ORNL/TM-2003/203

RAD/COMM “Cricket” Test Report

August 2003

Prepared by
Peter J. Chiaro, Jr.

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RAD/COMM "CRICKET" TEST REPORT

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EXECUTIVE SUMMARY

The Environmental Effects Laboratory of the Engineering Science and Technology Division of Oak Ridge National Laboratory performed a series of tests to further evaluate and characterize the radiological response of a "Cricket" radiation detection system. The Cricket, manufactured by Rad/Comm Systems Corporation of Ontario, Canada, is designed to detect radioactive material that may be contained in scrap metal. The Cricket's detection unit is designed to be mounted to the base of a grappler, allowing it to monitor material while the material is being held by the grappler tines.

The Cricket was tested for background stability, energy response, spherical response, surface uniformity, angular dependence, and alarm actuation. Some of these tests were repeated from a prior test of a Cricket at the Environmental Effects Laboratory as reported in ORNL/TM-2002/94. Routine environmental tests – normal temperature and relative humidity – were also performed as part of this testing process.

Overall, the Cricket performed well during the testing process. The design of the instrument and the inherent photon energy of the radionuclides had some affect on portions of the tests but do not detract from the value-added benefits of the Cricket's detection capabilities.

1. INTRODUCTION

A series of tests were performed at Oak Ridge National Laboratory (ORNL) to evaluate and characterize the radiological response of a "Cricket" radiation detection system. The "Cricket" is manufactured by RAD/COMM Systems Corp., which is located in Ontario, Canada. The system is designed to detect radioactive material that may be contained in scrap metal. The Cricket's detection unit is designed to be mounted to the base of a grappler, allowing it to monitor material while the material is being held by the grappler tines. It can also be used to scan material in an attempt to isolate radioactive material if an alarm occurs. Testing was performed at the Environmental Effects Laboratory located at ORNL and operated by the Engineering Science and Technology Division.

Tests performed included the following:

a. Radiation background stability,
b. Energy response using ^{241}Am, ^{137}Cs, and ^{60}Co,
c. Spherical response,
d. Surface uniformity,
e. Angular dependence,
f. Alarm actuation,
g. Normal Temperature, and
h. Relative Humidity.

This report presents a summary of the test results. Radiation background measurements were obtained prior to the performance of each individual test

2. TEST SUMMARY

Background Stability

A. Description
The Cricket was switched on and permitted to go through its power-up sequence. After allowing five minutes warm-up time, ten single-radiation background measurements for each channel (A and B, and T) were recorded in the following sequence – A, B, T, A, B, T… It should be noted that channel "T" provides the average counts per second (CPS) for both channel "A" and channel "B". Readings from channels (detectors) "A" and "B" are single count rate readings. The ambient background reading was taken using a Bicron microrem meter.

B. Results
Background measurements are listed in Table 1. No instability was observed.

Table 1. Background Stability Measurements
Background Reading = 5μR/hr

Reading	**Cricket Readout**		
#	**A**	**B**	**T**
1	348	354	740
2	313	394	729
3	364	384	742
4	354	323	748
5	369	384	750
6	303	349	753
7	404	374	743
8	389	374	733
9	460	374	740
10	480	308	744
Average	378	362	742
Standard Deviation	57	28	7
Coefficient of Variation	15.1%	7.8%	1.0%

Spherical and Energy Response

A. Description
Spherical response data was obtained using a series of gamma emitters, ^{241}Am, ^{137}Cs, and ^{60}Co. Data was taken using the fixture shown in Figures 1a and 2. Source positions are indicated in Figure 1a. The extensive data obtained as a result of this test will enable the development of a model that estimates activity required for an alarm based on radionuclide, source position, and attenuation by surrounding material. The number of circles formed by considering all possible measurements in all possible directions, results in a spherical shape. The spherical nature of the measurements can be attributed to the symmetry of the test fixture, the symmetrical shape of the detection unit, as well as the symmetry of the source's locations around the vertical centerline of the fixture. Readings were recorded from each channel (A, B, T) and obtained with each source rotated clockwise around the detector surface. Data presented in this summary is from ^{137}Cs.

Source positions within and on the surface of the sphere are identified as follows. For example, "M3-60-90" indicates that the source was in lateral position "M3", layer or radial position "60" (Figure 1a), and circular position "90" which is related to the surface position on the detection assembly (Figure 2).

