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Eberline Alpha 7L Test Report

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EBERLINE ALPHA 7L TEST REPORT

1. INTRODUCTION

An Eberline continuous alpha air monitor model Alpha 7L was evaluated at Oak Ridge National Laboratory (ORNL) using the capabilities available at the Environmental Effects Laboratory (EELab). A series of tests were performed to ensure that procured units meet the requirements of the purchasing facility, Los Alamos National Laboratory (LANL). In addition to reporting on the results of each test, other activities were performed to reduce discovered susceptibilities.

The parameters monitored during the tests typically included the airflow rate and/or net ^{239}Pu concentration values (pCi/liter). In addition, the spectrum display and operational status were monitored. Follow up tests were also performed on two LANL-provided production units. The results of those tests are at the end of this report.

2. TEST RESULTS

Temperature

Test Parameters - Exposure to –20 to +50 °C.

Results

No obvious susceptibilities were indicated from an initial review of the test results. We did notice that during the test, the unit became slightly erratic for about 4 hours. Scott Rogers of Eberline stated that this was expected. He explained that the operating program is set up such that after the unit collects 8000 counts it uses additional coefficients in the curve-fitting algorithm to obtain a more precise curve fit. No responses were over an alarm point.

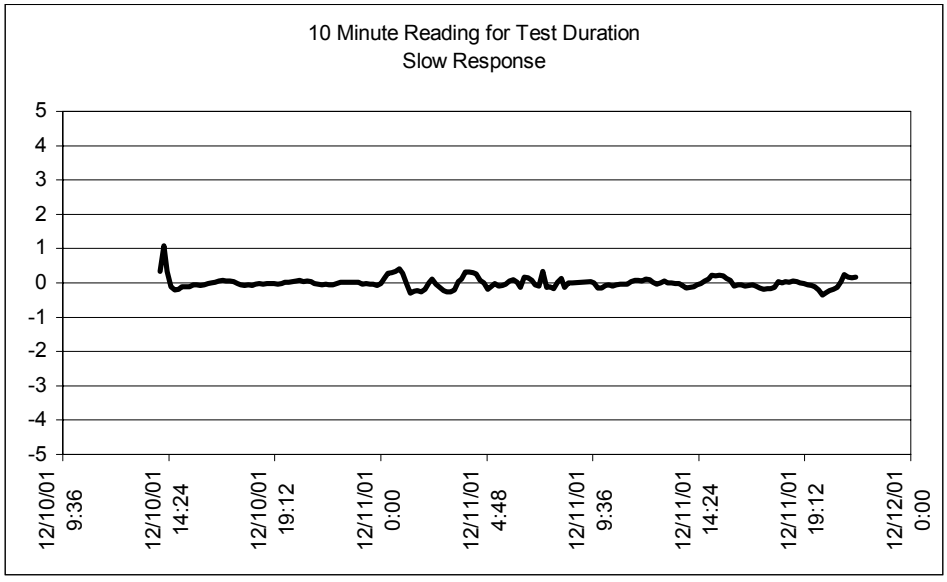

Figure 1. Test Duration Slow Response

Figure 1 shows "slow" response data obtained at 10-minute intervals over the entire temperature test range of –20 to +50 °C. The change in variability of response is apparent and doesn't appear to be related to temperature as stated by Eberline.

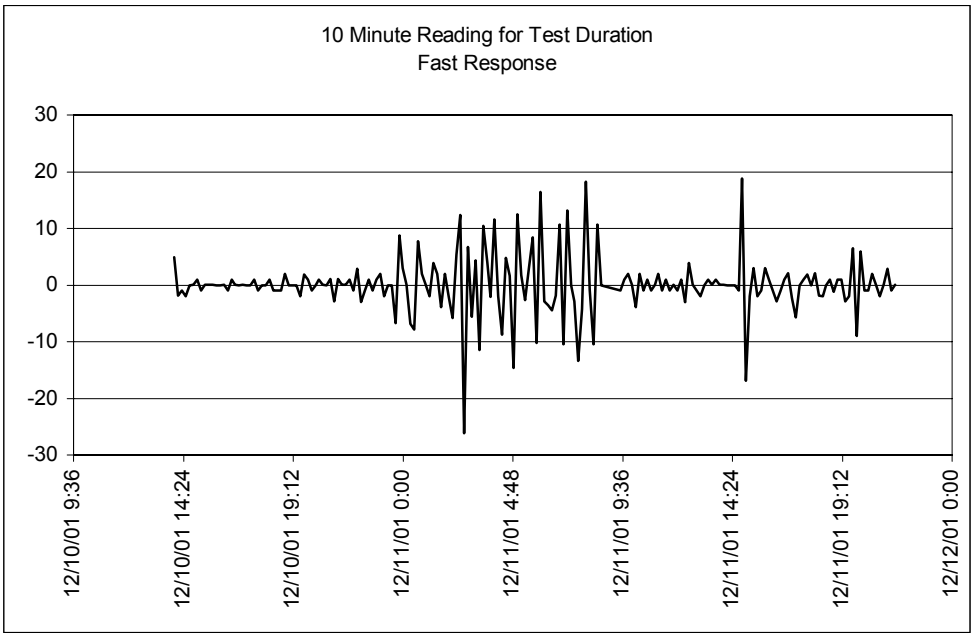

Figure 2. Test Duration Fast Response

Figure 2 contains "fast" response data taken at 10-minute intervals over the entire temperature test range. The change in variation is more obvious when compared to the "slow" results.

