OAK RIDGE
NATIONAL LABORATORY
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FOR THE DEPARTMENT OF ENERGY

ORNL/TM-2003/8

FLOOR PROBE/CONTAMINATION MONITOR (NE MODEL FLP3D)

TEST AND EVALUATION REPORT

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Prepared by
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EXECUTIVE SUMMARY

A floor contamination monitor model FLP3D manufactured by Saint-Gobain Crystals & Detectors UK Ltd was tested at Oak Ridge National Laboratory. The purpose of the test is to evaluate the monitor's performance as a mobile instrument capable of detecting alpha and/or beta contamination that may exist on a flat surface such as a floor. The monitor consists of a large area scintillation probe (600 cm^2) and a rate meter mounted on heavy-duty wheels with a 22 mm separation between the monitored surface and the probe. Performance was evaluated under normal and severe environmental conditions in terms of temperature and humidity variations, and exposure to RF and magnetic fields. Sensitivity measurements were also made to determine the probe's efficiency for detecting alpha and beta contamination.

The overall performance of the floor monitor is considered satisfactory under the various environmental conditions with no major problems observed. The monitor is approximately 50% efficient for $^{90}Sr/^{90}Y$ with the source placed in contact with the detector's protective grille (0 mm) and at a distance of 22 mm. However, in its present physical configuration, the floor monitor is inefficient in detecting alpha contamination due to the 22 mm separation between the surface to be monitored and the detector's surface. The alpha detection efficiency can be enhanced to a reasonable value by redesigning the brackets holding the heavy-duty wheels to reduce the height between the surface to be monitored and the surface of the probe to a few millimeters. For use at ORNL, this change is recommended.

1. INTRODUCTION

A floor contamination monitor model FLP3D manufactured by Saint-Gobain Crystals & Detectors UK Ltd was tested at Oak Ridge National Laboratory (ORNL). The purpose of the test is to evaluate the monitor's performance as a mobile instrument capable of detecting alpha and/or beta contamination that may exist on a flat surface such as a floor. The monitor's performance was evaluated under normal and severe environmental conditions in terms of temperature and humidity variations, and exposure to RF and magnetic fields. Tests included gradual temperature variations from ambient to extreme temperatures (50^{o} C, -10^{o} C), thermal shock by rapid temperature cycling between ambient and extreme temperatures, exposure to radio frequency fields over a wide range of frequency (0.1 MHz to 1000 MHz), and exposure to AC and DC magnetic fields. Sensitivity measurements were also made to determine the probe's efficiency for detecting alpha and beta contaminations.

2. BRIEF DESCRIPTION

The FLP3D floor monitor consists of a scintillation probe model FLP3 with a 600 cm^2 sensitive area, and a ratemeter model DELTA5B. The probe, photomultiplier tube, and thick film resistor network are housed in a light-tight plastic housing. The ratemeter is designed to fit securely on top of the probe housing through two runners and can be easily detached. High voltage required for probe operation is supplied by the ratemeter. Various modes of operation can be selected to monitor alpha contamination only, beta contamination only, or alpha plus beta. Measurement capability includes measured count rate or contamination level. User-selectable display units include:

- Count per second (cps)
- Count per minute (cpm)
- Bq
- Dpm, Bq/cm^2

Specific Notes:

1. For better results, the manufacturer recommends allowing a one-second exposure time so that the entire sensitive area of the probe is exposed to the measurement area. Based on the probe dimension of 20 cm in the monitoring direction, the recommended speed is 20 cm per second.

2. The standard floor monitor has four small wheels (balls) attached to the bottom of the probe housing in such a way that the height between the probe and the surface to be monitored can be adjusted to either 2 mm (recommended for better alpha efficiency) or 8 mm for beta. The floor monitor under evaluation is equipped with castors for mobility on rough surfaces. The use of the castors option causes an increase in the minimum distance from 2 mm to 22 mm. Alpha efficiency is severely reduced. A change in the castor design is highly recommended.

3. TEST PROCEDURES

The following tests were performed to evaluate the overall performance of the floor monitor for detecting alpha and beta contamination under various environmental conditions. A brief description of each test procedure is given in section 4.

- Normal Temperature
- Temperature Shock
- Relative Humidity
- Radio Frequency (RF) Susceptibility
- Magnetic Field Susceptibility
- Detection Sensitivity Test

Test results are listed in Appendix A, B, C, and D.