B. Results

Nineteen data sets, 12 measurements each set, were taken representing the Cricket detectors' response at 12 positions around the surface (0^o, 30^o, 60^o, ….., 330^o). Each data set was taken with the source mounted at a different location on the test fixture as shown in Figure 1a. Table 2 tabulates measurements (CPS and efficiency) taken at a position of 90^o at the surface of the detector, as shown in Figure 2. Table 3 represents measurements taken with the source placed at different locations forming radial paths (M1-M2-M3, M1-M2-M3-M4, M1-M2-M3-M4-M5). Additional clarity can be seen in Figure 1b.

Figure 3a depicts the sensitivity values based on arc positions (M1, M2, M3, etc.) Figure 3b shows the sensitivity values based on layer (radial) positions. Data obtained indicates that sensitivity increases as the source is moved towards the center of the sphere.

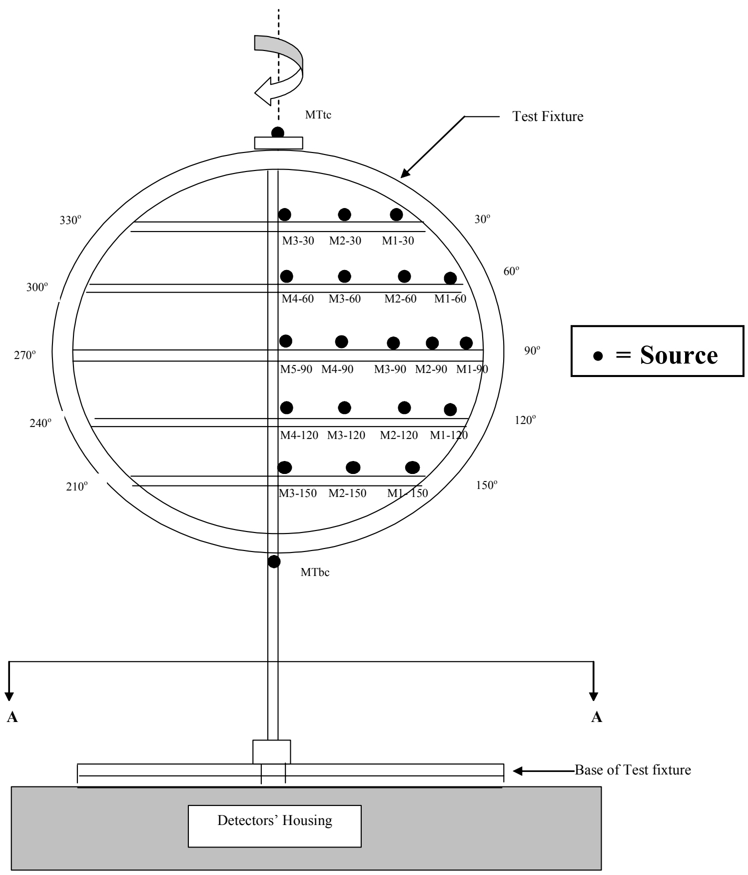


Figure 1a. Cricket measurements (CPS and efficiency) showing test fixture and test source locations in reference to detectors' surface.

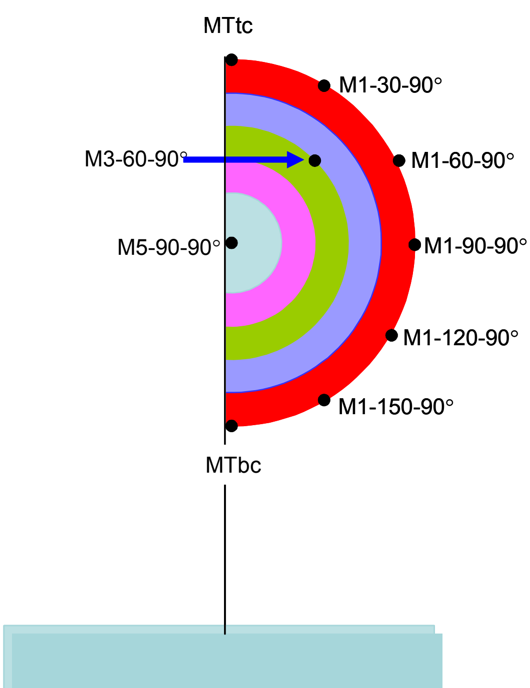


Figure 1b. Cricket measurements with the source at different locations forming radial paths.