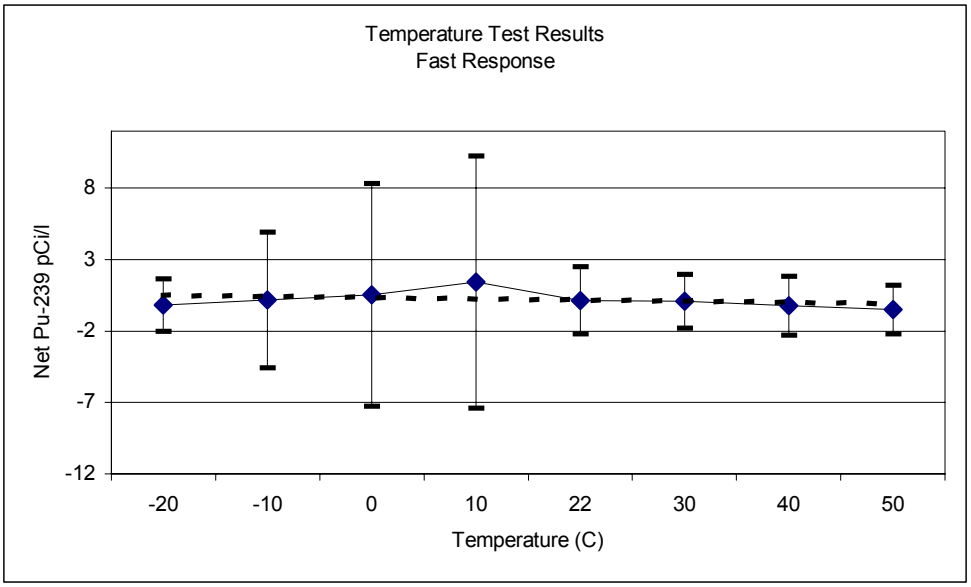

Figure 3. Temperature Test Results – Fast Response

Figures 3 and 4 show the error bars associated with each average response at the temperature set point. Note the y-scale when comparing the fast response to the slow response (Figure 4).

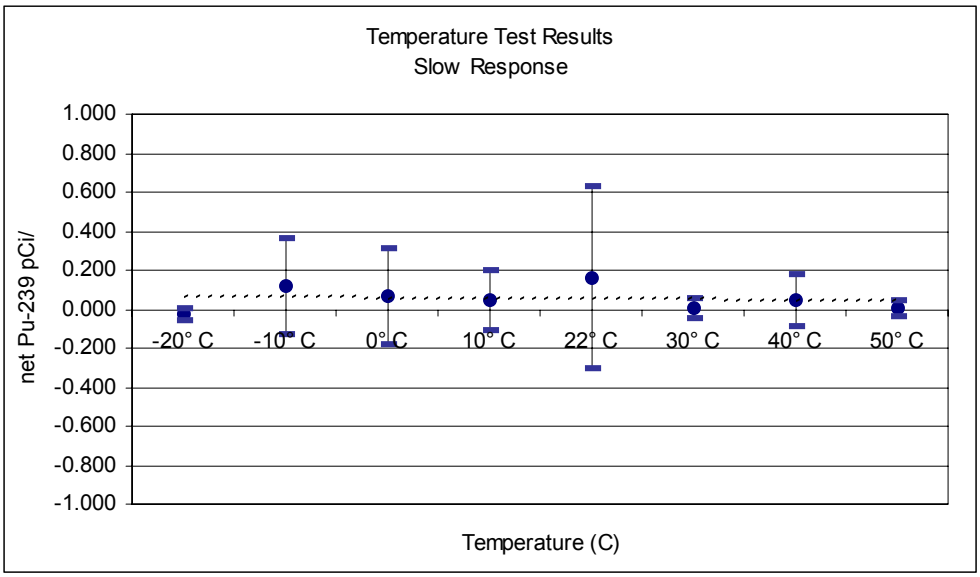

Figure 4. Temperature Test Results – Slow Response

No susceptibilities of any consequence were observed during the test. The observed variations in response were expected due to the techniques used to determine the fast response value.

Humidity

Test Parameters – Exposure to 40% to 95% relative humidity (non-condensing) at a temperature of 35°C ± 2°C

Results

No obvious susceptibilities were indicated from an initial review of the test results. We did notice that the unit became somewhat erratic at 95% humidity and eventually settled (about an hour). Excursions were observed to about 2 DAC (alarm point is 8 DAC-hrs). No responses were over an alarm point. Humidity did appear to load the filter somewhat, which affected the flow rate. It should be noted though that the filter used for this test was the same as that used for the temperature test since the humidity test is performed without stopping after the temperature test.

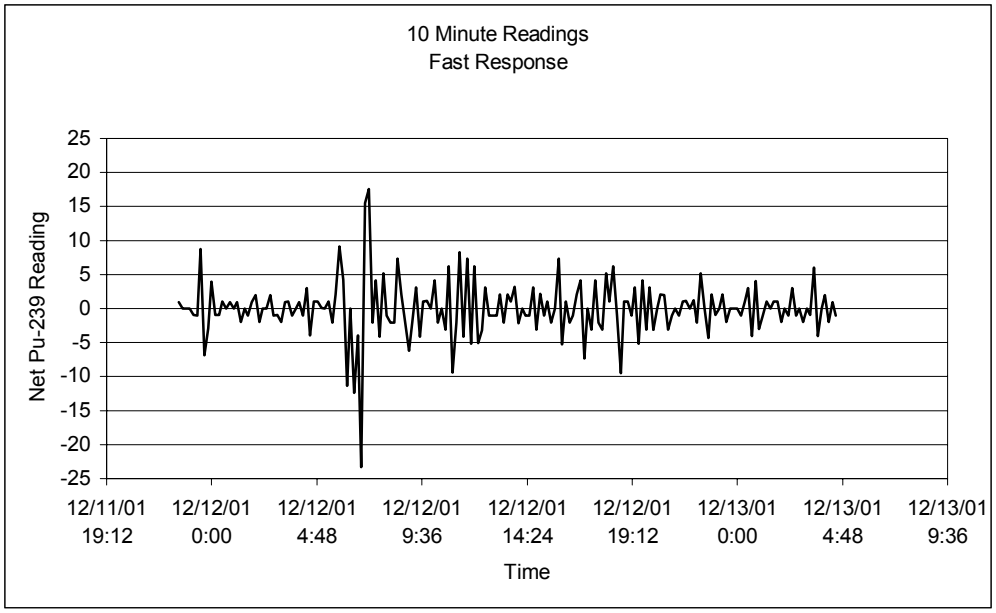

Figure 5. 10 Minute Readings – Fast Response

Figures 5 and 6 contain 10-minute response data (fast and slow, respectively) for the entire test from 40% to 95% and back to 40% RH at a temperature of 35° C. The 95% exposure lasted 16 hours and the initial and final 40% exposures were for four hours each. Other than the change in variability at the initial 95% exposure, not other susceptibilities were indicated.

