to confirm if the degradation was a catastrophic event at the end of the stated life, it was assumed for conservatism that the decline occurred over the life of the tube. For purposes of this calculation, however, a 4% of point value will be assigned to provide additional conservatism.

The 15 volt value for the HVPS was obtained from the vendor's power supply specification. It should be noted that a change in the High Voltage results in a corresponding change in the GM tube's output, depending upon the manufacturer's plateau slope. The GM tube manufacturer specifies a maximum plateau slope of 0.3% per volt for the 5 decade instrument and a 0.08% slope for the 4 decade instrument.

An 80% value (i.e. 12 volts) of the maximum drift (i.e. 15 volts) was utilized, per engineering judgement, to allow additional time for the operator to observe the change in voltage and take corrective action (Attachment 1).

By limiting the drift to 12 volts before corrective action must be taken to reinitialize the HVPS back to 575, a maximum cumulative deviation of only 27 volts would occur (i.e. 11.9 volts maximum for the first month without resetting the voltage, followed by the maximum drift of 15 volts prior to any adjustment, for a total of 26.9 volts). Therefore, a value of 548 volts will be used as the endpoint of the cumulative voltage drift.

3. CALCULATION

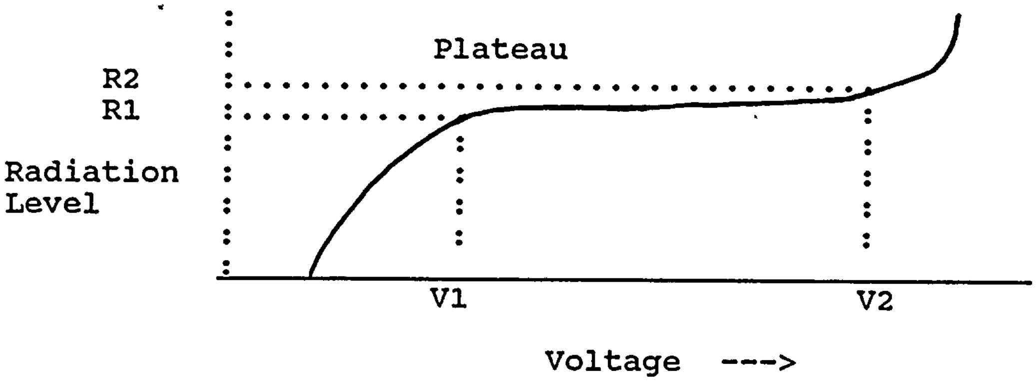
In order to examine what impact that the GM tube and HVPS have on loop drift, the following calculation is performed. It is postulated that a reduced reading from the actual mR/hr value would provide the most conservative or limiting case. This is true because the actual tripping action would therefore take place at a higher value due to the under reading of the instrumentation.

To establish the mR/hr impact that the high voltage reduction will have on the reading, the following equation will be utilized:

$$\frac{100\,(R2 - R1)/R1}{V2 - V1} = S$$

where V2 = nominal GM tube voltage
V1 = reduced voltage of interest
R2 = radiation reading associated with V2
R1 = radiation reading associated with V1
S = percent per volt relative slope

and utilizing the following association:



and where:

V1 = 548 Volts (See discussion above)
V2 = 575 Volts (From Attachment 1, sheet 3 of 4)
R2 = 100 mR/hr (Technical Specification value)
S = Manufacturer's maximum plateau slope. For the 5 decade instrument S equals 0.3; for the 4 decade instrument S equals 0.08

Solving for R1,

$$\frac{100(100 - R1)/R1}{575 - 548} = 0.3$$

R1 = 92.51 for the 5 decade instrument and

$$\frac{100(100 - R1)/R1}{575 - 548} = 0.08$$

R1 = 97.88 for the 4 decade instrument

Therefore, a 30 day drift or reduction of 7.5 mR/hr (i.e. 100 -92.51) could be seen for the 5 decade instrument and a 2.1 mR/hr reduction (i.e. 100 - 97.88) for the 4 decade instrument.

Combined Drift:

The combined drift is the square root sum of the squares summation of the drifts attributed to the GM tube and the HVPS.

(1). <u>GM tube</u>: Drift is established at 4% of point per plant cycle. This value was derived, as previously noted in the Cycle Calibration Evaluation, from an engineering assumption that the tube sensitivity would drift downward at a constant rate during the manufacturer's predicted life for the GM tube. For the predicted life of the tube, (i.e. 105 years), the loss of sensitivity was determined to be less than 2% of point for the calibration cycle. For the purposes of this calculation, however, a value of 4% of point per will be used to provide conservatism for this parameter.

The value of 4% of point is directly translated into a mR/hr value by multiplying it times the technical specification value (i.e. .04 X 100 mR/hr = 4 mR/hr).

(2). <u>High Voltage Power Supply</u>: Since the High Voltage Power Supply deviations will be maintained within ±12 volts (per conclusion 1 of the Calibration Cycle Evaluation), the resultant reading from a reduced high voltage (i.e. 548 volts) is a maximum of 7.5 mR/hr for the 5 decade device and 2.1 mR/hr for the 4 decade device.