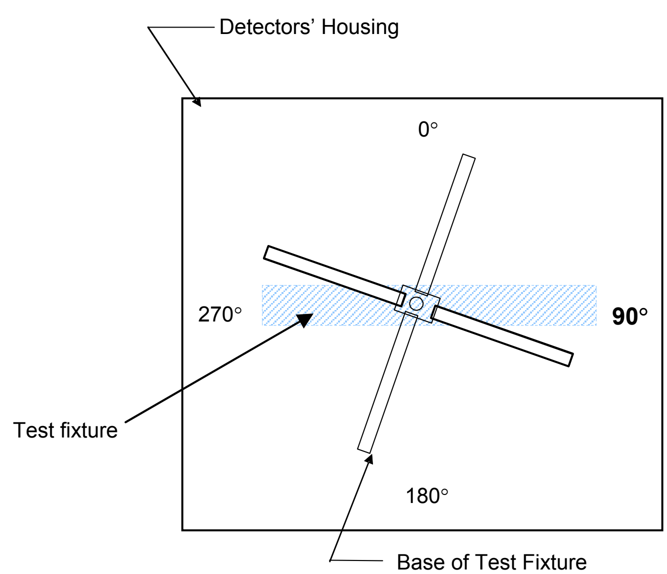


Figure 2. (View A – A) Top surface of detectors' housing, base of test fixture, and 90^{o} position where data in Tables 2 and 3 were taken.