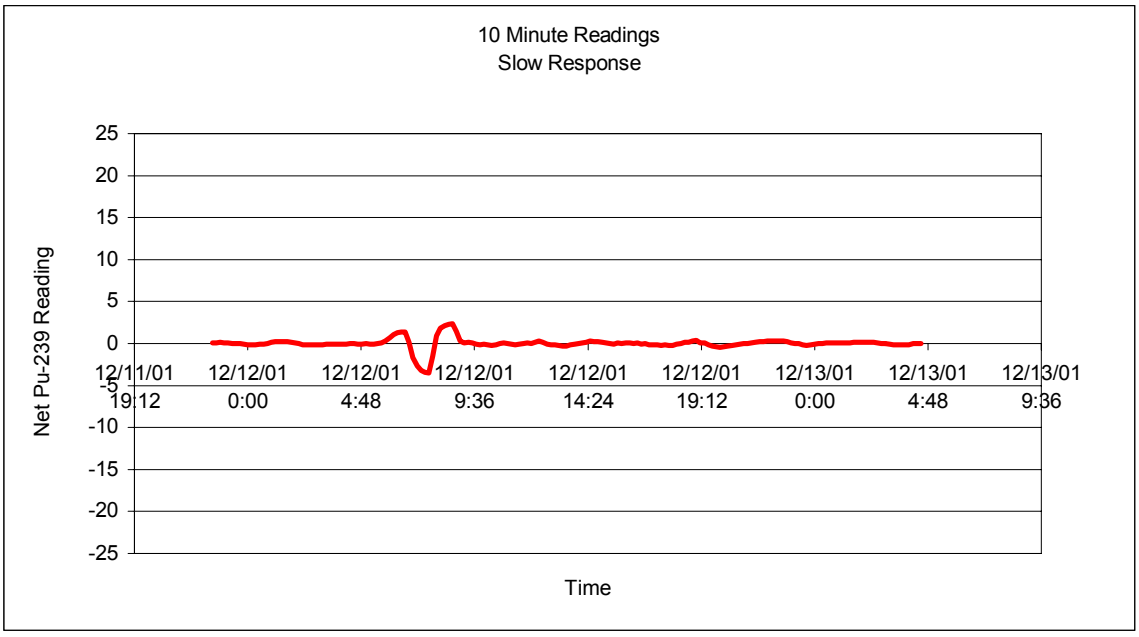

Figure 6. 10 Minute Readings – Slow Response

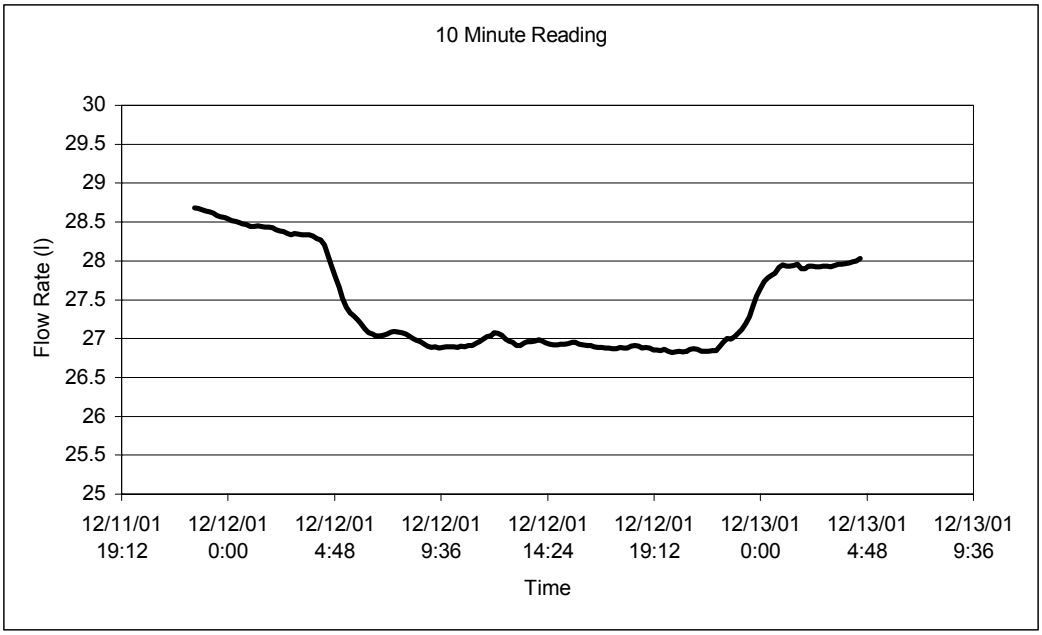

Figure 7. 10 Minute Readings

Figure 7 contains 10-minute readings of the measured flow rate. The flow dropped during the 95% exposure and recovered after returning to 40%, although not completely.

No susceptibilities were observed except for the changes discussed when first exposed to the 95% RH field. Flow rates were affected probably due to moisture loading of the filter. No alarms or failures were indicated for the duration of the test.

Radio Frequency

Test Parameters – Exposure to amplitude modulated (1 kHz at 80 %) RF energy at 20 Volts/meter over a frequency from 20 MHz to 1000 MHz.

Results

Susceptibilities were indicated as counts on the spectrum at 30 MHz, 102, 460, 770, and 895-960 MHz. Most of the counts were in the lower range of the spectrum but nonetheless caused curve fit problems that caused the unit to fail.

Additional analyses were performed to characterize the affects. Tests were performed with the unit entirely in the RF cell, with each main component in the cell (display or detector), and the entire unit with a braided shield over the interconnecting cable (detector to display). Figures 8 through 11 contain charts of the data obtained. Note the Y-axis on each chart. It has been fixed at 300 cps even though some of the data was much greater than 300 cps. In addition, it must be stated that when susceptibility occurred, the unit took itself out of operation indicating poor curve fit.