4. DISCUSSIONS

The following discussions summarize the findings from each test performed.

4.1 Normal Temperature, Temperature Shock, Relative Humidity Test

The floor monitor was tested under various temperature and humidity conditions using capabilities available at the Environmental Effects Laboratory (EELab). The test was conducted with the monitor exposed to a plated source, ^{137}Cs. The purpose of the test was to expose the equipment to an environment of changing temperatures and humidity at varying rates, simulating normal as well as harsh operating environments. Data collected is reported in Appendix A.

Conclusion: The overall performance of the monitor was satisfactory during the normal temperature test cycle, the temperature shock cycle, and the humidity test cycle. Minor deviations were noted during the temperature shock cycle at two steps. Between -10^{o} C and 22^{o} C, the confidence (+) interval was slightly higher than the calculated value. Between 22^{o} C and 50^{o} C, the mean and the confidence (-) interval were slightly lower than the calculated values. These deviations do not constitute any operational limitation and are not considered indicators of a serious systematic problem.

4.2 Radio Frequency Test

The floor monitor was tested to determine its susceptibility to RF fields. The test was conducted with the monitor inside the GTEM test chamber while being exposed to a ^{137}Cs source. An RF field was applied at 20 V/m intensity from 100 kHz to 1000 MHz (1 GHz). Data collected from this test is reported in Appendix B.

Conclusion: The floor monitor performed satisfactorily over the test frequency range with the exception being between 75 MHz and 82 MHz. At these frequencies, the display became erratic and various status/mode indicators flashed ON and OFF.

4.3 Magnetic Field Test

The magnetic field test was conducted by placing the floor monitor inside a Merrit Coil magnetic field generator with the capability to apply a DC magnetic field up to 12.5 Gauss and an AC magnetic field up to 4.5 Gauss at 60 Hz. Measurements were made in two different orientations that were 90^{o} apart at an intensity of 10 Gauss. The system's performance was measured using a 7 μCi ^{137}Cs source. Test results are reported in Appendix C.

Conclusion: The monitor was susceptible when exposed to the DC field in both orientations. No susceptibilities were observed when the monitor was exposed to the AC fields.

4.4 Detection Sensitivity Test

Several measurements were made to determine the probe's sensitivity to detecting alpha and/or beta contamination across the probe's surface area. As illustrated by Figure D1, nine alpha and nine beta measurements were taken along the perimeter and the center of the probe using ^{239}Pu and $^{90}Sr/^{90}Y$ sources with known activities. Two sets of data were obtained for each source; one with the source in contact with the probe's grille, marked as zero mm, and the other with the source at a distance of 22 mm. According to the present monitoring configuration, the 22 mm distance represents the lowest possible height between the surface to be monitored and the probe's surface. Data are tabulated in Tables D1 and D2.

Table D1 contains the data recorded for alpha and beta at the zero mm position. The beta measurements clearly indicate that the measurements are fairly uniformly distributed over the probe's active area with an efficiency of approximately 50%, except for the center where it's slightly higher, 63%, as illustrated by Figure D2. The alpha measurements, on the other hand, indicate a uniform distribution with much lower efficiency, approximately 14%, as shown in Figure D4. The alpha and beta measurements for the 22 mm position are tabulated in Table D2. Consistency in beta measurements at each position is quite obvious as indicated by the uniformity of the data and the detection efficiency as shown in Figure D3. Alpha radiation sensitivity is quite poor at the 22 mm position as can be seen in Figure D4. The efficiency determined with the source in the center position is greatest (~2.5%) and drops off sharply as it is moved from the center position. When the detector-to-source distance is reduced to contact, the sensitivity is greatly improved and relatively flat over the sensitive surface of the detector as can be seen in Figure D5.

Conclusion: The floor monitor in its present physical configuration appears to be efficient and reliable in detecting and monitoring beta contamination. As an alpha contamination monitor, it's considered to be inefficient and unreliable. Enhancement can be made in alpha contamination detection by redesigning the brackets holding the wheels allowing the probe's surface to be much closer to the surfaces to be monitored.

5. RECOMMENDATION

In order to utilize the full capabilities of the floor monitor, it is recommended that the brackets holding the heavy-duty wheels be redesigned to bring the probe closer to the surface to be monitored. The manufacturer recommended height for an efficient alpha detection is 2 mm. Such a design change would allow the monitor to be useful for monitoring alpha and beta contamination.