The combined values of these drifts are then:

$\{(4)^2 + (7.5)^2\}^{1/2}$ = 8.5 mR/hr for the 5 decade instrument

and

$\{(4)^2 + (2.1)^2\}^{1/2}$ = 4.5 mR/hr for the 4 decade instrument

Notice that although 8.5 mR/hr and 4.5 mR/hr are 30 day values, they are still applicable since the HVPS deviation will be limited per procedure to 575 ±12 vDC and reinitialized if it exceeds this value. Therefore, the 30 day maximum value is also the maximum value that can occur over the plant cycle.

4. COMPARISON BETWEEN 90 DAY CYCLE and 18 MONTH CYCLE

The calculated values of 8.5 and 4.5 are less than the stipulated values of 10.2 and 8.1% for the 5 decade and 4 decade instruments, respectively.

5. CONCLUSIONS

The calculated drift/error for plant cycle interval is within the permissible values of 8.1 and 10.2 %

REACTOR BUILDING VENTS RADIATION MONITORING SYSTEM

(RBVRM)

CALIBRATION CYCLE EVALUATION

FOR

TENNESSEE VALLEY AUTHORITY

BROWNS FERRY NUCLEAR PLANT

DRF: D11-00017

Prepared by: D D Akers 3/20/92
D. D. Akers - Principal Engineer

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U. E. Dennis - Principal Engineer

The Reactor Building Vents Radiation Monitor (RBVRM) system Technical Specification, allowable value, is 100 mR/Hr. The RBVRM upscale trip set point, 72 mR/Hr, is the technical specification value minus the loop normal measurement accuracy. The loop normal measurement accuracy, per TVA procedures, accommodates 90 day drift. The drift allocation is 8.1% of point for the 4 decade sensor and 10.2% of point for the 5 decade sensor.

The objective of this evaluation is to establish a basis for extending the calibration interval to one plant cycle of 18 months plus or minus 25 percent.

The identified drift sources, from sensor to upscale trip, include: GM tube, High Voltage Power Supply, and Discriminator, which are evaluated below.

1. GM TUBE CHARACTERISTICS

The GM tube has no characteristic drift mechanism until onset of end of life degradation. A GM tube vendor (LND) quotes 5 X 10^{10} counts as usable life. The same value is published in the Amperex data sheet for the ZP1300 tube. Tube life is established at 10^{10} counts integrated dose to preclude onset of an end of life condition. Two different GM tubes are used in this application although the Technical Specification trip point and trip set point are the same. There are two vendors for each of the GM tubes which have the same purchase part drawing characteristics and are therefore concluded interchangeable relative to this evaluation.

The background radiation level is assumed lower than the sensor bug source so that integrated dose is due to the bug source.

EQUIPMENT PART NUMBER	SENSOR RANGE mR/Hr	SENSOR SENSITIVITY C/Sec/mR/Hr	RADIATION LEVEL MR/HR	COUNTS PER YEAR	YEARS TO 10^{10} CTS
140 141	10^1 TO 10^6	0.3	3	2.8 E7	350+ YEARS
142 143	10^{-1} TO 10^3	10	.3	9.4 E7	105+ YEARS

The 10^{10} accumulated count, end of life, condition does not occur within the first plant cycle.

An alternate evaluation: assume that the tube sensitivity drifts at a linear rate during the predicted life with a linear degradation from 100% to 0%. For the 105 year predicted life the loss of sensitivity is 1% of point per year or less than 2% of point per plant cycle which is well within the 8.1% allocation.

The GM tube must be vacuum sealed to assure against a drift condition. Tubes are 100% tested at incoming inspection. A similar test can be designed to verify the continued integrity of the GM tube installed in the sensor per SIL 327 Rev-1. Removal of the tube to perform such test, which might fracture the envelope, is specifically not recommended.

CONCLUSION: The GM tube performance characteristics support a plant cycle calibration interval.

2. HIGH VOLTAGE POWER SUPPLY DRIFT RATE IMPACT ON PLATEAU SLOPE

The High Voltage Power Supply specified drift rate, including the combined affect for rated change in source voltage, load, and temperature, is 2% of full scale, 1500 volts, for 2 months or 15 volts per month.

The GM tube usable plateau width is 500 to 600 volts and the quiescent operating voltage is 575 volts. If the high voltage power supply drifts at the maximum rate then it would drift beyond the plateau limit within two months of operation.

The vendor specified plateau slope is 0.08% per volt for the 4 decade tube and 0.3% per volt for the 5 decade tube. The permitted drift occurs in 8.1% / .08%/volt / 15 volts/month = 6.7 months for the 4 decade tube and 10.2% / .3%/volt / 15 volts/month = 2.3 months for the 5 decade tube.

The operating voltage drifts off the plateau before the plateau slope variation on signal gain limits performance. Power supply drift off the plateau is the limiting consideration.

High voltage power supply performance is monitored by the NUMAC instrument such that the voltage at the detector is observable at the instrument chassis in the control room. The high voltage should be monitored on a periodic, initially 30 day, surveillance interval. If the indicated voltage deviates by more than 12 volts, half the allowable variation from the set value, adjustment is necessary.