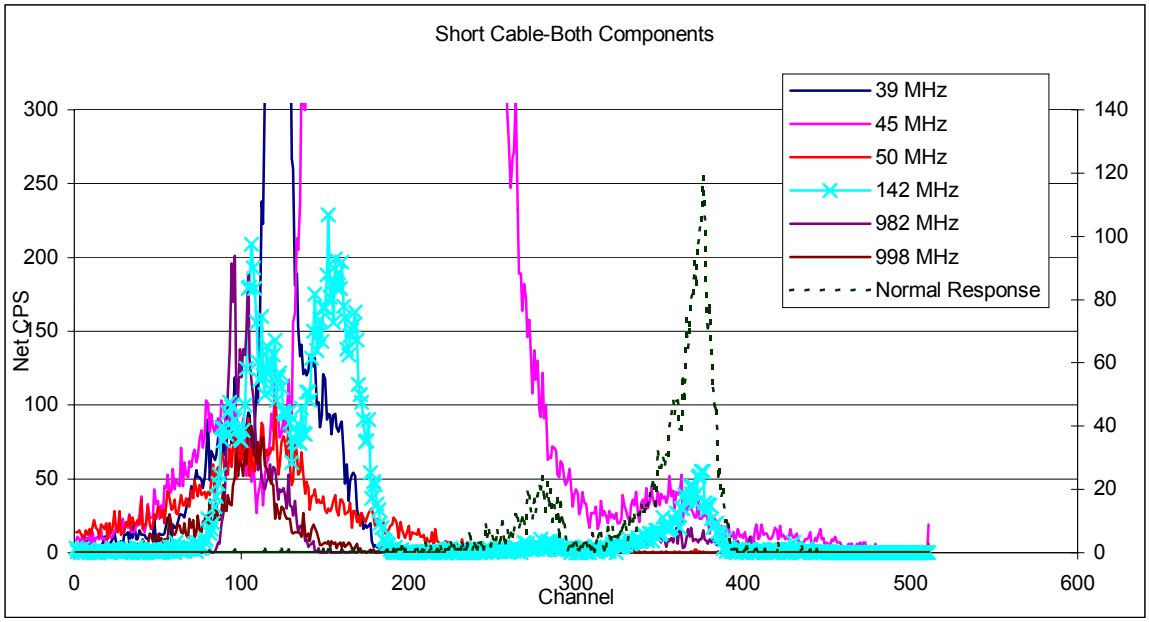

Figure 8. Short Cable, Both Components

Figure 8 shows the net cps readings taken with the entire unit in the GTEM (RF) cell. The table on the right indicates where susceptibilities were observed.

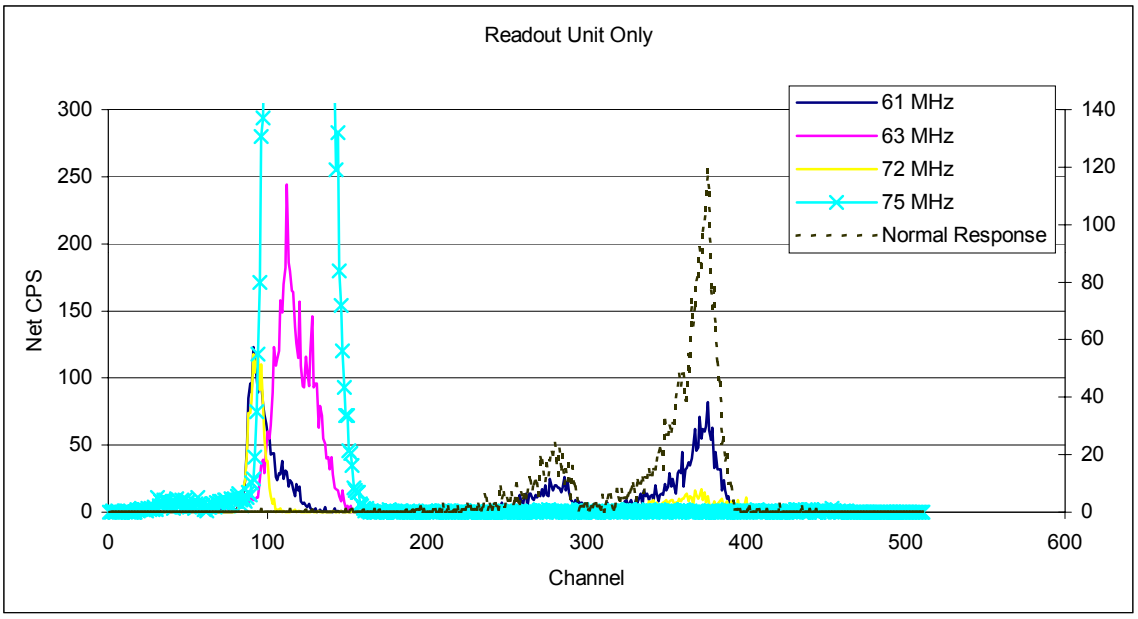

Figure 9. Readout Unit Only

Figure 9 presents the net cps readings obtained with the readout or display component in the RF cell only.