APPENDIX A

ENVIRONMENTAL EFFECTS LABORATORY TEST RESULTS (TEMPERATURE, TEMPERATURE SHOCK, HUMIDITY)

Environmental Effects Laboratory
Test Report

Normal Temperature

Manufacturer: Bicron/ NE Technology Delta 5 Floor Monitor
Model: FLM30
Date(s) Tested: 10/23/2002 thru 10/26/2002
Number Tested: 1 **Serial Number(s):** 129
Range(s) Tested: N/A
Procedure Used: ORNL-EF-01 Rev 0
Basic Test Parameters: -10 to +50 C (+14 to 122 F)
Acceptance Criteria: ± 15% of the nominal mean from 0 to 40, ± 20% of the nominal mean at -10 and 50
Data Collection Method: Data was obtained by observing each unit's response before and during exposure. Confidence intervals, determined using the 0.95 quantile of the students t distribution (95% confidence interval), are used to ascertain whether results are conclusive or inconclusive.

Observations

Degrees C	Mean Readings		Results Conclusive		Description
	In	Out	Yes	No	
-10	1		1		
0	1		1		
10	1		1		
30	1		1		
40	1		1		
50	1		1		

key: h=high, l=low

General Comments: None

Environmental Effects Laboratory
Test Report

Temperature Shock

Manufacturer: Bicron/ NE Technology Delta 5 Floor Monitor

Model: FLM30

Date(s) Tested: 10/23/2002 thru 10/26/2002

Number tested: 1 Serial Number(s): 129

Range(s) tested: N/A

Procedure Used: ORNL-EF-02, dated 03/03/95

Basic Test Parameters: Unit(s) exposed to rapid temperature changes of 22 to -10, -10 to 22, 22 to 50, and 50 to 22 (in C).

Acceptance Criteria: ± 15% of the nominal mean taken at 22 C.

Data Collection Method: Data was obtained by observing each unit's response using a camera and VCR. Confidence intervals, determined using the 0.95 quantile of the students t distribution (95% confidence interval), are used to ascertain whether results are conclusive or inconclusive.

Observations

	Mean Readings		Results Conclusive ?		
	In	Out	Yes	No	Description
22 to -10	1		1		
-10 to 22	1			1	Conf-Int (+) > Acceptance Range
22 to 50		1 (l)	1		Mean < Acceptance Range Conf-Int (-) < Acceptance Range.
50 to 22	1		1		

key: h=high, l-low

General Comments: None

Environmental Effects Laboratory
Test Report

Relative Humidity

Manufacturer: Bicron/ NE Technology Delta 5 Floor Monitor
Model: FLM30
Date(s) Tested: 10/23/2002 thru 10/26/2002
Number Tested: 1 **Serial Number(s):** 129
Range(s) Tested: N/A
Procedure Used: ORNL-EF-03 Rev. No. 0
Basic Test Parameters: 40% relative humidity (RH) and 95% RH at 35° +/- 2 °C
Acceptance Criteria: **± 15% of the nominal mean determined at 40% when exposed 95% then back 40%.**
Data Collection Method: Data was obtained by observing each unit's response before and during exposure. Confidence intervals, determined using the 0.95 quantile of the students t distribution (95% confidence interval), are used to ascertain whether results are conclusive or inconclusive.

Observations

Relative Humidity	Mean Readings In	Mean Readings Out	Results Conclusive ? Yes	Results Conclusive ? No	Description
95%	1		1		
40%	1		1		

key: h=high, l-low

General Comments: The 95% soak time was 19 hours.

APPENDIX B

RADIO FREQUENCY FIELD TEST RESULTS

Environmental Effects Laboratory

Test Report

Radio Frequency - Microwave Field

Manufacturer: Bicron NE Technology Delta 5 Floor Monitor
Model: FLM30
Date(s) 11/5/2002
Number tested: 1 Serial Number(s): 129
Range(s) tested: N/A
Test Plan/Procedure Used: ORNL-IR-02, Rev. 1
Basic Test Parameters: Frequency Scan of 0.1 to 1000 MHz.
20 (± 2) Volts/meter Amplitude Modulated with 1 kHz at 80%.
Acceptance Criteria: ± 15% of the nominal mean and stability during scan.
Data Collection Method:

Data was obtained by observing each unit's response before and during exposure. Confidence intervals, determined using the 0.95 quantile of the students t distribution (95% confidence interval), are used to ascertain whether results are conclusive or inconclusive.