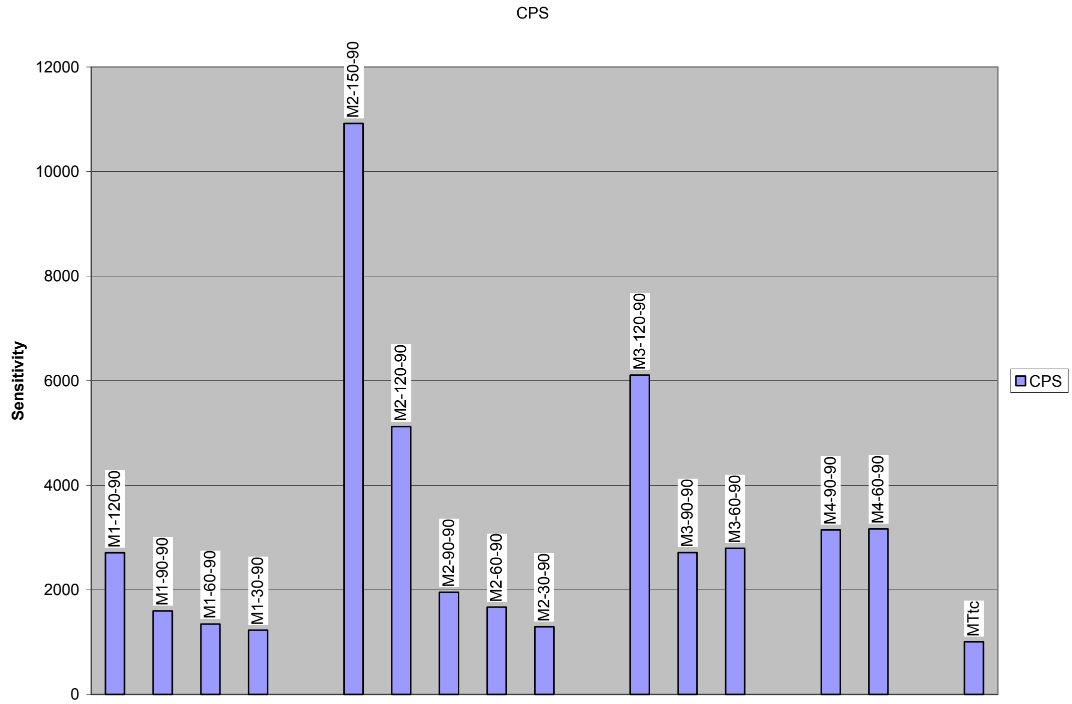


Figure 3a. Sensitivity values based on arc positions

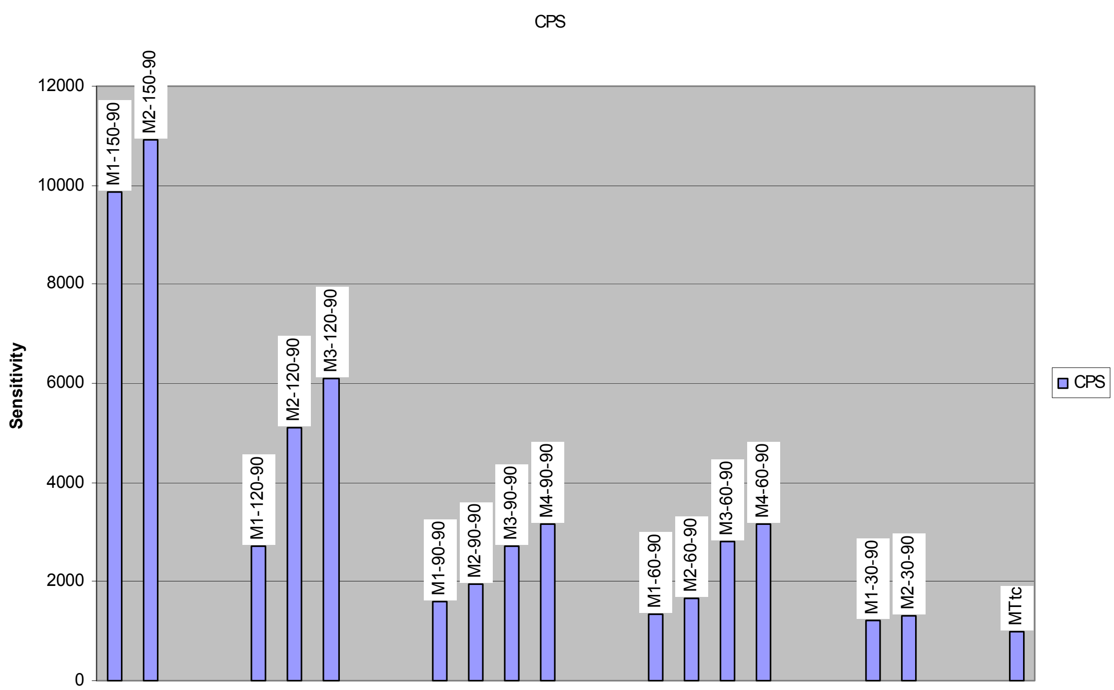


Figure 3b. Sensitivity values based on layer (radial) positions

Table 2. Spherical data (arc measurements)

Measurement Point	Total Activity in CPS	Total Efficiency %
MTtc	1002	0.0012
M1-30-90	1228	0.0014
M1-60-90	1347	0.0016
M1-90-90	1597	0.0018
M1-120-90	2711	0.0031
M1-150-90	9864	0.0114
M2-30-90	1295	0.0015
M2-60-90	1669	0.0019
M2-90-90	1951	0.0023
M2-120-90	5122	0.0059
M2-150-90	10921	0.0126
M3-60-90	1838	0.0021
M3-90-90	2715	0.0031
M3-120-90	6105	0.0071
M4-90-90	3148	0.0036
MTbc	11513	0.0133

Table 3. Spherical data (lateral measurements)

Measurement Point	Total Activity in CPS	Total Efficiency %
M1-30-90	1228	0.0014
M2-30-90	1295	0.0015
M1-60-90	1347	0.0016
M2-60-90	1669	0.0019
M3-60-90	2793	0.0032
M4-60-90	3164	0.0037
M1-90-90	1597	0.0018
M2-90-90	1951	0.0023
M3-90-90	2715	0.0031
M4-90-90	3148	0.0036
M1-120-90	2711	0.0031
M2-120-90	5122	0.0059
M3-120-90	6105	0.0071
M1-150-90	9864	0.0114
M2-150-90	10921	0.0126

Surface Uniformity

A. Description

The detector surface was divided into nine equal sections. The analysis was performed using a ^{137}Cs source placed at the center of each section. Data from each channel was obtained and used to develop a surface plot.