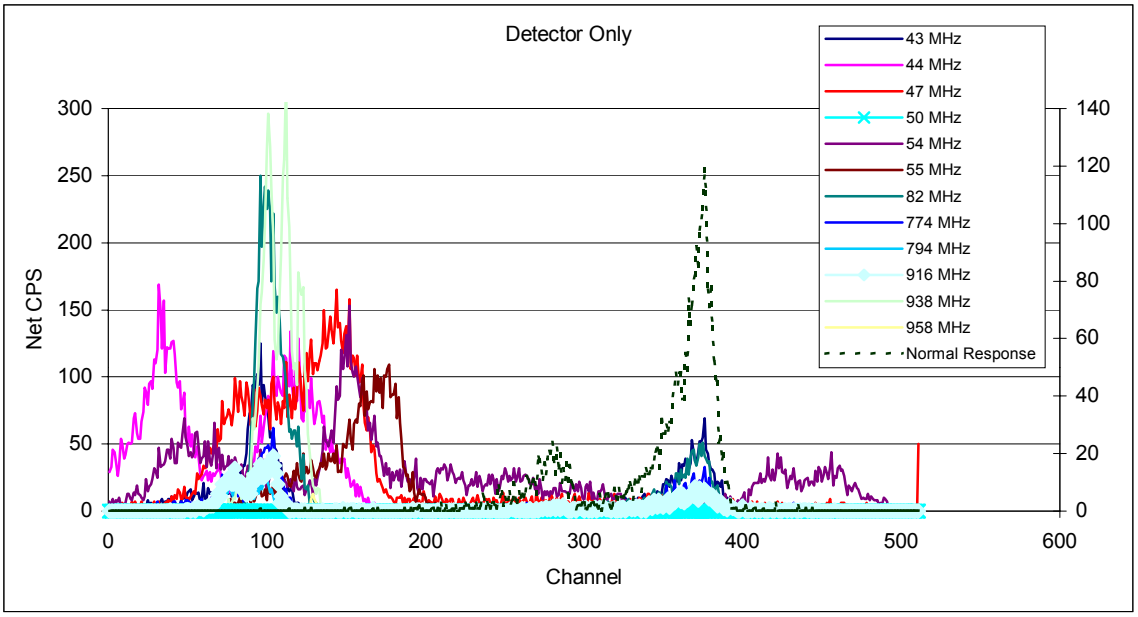

Figure 10. Detector Only

Figure 10 contains the net cps readings with the detector component in the RF cell only. Note the difference between the detector only and the display only results.

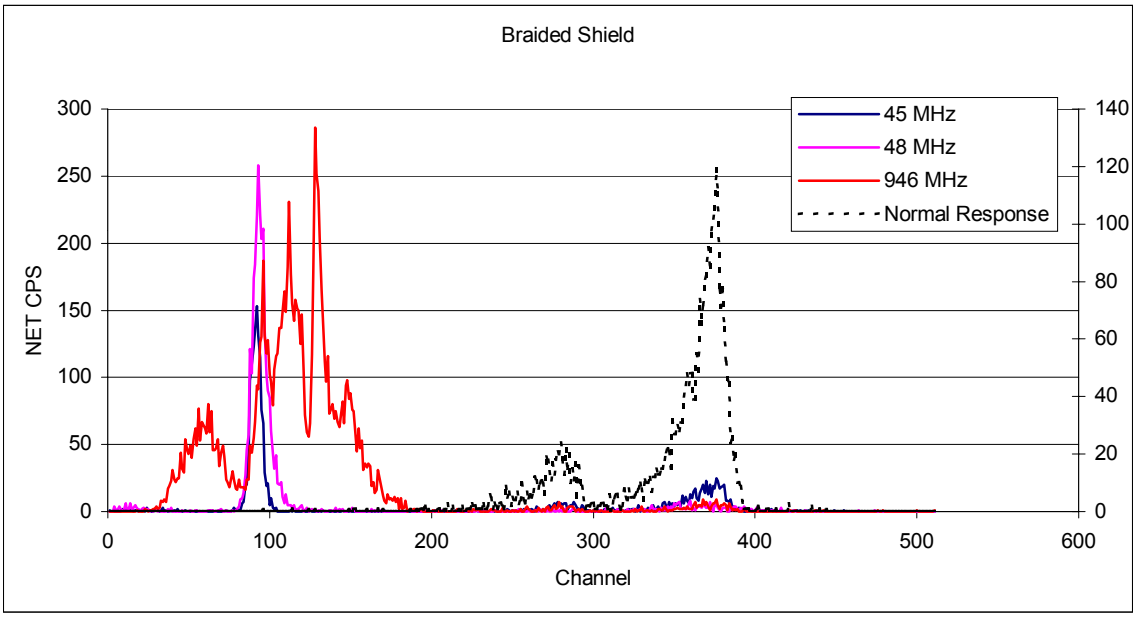

Figure 11. Braided Shield

Figure 11 shows the net cps readings with the entire unit in the RF cell, but now with the interconnecting cable covered with a braided shield. The intensity of the susceptibility was substantially reduced.

Follow-Up Radio Frequency Testing

Based on observations made during initial RF testing, Eberline provided a replacement communications cable that was better shielded. The cable was replaced, and with the detector shield in place, the unit was re-tested. Table 1 lists the frequency bands, MeV ranges affected, and the observations made.

The primary concern for the users (LANL) of the Alpha 7L is from 406 and 420 MHz. The unit tested with the detector shield and shielded communications cable displayed susceptibilities from 402 to 406 and 412-414 MHz with the detector head-to-display unit cable coiled. During exposure, flow measurement was unaffected, the calculated Pu-239 value was unaffected, and the status indication remained normal. Susceptibility was indicated by extra counts observed from approximately 2.5 to 3.0 MeV. The test was performed at 20 Volts/meter. Further tests were performed with the cable uncoiled, as it should be set up during use. No susceptibilities were indicated over the test range of 350 MHz to 500 MHz at 20 Volts/meter. Susceptibilities remain, but much reduced, at the higher frequencies as shown on Table 1.