Observations

The following anomaly was observed:

Between 75Mhz and 82Mhz the display became erratic, with numbers disappearing, over-range indicated on bar display, and various other status or mode indicators flashing on and off in an unpredictable way.

At all other frequencies, values were within the acceptance range.

General Comments: None

APPENDIX C

MAGNETIC FIELD RESPONSE TEST RESULTS

Environmental Effects Laboratory
Test Report

Magnetic Field

Manufacturer: Bicron Delta 5 Floor Monitor

Model: FLM 3D

Date(s) Tested: 10/30/2002

Number Tested: 1 Serial Number(s): 129

Range(s) Tested: N/A

Procedure Used: ORNL-IR-05

Basic Test Parameters: 10 Gauss (10 Oersted) DC and 60 Hz (1.26 Gauss) AC in two orientations relative to the magnetic field.

Acceptance Criteria: ± 15% of the nominal mean without any field present.

Data Collection Method: Data was obtained by observing the response of each unit under test before and during exposure. Confidence intervals, determined using the 0.95 quantile of the students t distribution (95% confidence interval), are used to ascertain whether results are conclusive or inconclusive.

Observations

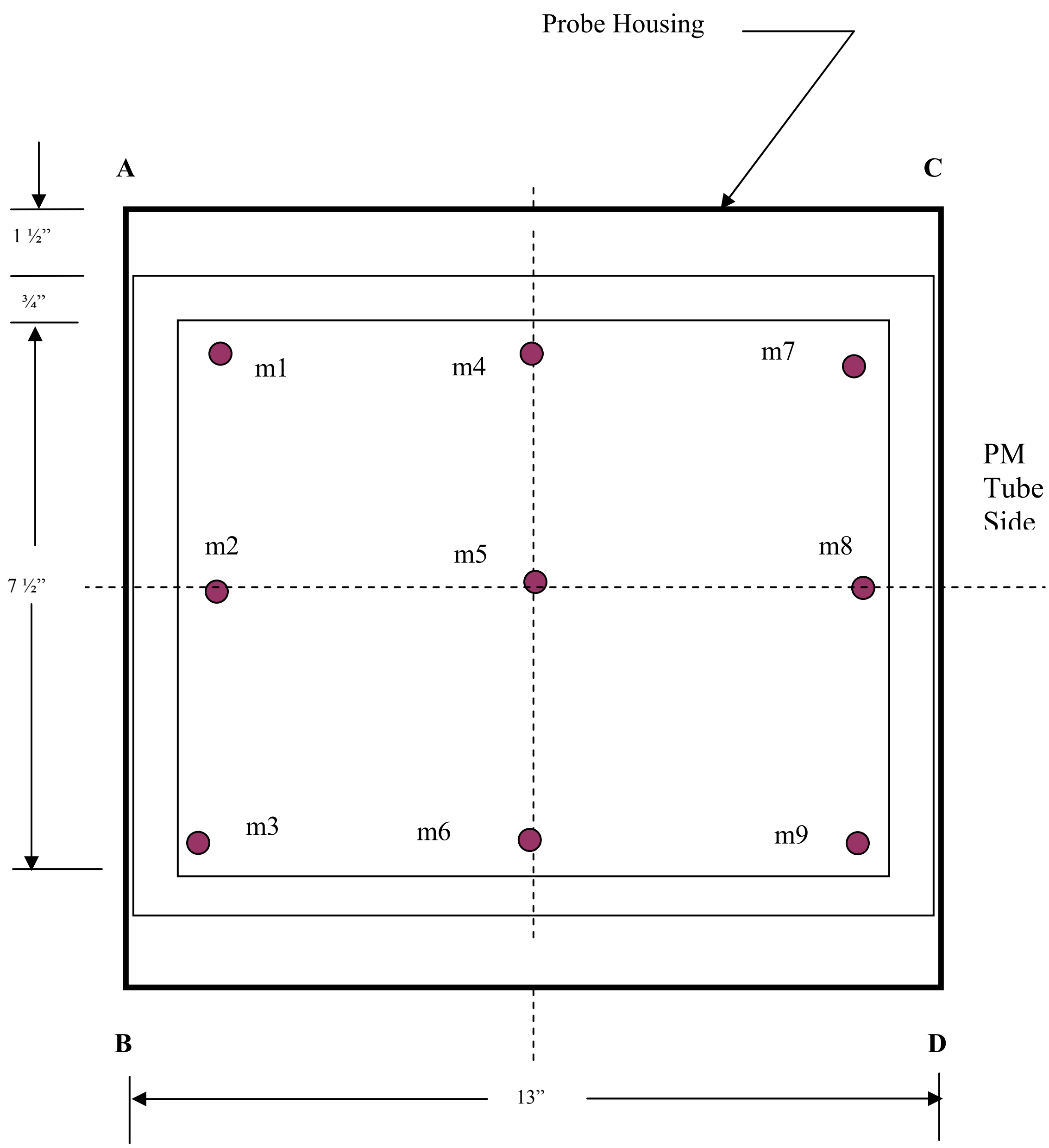
	Mean Readings		Results Conclusive ?		
	In	Out	Yes	No	Description
10 Gauss DC Orientation 1		1 (L)	1		
10 Gauss DC Orientation 2		1 (L)	1		
60 Hz AC Orientation 1	1		1		
60 Hz AC Orientation 2	1		1		