B. Results

Based on previous test results (ORNL/TM-2002/94), some areas of less efficiency were expected during the surface uniformity testing. Figures 4, 5, and 6 show the response to ^{137}Cs in total net CPS with the source against the detector, at 0.5 meter and 1 meter, respectively. The detector's response to ^{137}Cs in total percentage of efficiency at the same distances is shown in Figures 7, 8, and 9, respectively. Figure 7, with the source directly against the detector surface, clearly indicates a narrow dead zone in the center of the detector. This dead zone is caused by the design of the detector assembly. There is a brace placed between each detector that provides support for the center of the assembly. This brace also creates a gap between each detector. By moving away from the center, the efficiency increases sharply. Figures 8 and 9 with the source 0.5 and 1 meter from the detector, respectively, show more uniform efficiency with slightly higher values in the center.

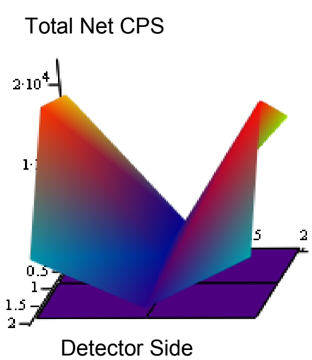


Figure 4. Surface Uniformity at Zero Source to Detector Distance using ^{137}Cs

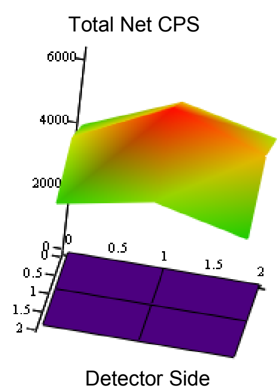


Figure 5. Surface Uniformity at 0.5M Source to Detector Distance Using ^{137}Cs

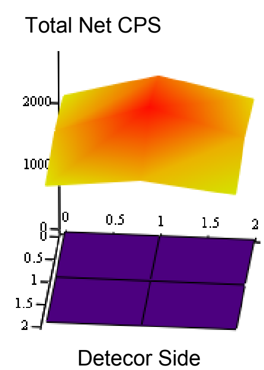


Figure 6. Surface Uniformity at 1M Source to Detector Distance using ^{137}Cs

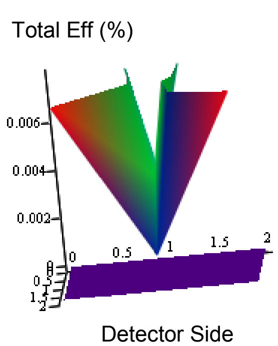


Figure 7. Total Detector Efficiency at Zero Source to Detector Distance using ^{137}Cs

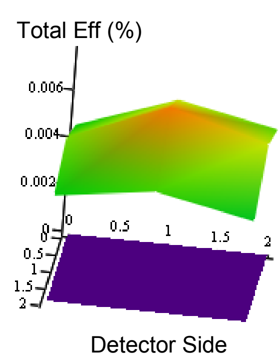


Figure 8. Total Detector Efficiency at 0.5M Source to Detector Distance using ^{137}Cs

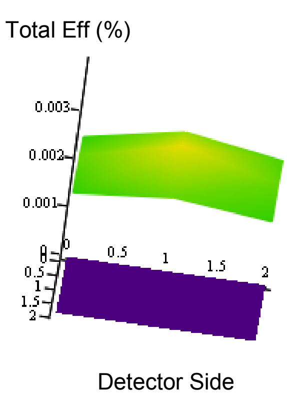
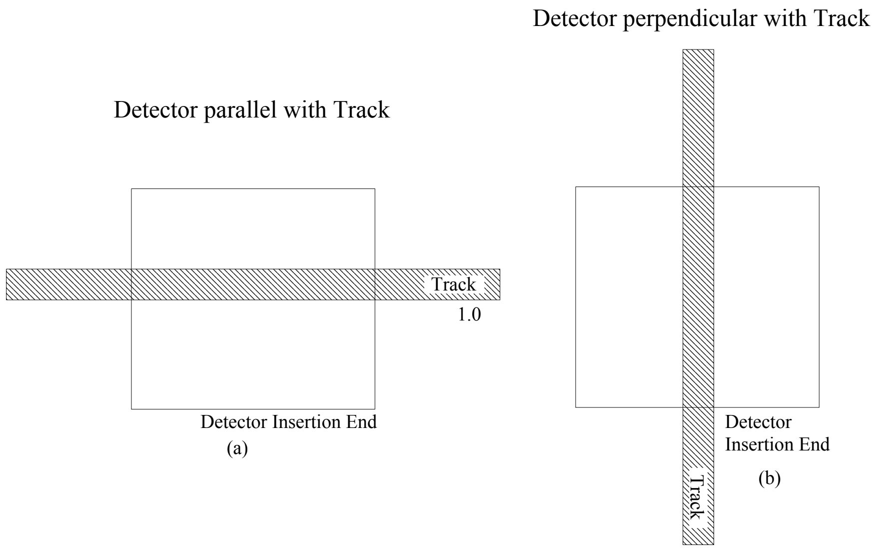