Table 1. Follow Up RF Test Results

Susceptibility Band (MHz)	**MeV**	**Anomalies / Status**
48 - 51	2.5 - 3.3	Flow: OK; Pu-239 value: Unaffected; Status: Normal
63 - 69	2.5 - 4.0	Flow: OK; Pu-239 value: Affected; Status: Poor curve fit
86 - 87	2.5 - 3.5	Flow: OK; Pu-239 value: Unaffected; Status: Normal
133 - 137	2.5 - 3.5	Flow: Low; Pu-239 value: Unaffected; Status: Flow Failure
145 - 148	2.5 - 3.5	Flow: Low; Pu-239 value: Unaffected; Status: Flow Failure
253 - 270	2.0 - 4.5	Flow: Low; Pu-239 value: Affected; Status: Fast Alarm
379 - 390	1.0 - 3.5	Flow: OK; Pu-239 value: Affected; Status: Fast Alarm
390 - 395	2.5 - 3.3	Flow: OK; Pu-239 value: Unaffected; Status: Normal
402 - 406	2.5 - 3.0	Flow: OK; Pu-239 value: Unaffected; Status: Normal
412 - 414	2.5 - 3.0	Flow: OK; Pu-239 value: Unaffected; Status: Normal
866 - 886	2.0 - 2.8	Flow: OK; Pu-239 value: Unaffected; Status: Normal
886 - 908	1.0 - 4.2	Flow: OK; Pu-239 value: Unaffected; Status: Normal
908 - 942	2.2 - 3.3	Flow: OK; Pu-239 value: Unaffected; Status: Normal
942 - 948	2.2 - 6.0	Flow: OK; Pu-239 value: Affected; Status: Poor curve fit
948 - 954	.0 - 7.0+	Flow: OK; Pu-239 value: Affected; Status: Fast Alarm
954 - 962	1.0 - 4.0	Flow: OK; Pu-239 value: Affected; Status: Fast Alarm
962 - 966	2.5 - 2.8	Flow: OK; Pu-239 value: Unaffected; Status: Normal
992- 1000	1.0 - 3.3	Flow: OK; Pu-239 value: Unaffected; Status: Normal

Conducted RF

Test Parameters – Exposure to injected RF energy over a frequency range of 150 kHz to 80 MHz at an intensity of 140 dB (μV).

Results

The unit was tested using a coupling/decoupling network (CDN) by injecting RF transients onto the power line. No alarms or operational changes were observed during the exposure.

Figure 12 contains a chart showing the net cps response during the scan. The frequencies shown do not include all the frequencies used during the scan test. Although a minimal increase in the net cps value can be seen, this was most likely due to the normal fluctuations of the instrument from radon.

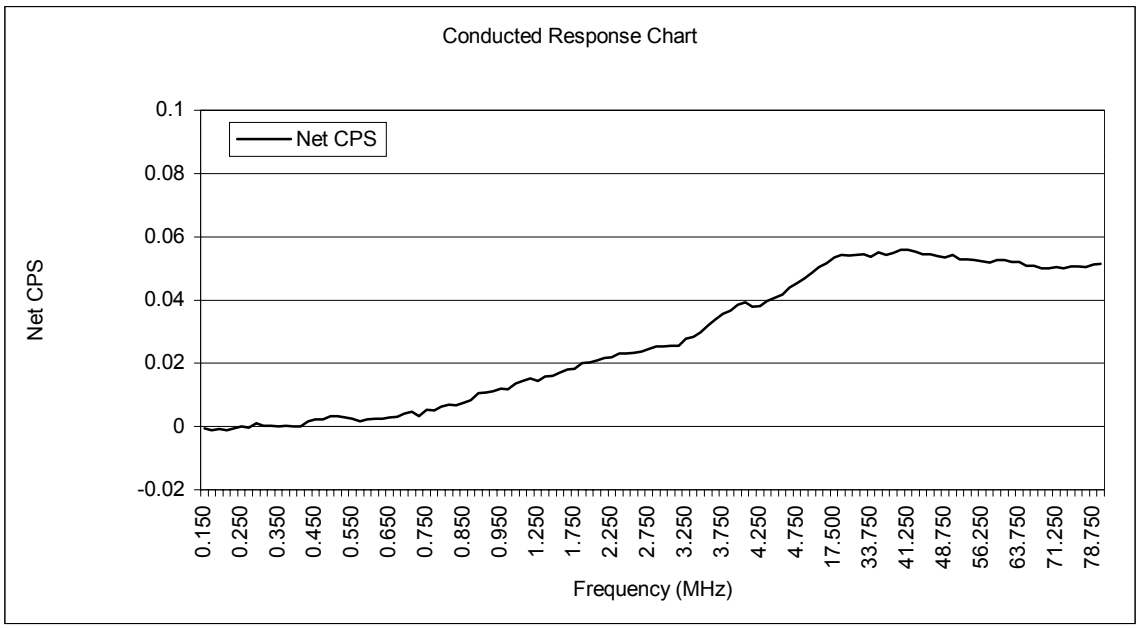

Figure 12. Conducted Response Chart

Magnetic Fields

Test Parameters – Exposure to 10 Gauss magnetic fields in two orientations.

Results

The Alpha 7L was exposed to a 10 gauss magnetic field in two orientations relative to the magnetic field lines. No alarms or operational changes were observed during the test. Figure 13 shows the net cps values taken during exposure for each magnetic field and orientation.