key : H=high, L = low

Comments: None

APPENDIX D

DETECTION SENSITIVITY TEST RESULTS



AB: Front Edge
CD: Rear Edge

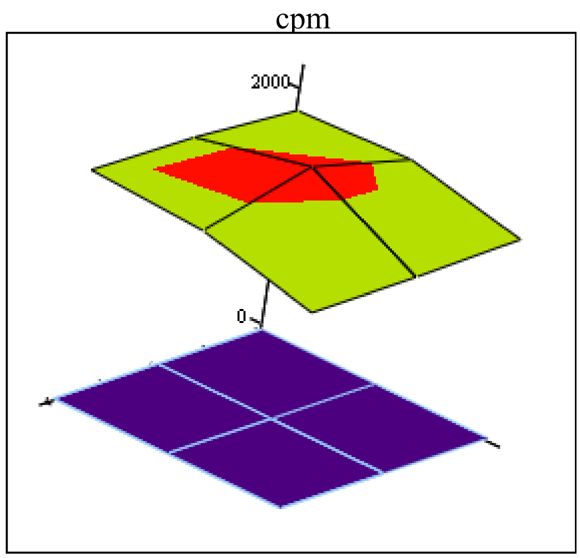
Figure D1. Bottom view of probe indicating radiological measurement locations

Table D1. Sensitivity Measurements at 0 mm (Source touching detector)

	Source: $^{90}Sr^{90}Y$ (#4853), 2" Daim, 4,010/3400dpm					**Source:** ^{239}Pu (#Pu-239-3602), 1" Diam., 115,052 dpm				
Measurement Point	**Beta at 0 mm (cpm)**			**Beta Average**	**Beta Effeciency (%)**	**Alpha at 0 mm (kcpm)**			**Alpha Average**	**Alpha Effeciency (%)**
m1	1961.0	1838.0	1778.0	1859.0	54.7	15.7	15.4	15.2	15.4	13.41
m2	1938.0	2003.0	1841.0	1927.3	56.7	17.2	17.4	17.6	17.4	15.12
m3	1946.0	1871.0	2021.0	1946.0	57.2	15.2	15.8	15.6	15.5	13.50
m4	1941.0	1841.0	1934.0	1905.3	56.0	14.6	14.5	14.2	14.4	12.55
m5	2145.0	2280.0	2003.0	2142.7	63.0	17.0	16.8	16.4	16.7	14.54
m6	1913.0	1860.0	1913.0	1895.3	55.7	14.7	14.8	15.0	14.8	12.89
m7	1818.0	1710.0	1549.0	1692.3	49.8	14.0	13.9	13.7	13.9	12.05
m8	1673.0	1628.0	1703.0	1668.0	49.1	14.8	14.7	15.0	14.8	12.89
m9	1658.0	1721.0	1616.0	1665.0	49.0	12.9	13.5	14.1	13.5	11.73