Figure 9. Total Detector Efficiency at 1M Source to Detector Distance using ^{137}Cs

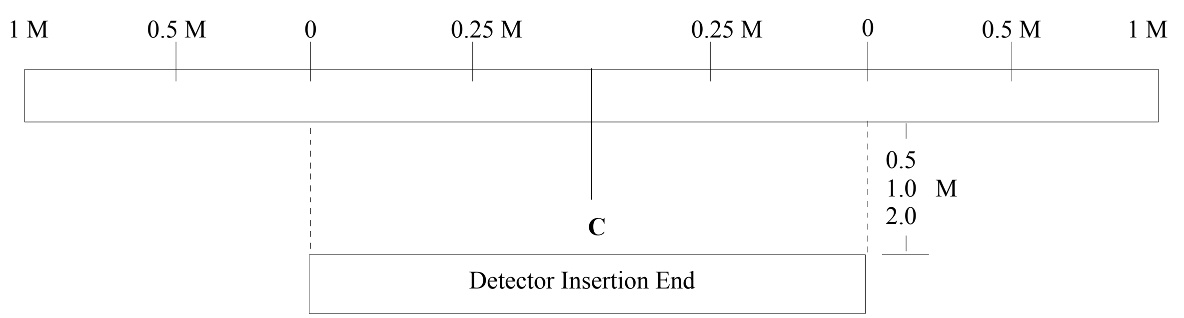
Angular Dependence

A. Description

For the angular dependence analysis, a ^{137}Cs source was positioned 0.5, 1, and 2 meters above the surface of the detector and readings were recorded for channels A, B, and T as the source was moved horizontally on a track in an East-West direction marked parallel, as shown in Drawing 1-a. Measurements were then repeated using the same source and at the same heights (0.5, 1, 2 meters) from the surface except with the track positioned in a perpendicular direction (North-South), as shown in Drawing 1-b. Drawing number 2 shows source locations where measurements were made. The measurements started at 1 meter from the edge of the detector and proceeded across the detector to a position 1 meter from the opposite edge.



Drawing No. 1 Track Position Over Detector



Drawing No. 2 Measurement Stop Points

B. Results

Due to the inherent photon energy of the radionuclides, the Cricket was most efficient for the detection of ^{60}Co and ^{137}Cs and least efficient for ^{241}Am. Figures 10, 11, and 12 show the Cricket's response in the parallel measurement position to the three sources used in this test. The vertical measurement position for ^{60}Co and ^{137}Cs is shown by Figures 13 and 14. As shown in Figures 11 and 13, the detector response for ^{60}Co is almost the same in both the vertical and parallel measurements. The response for ^{137}Cs is also very similar in both the vertical and parallel measurements ss shown by Figures 12 and 14.

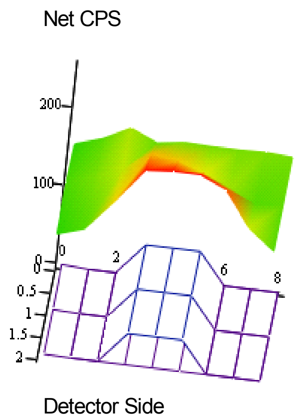


Figure 10. Total Count Rate (CPS) with ^{241}Am Source (Parallel Measurements)

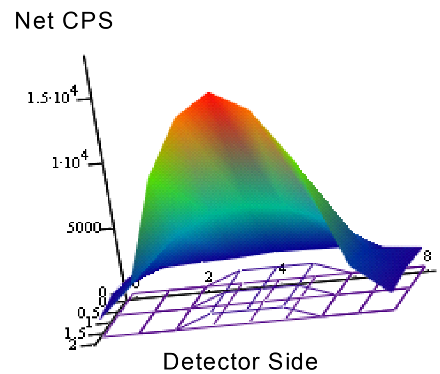


Figure 11. Total Count Rate (CPS) with ^{60}Co Source (Parallel Measurements)