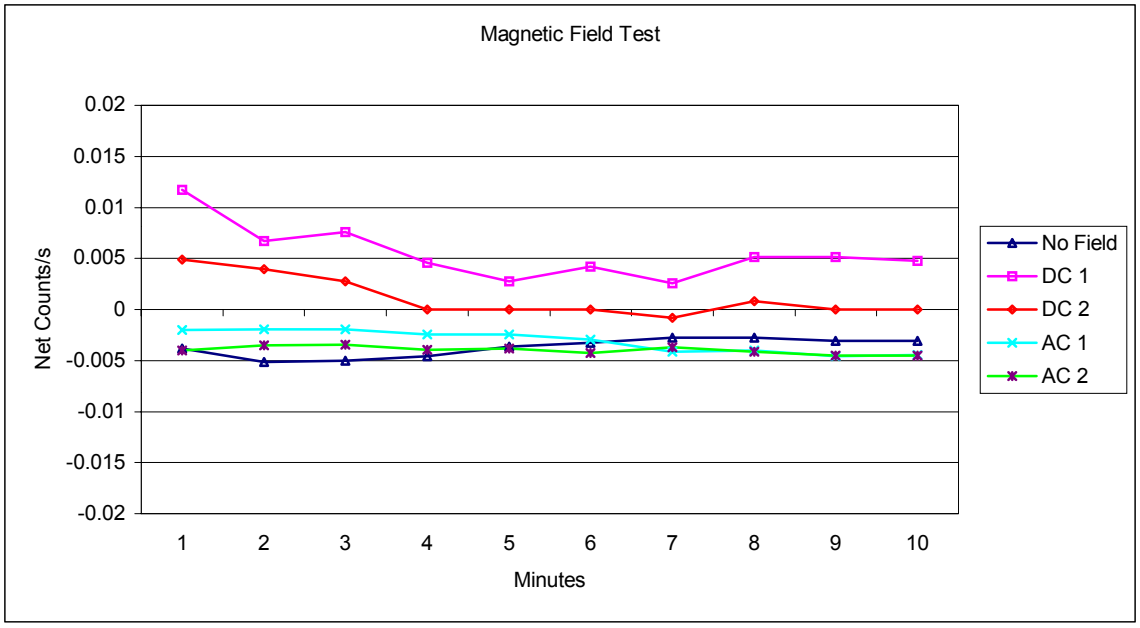

Figure 13. Magnetic Field Test

AC Line Power Variations

Test Parameters – Operations with line voltages from 103 V and 129 V.

Results

No alarms or operational changes were observed during the test. Figure 14 contains the net cps values taken during exposure.

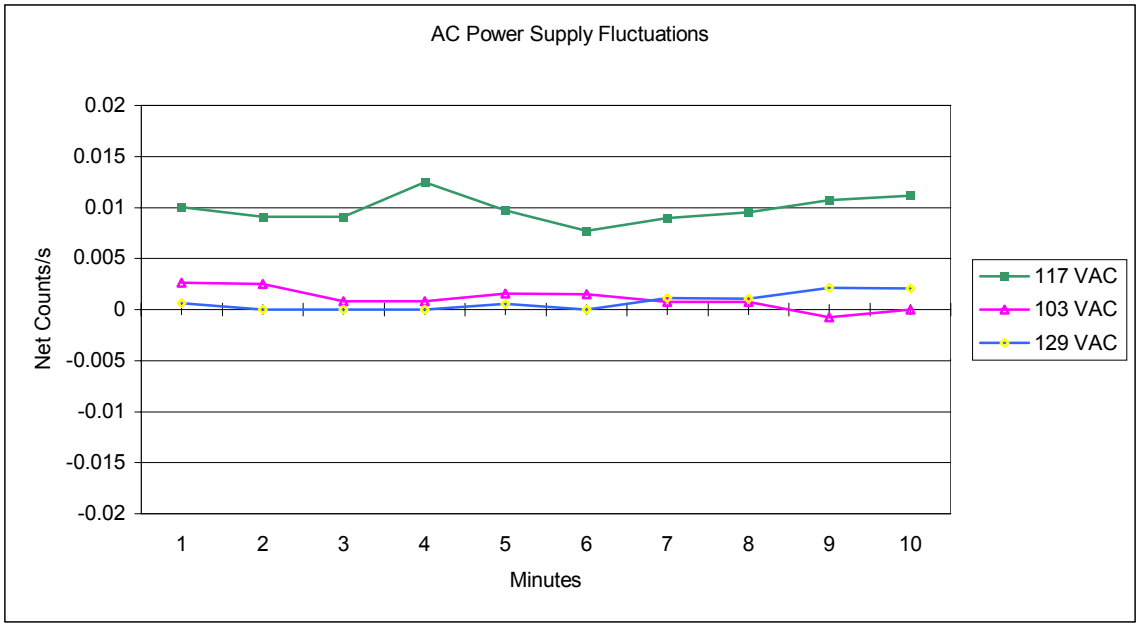

Figure 14. AC Power Supply Fluctuations

Surge Immunity

Test Parameters – Exposure to surges over the power line.

Results

The Alpha 7L was exposed to two different pulse types, combination and ring wave. Pulses were applied to the main supply through the vendor-provided power cord. A series of fast DAC-h readings were taken prior to and after each exposure to determine if any post-test affects occurred. In addition, the unit was monitored during each exposure to document if alarms or other affects were indicated.

Combination Wave

The Alpha 7L was exposed to ten pulses consisting of a combination wave (1.2/50 μs – 8/20 μs) at 2,000 volts peak amplitude. No post-test effects were indicated. The airflow rate, DAC-h readings, and alarms were monitored during the test with no anomalies indicated.

Ring Wave

The Alpha 7L was exposed to ten pulses consisting of a 100 kHz ring at 2,000 volts peak amplitude. No post-test effects were indicated. The airflow rate, the DAC-h reading, and alarms were monitored during the test with no anomalies indicated.

Interfering Ionizing Radiation

Test Parameters – Exposure to gamma and neutron radiation fields.

Results

The Alpha 7 was tested to determine the affects of gamma or neutron radiation on the operations of the unit. The instrument was allowed 30 minutes to obtain a radon spectrum before being exposed to the interfering radiation. Exposure was to both components.

The gamma field used was from ^{137}Cs at an intensity of 1 rad/hr. An unmoderated ^{252}Cf source was used to provide a neutron intensity of 1 rem/hr.

Once the radon spectrum was obtained, the unit was exposed to the ionizing radiation field for two minutes. No abnormalities were observed from exposure to gamma. The neutron field caused the unit to go into alarm. The display unit was moved away from the field and the test was repeated. The results were the same with the detector only in the field. These results were expected.

3. FOLLOW-UP TESTS

Two additional production Alpha 7L units were provided by LANL for evaluation. Each unit included the recommended upgraded detector head to display unit communication cable, but didn't include the RF screen that is placed over the radial entry detector.

Tests performed included Temperature, Relative Humidity, and Radio Frequency.

Temperature

Test Parameters - Exposure to –10 to +50 °C

Results

No susceptibilities were indicated throughout the test. The calculated ^{239}Pu concentration level remained within ± 4E-3 pCi/liter and the operating status remained "Normal." Figure 15 shows the ^{239}Pu concentration value and the actual temperature readings from the test.