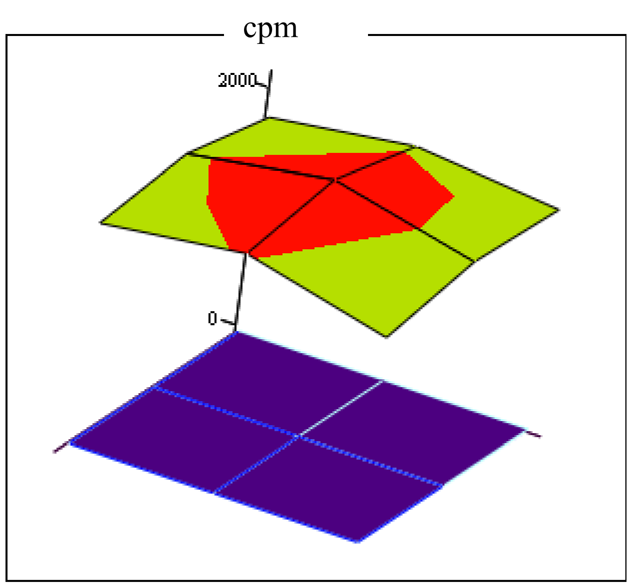
Table D2. Sensitivity Measurements at 22 mm (Source 22 mm away from detector)

	Source: $^{90}Sr^{90}Y$ (#4853), 2" Daim, 4,010/3400dpm					**Source:** ^{239}Pu (#Pu-239-3602), 1" Diam., 115,052 dpm				
Measurement Point	**Beta at 22mm (cpm)**			**Beta Average**	**Beta Effeciency (%)**	**Alpha at 22mm (cpm)**			**Alpha Average**	**Alpha Effeciency (%)**
m1	1,864.0	1,800.0	1,740.0	1,801.3	53.0	128.0	113.0	93.8	111.6	0.10
m2	2,048.0	1,969.0	1,890.0	1,969.0	57.9	371.0	304.0	274.0	316.3	0.27
m3	1,838.0	1,834.0	1,909.0	1,860.3	54.7	234.0	161.0	135.0	176.7	0.15
m4	2,020.0	1,969.0	1,924.0	1,971.0	58.0	709.0	780.0	810.0	766.3	0.67
m5	2,230.0	2,175.0	2,094.0	2,166.3	63.7	2,611.0	2,562.0	3,379.0	2,850.7	2.48
m6	1,984.0	1,969.0	2,100.0	2,017.7	59.3	870.0	828.0	739.0	812.3	0.71
m7	1,841.0	1,830.0	1,894.0	1,855.0	54.6	18.8	15.0	22.5	18.8	0.02
m8	1,945.0	1,879.0	1,845.0	1,889.7	55.6	11.3	15.0	18.8	15.0	0.01
m9	1,645.0	1,759.0	1,823.0	1,742.3	51.2	7.5	11.3	15.0	11.3	0.01



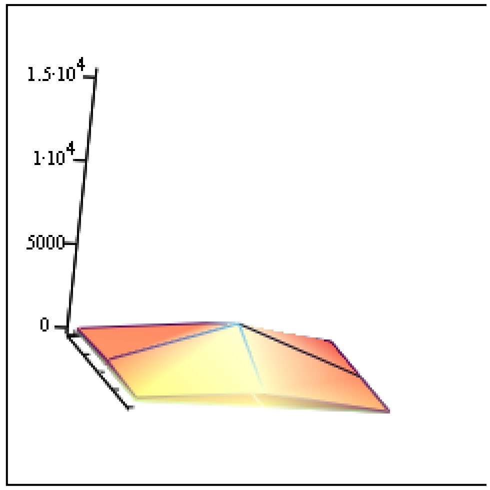
X, Y, BC0

Figure D2. Beta Sensitivity at 0 mm



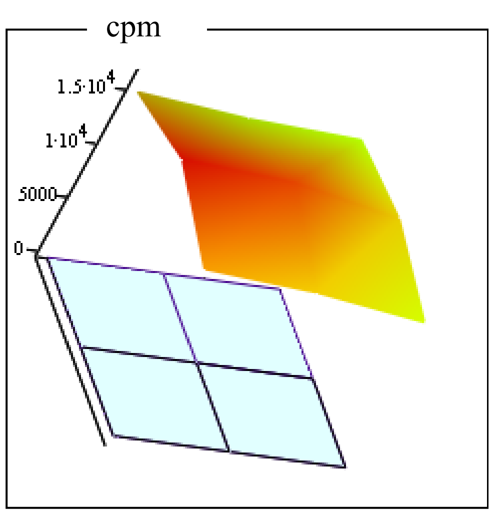
X, Y, BC22

Figure D3. Beta Sensitivity at 22mm



X, Y, AC22

Figure D4. Alpha Sensitivity at 22 mm



X, Y, AC0

Figure D5. Alpha Sensitivity at 0 mm

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