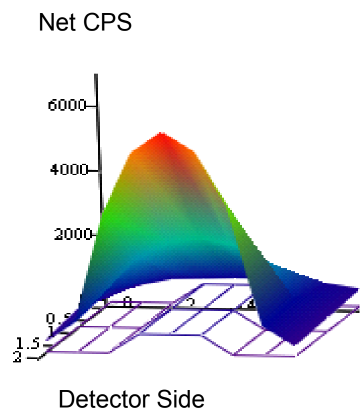


Figure 12. Total Count Rate (CPS) with ^{137}Cs Source (Parallel Measurements)

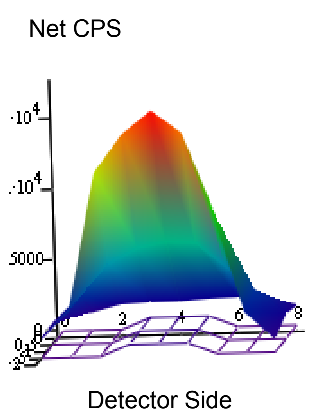


Figure 13. Total Count Rate (CPS) with ^{60}Co Source (Vertical Measurements)

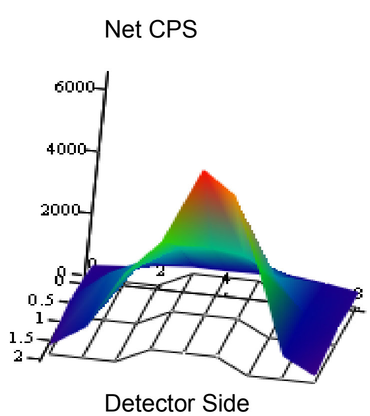


Figure 14. Total Count Rate (CPS) with ^{137}Cs (Vertical Measurements)

Alarm Actuation

A. Description
This test was performed in two different operating modes, "normal" and "tines closed." The test was performed using a linear positioning system to ensure that once an alarm occurred, the radiation source remained in the same position, allowing for a more controlled analysis and greater confidence in the stability of the readings recorded. In addition to recording each channel's response, the source was left in position after alarm activation to ensure that the alarm remained activated or latched.

These results were obtained through visual observation of the display readings. This was not the desired technique and it is undetermined if this method of data collection may have influenced the final results. The desired method for data collection was through access to the actual response data via the monitor but was unavailable for these tests. The test results indicate the monitor is substantially more sensitive in the tines-closed mode.

B. Results
Normal Mode – This test was performed using a ^{137}Cs source. The source was placed at 0.5 meters from the detection surface and moved over the surface until an alarm occurred. This was repeated at 1 meter from the detection surface until an alarm occurred. The background was approximately 767 (T) CPS. The alarm was activated at a net count rate of approximately 3553 CPS at the 0.5M distance. The alarm remained on until manually cleared. When post-exposure count rates were compared with those recorded prior to the test the differences were minimal.

Tines Mode – The test was performed using a ^{137}Cs source. Alarms were activated at a lower value than when compared to alarm activation in the normal mode. This would indicate that alarm algorithm function differently when the tines are closed. In the unaltered background, the tines-mode alarm was activated at a level that was approximately 18% of the normal mode level.

Temperature

A. Description
Tests were performed with the detectors removed from their housing. Data was obtained by observing each unit's response before and during exposure to the thermal environment. Temperatures ranged from -10° C to +50° C. Acceptance criteria was ±15% of the nominal mean from 0° C to 40° C and ± 20% of the nominal mean at -10° C and +50° C.

B. Results
No susceptibilities were observed over the temperature test range.

Relative Humidity

A. Description
Tests were performed with the detectors removed from their housing. Data was obtained through observation of each detector before and during humidity exposure. Exposure was at 40% relative humidity (RH) and 95% RH at 30° ± 2° C. Acceptance criteria was ± 15% of the nominal mean determined at 40% when exposed at 95% then back to 40%.

B. Results
No susceptibilities were observed when exposed to a relative humidity level of 95% (non-condensing) for 24 hours.

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