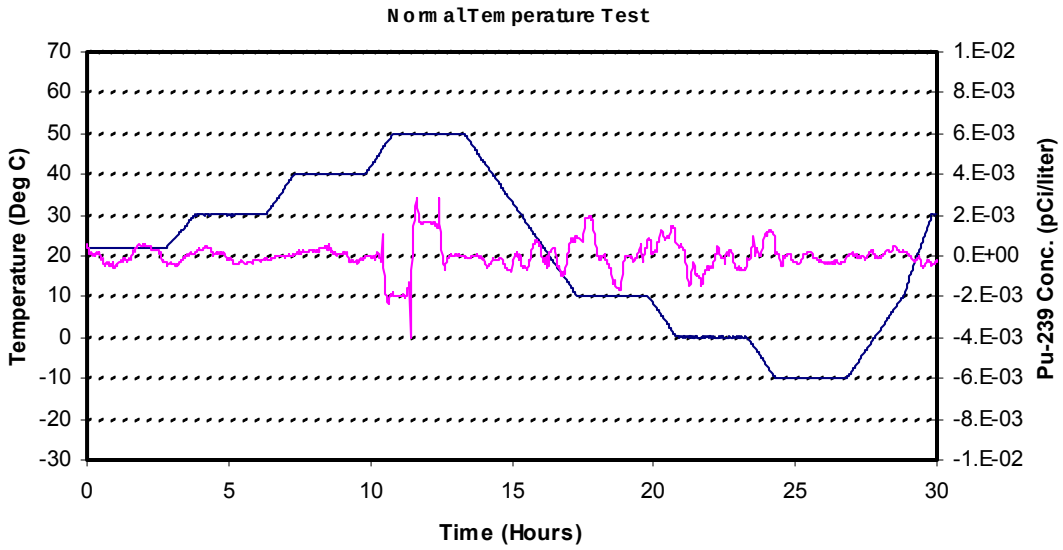

Figure 15. Temperature Test

Relative Humidity

Test Parameters – Exposure to 40% to 95% relative humidity (non-condensing) at a temperature of 30°C ± 2°C

Results

No susceptibilities were indicated until near the end of the 24-hour exposure at 95% RH. The unit became more erratic and the "Fast Concentration Alarm" activated. Figure 16 shows the ^{239}Pu concentration level and the actual RH conditions from the test.

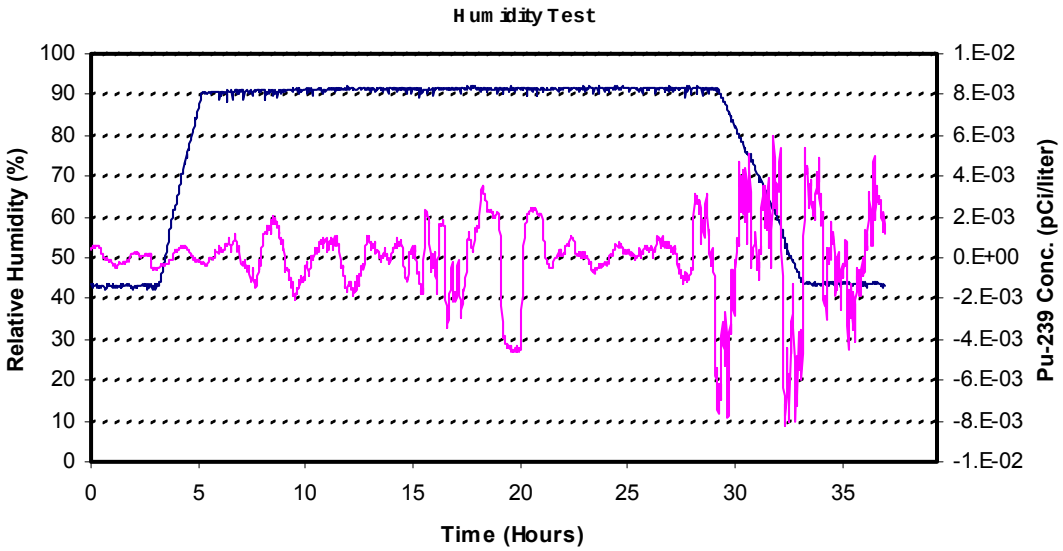

Figure 16. Humidity Test

Radio Frequency

Test Parameters – Exposure to amplitude modulated (1 kHz at 80 %) RF energy at 20 Volts/meter over a frequency range from 25 MHz to 1000 MHz.

Results

Susceptibilities were indicated at different frequencies throughout the test. Most of the susceptibilities were indicated as counts on the lower energy range of the spectrum and didn't affect the monitor's ability to determine the ^{239}Pu concentration level. Frequency ranges that caused response affects are shown in the following table.

Table 2. Frequency Ranges

Susceptibility Band (MHz)	**MeV**	**Anomalies / Status**
42 – 44.6	o Spectrum	Flow:?; Pu-239 value: Affected; Status: MCA Failure
5.3 – 47.3	2.0 - 7.0	Flow: OK; Pu-239 value: Affected; Status: Fast Dose
53 – 56	2.0 - 10	Flow: OK; Pu-239 value: Affected; Status: Normal
56 – 62	o Spectrum	Flow:?; Pu-239 value: Affected; Status: MCA Failure
342 – 362	1.0 - 10	Flow: OK; Pu-239 value: Affected; Status: Fast Dose
720 – 750	1.5 – 6.0	Flow: OK; Pu-239 value: Affected; Status: Normal

4. SUMMARY

Although various susceptibilities were observed during the performance of this evaluation, the Eberline Alpha 7L appeared to operate well during most environmental conditions. The manufacturer provided excellent support when problems needed to be addressed, with those primarily involving susceptibility to radio frequency fields. Recommendations were made to the user organization with regards to cable placement to also reduce the susceptibility of the monitor to RF. It is recommended that some level of routine testing be performed to ensure that no degradation of components occurs during the operating life of the equipment that could go unnoticed by the user. It must be noted that all susceptibilities were indicated as operational status changes by the monitor.

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