CONCLUSION: Periodic readjustment of the detector high voltage is necessary to limit the drift component to an acceptable value.

3. DISCRIMINATOR CHARACTERISTICS

The discriminator is set to discriminate pulse heights greater than 35 millivolts. Detector pulses height is approximately 1 volt when measured at the discriminator input. The discriminator circuit is constructed of precision components and no significant drift of the discriminator threshold is expected. The discriminator design does not include a threshold set point adjustment. The combination of discriminator set point to pulse height margin insignificant discriminator threshold drift assures long term stable discriminator operation.

CONCLUSION: The discriminator does not contribute to the instrument drift rate.

4. DIGITAL CIRCUITS

At the output of the discriminator the signal level is counted into a digital register the contents of which are transmitted to the RS-422 input card in the RBVRM chassis then to the CPU where count rate is established and comparison is made to the digital trip reference point. The CPU is crystal controlled such that there is no significant contribution to drift rate in the digital instrument.

CONCLUSION: The digital circuits do not contribute to the instrument drift rate.

CONCLUSIONS AND RECOMMENDATONS

1. RBVRM signal channels should be recalibrated once per plant cycle, of 18 months plus or minus 25 percent, provided HVPS voltage is maintained within plus or minus 12 volts of the 575 volt operating point on a periodic surveillance interval.

2. An accumulation of 10^{10} counts is the recommended end of life point for each of the GM tubes.

3. Periodic surveillance of GM tube performance as identified by SIL-327 Rev-1 is recommended.

VERIFICATION INSTRUCTION - RBVRM SYSTEM CALIBRATION CYCLE EVALUATION

Sheet 1 of 2.

1. Verify Technical Specification allowable value 100 mR/Hr from Technical Specification BFN Unit 2, Table 3.2.A (See Laforce). ✓UED

2. Verify Upscale trip setpoint, (72mR/Hr) from document GENE-533-02-0191, DRF D11-00017. ✓UED

3. Verify drift allocation 8.1% and 10.2% from document GENE-533-02-0191, DRF D11-00017. ✓UED

4. Verify sensor life from Amperex data sheet which becomes a part of the design package, sheet 2 of this document. ✓UED

5. Verify that E10 counts is ~~or is not~~ a reasonable end of life assumption. UED

6. Verify life calculations. ✓UED

7. Given that the GM tubes have passed, 100% inspected, incoming inspection and therefore exhibit a pulse of greater than 1 volt verify that when installed in the circuit, per schematic diagram 945E977, confirm whether the nominal 1 volt pulse amplitude is credible. ✓UED

8. Verify the 35 millivolt discriminator assertion from 23A5071 paragraph 3.6.5. Confirm from the Sensor schematic 945E977 that this is a credible value. ✓UED

9. Verify the evaluation for accuracy and completeness of the evaluations and conclusions. ✓UED

Responsible Engineer: DD Akers 3/20/92.
D. D. Akers

Verification Statement:
The instructions given above are adequate for verification of subject document. Each of the above nine (9) items were verified to be correct. Subject document is design verified.
Verified By: UE Dennis 3/20/92
U. E. Dennis

VERIFICATION INSTRUCTION - RBVRM SYSTEM CALIBRATION CYCLE EVALUATION

Sheet 2 of 2.

ZP1300

OPERATING CHARACTERISTICS (Ambient temperature ≈ 25 °C)

Measured in circuit of Fig.2

Starting voltage	max.	400	V
Plateau threshold voltage	max.	500	V
Plateau length		100	V
Recommended supply voltage		550	V
Plateau slope	max.	0.3	%/V
Background (shielded with 50 mm Pb with an inner liner of 3 mm Al), at recommended supply voltage	max.	1	count/min
Dead time, at recommended supply voltage	max.	11	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	min.	2.2	MΩ
Anode voltage	max.	600	V
Ambient temperature continuous operating	max.	+70	°C
	min.	−40	°C
storage	max.	+75	°C

LIFE EXPECTANCY

Life expectancy at ≈ 25 °C	5×10^{10}	count

MEASURING CIRCUIT

R_1 = 2.2 MΩ
R_2 = 47 kΩ
C_1 = 1 pF*

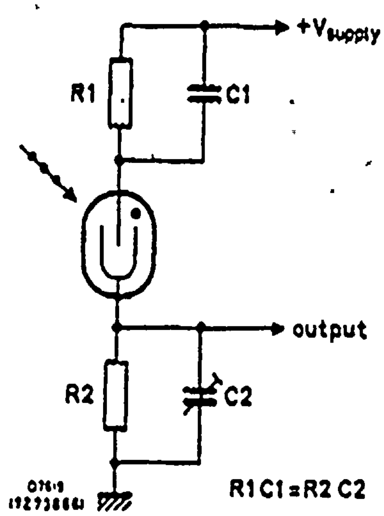

Fig.2

ATTACHMENT 1

SHEET 6 OF 6

*See General Information (paragraph 5.5)

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