

RAM GENE-1

Type Test Report

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1. Traceability:

All the radiation qualities used for the measurements performed in this report conform to the relevant ISO Standards.

All equipment associated with the measurements performed in this report have calibrations directly traceable to national standards via the National Physical Laboratory or UKAS accredited calibration facilities.

2. Uncertainties:

The uncertainties associated with the measurements performed in this report are better than $\pm 10\%$ expressed at the 95% confidence level. Where applicable all uncertainties are summed in quadrature.

The sections of this report, relating to radiological issues, were presented by the NRPB (Report No: 36406). We would like to take this opportunity to thank them for their services.

3. General Description

The Rotem RAM GENE-1 is a portable dose rate survey instrument capable of the measurement of x and gamma radiation with a compensation filter-cap in place and detection of alpha and beta contamination with the filter removed. In dose rate mode, the quantity of measurement is ambient dose equivalent over the dose rate range of approximately $0.5 \mu\text{Sv h}^{-1}$ to approximately 6 mSv h^{-1} . In contamination survey mode, the maximum count rate is approximately $40,000 \text{ counts s}^{-1}$. The instrument is manufactured by Rotem Industries, Israel and supplied in the UK by Pycko Scientific. The serial number of the unit tested was 2304-006.

4. Facilities and Controls

Detector	Pancake style Geiger-Muller tube LND type 7313 located on the base of the instrument
Compensation	Removable filter-cap to enable detection of contamination. The filter consists of a combination of lead, tin aluminium and the plastic cap. The filter fits over the window of the detector.
Controls	The instrument has a sensor, which is activated by the filter-cap. This automatically switches the instrument from dose rate mode to contamination mode when the cap is removed. There are three buttons on the front face of the instrument, on/off, reset and audio mute.
Display	The instrument has a digital display which may indicate four digits. LEDs marked $\mu\text{Sv/h}$ or CPS indicate which mode is in use. Over range is indicated as OFLO.
Alarm	The instrument has a pre-set alarm level in both modes; when these are activated, an audible signal is produced and the display flashed Alr intermittently.

5. Dose Rate Mode Tests

5.1. Relative Intrinsic Error and Statistical Fluctuation

Test Procedure

The instrument indication is the mean of ten statistically independent readings. The instrument's relative intrinsic error was determined over the entire indicated dose equivalent rate range using ¹³⁷Cs gamma radiation. The response factor, defined as the ratio of the indicated dose equivalent rate to the true ambient dose equivalent rate, above background, is provided in Table 1. The statistical fluctuation is given as the standard deviation of the indicated dose equivalent rate over the mean indicated dose equivalent rate, multiplied by one hundred.

Ambient Dose Equivalent Rate ($\mu\text{Sv h}^{-1}$)	Instrument indication ($\mu\text{Sv h}^{-1}$)	Response Factor	Statistical Fluctuation	Uncertainty
Background	0.11	--	21%	$\pm 10\%$
2.29	2.36	0.98	7.5%	$\pm 10\%$
6.14	6.02	0.96	3.4%	$\pm 10\%$
19.5	19.0	0.97	2.3%	$\pm 10\%$
65.2	65.9	1.01	1.7%	$\pm 10\%$
209	207	0.99	2.3%	$\pm 10\%$
604	584	0.97	1.1%	$\pm 10\%$
1462	1483	1.01	0.5%	$\pm 10\%$
2339	2466	1.05	0.5%	$\pm 10\%$
4584	4847	1.06	1.2%	$\pm 10\%$
5659	6178	1.09	1.3%	$\pm 10\%$

Table 1. Relative Intrinsic Error

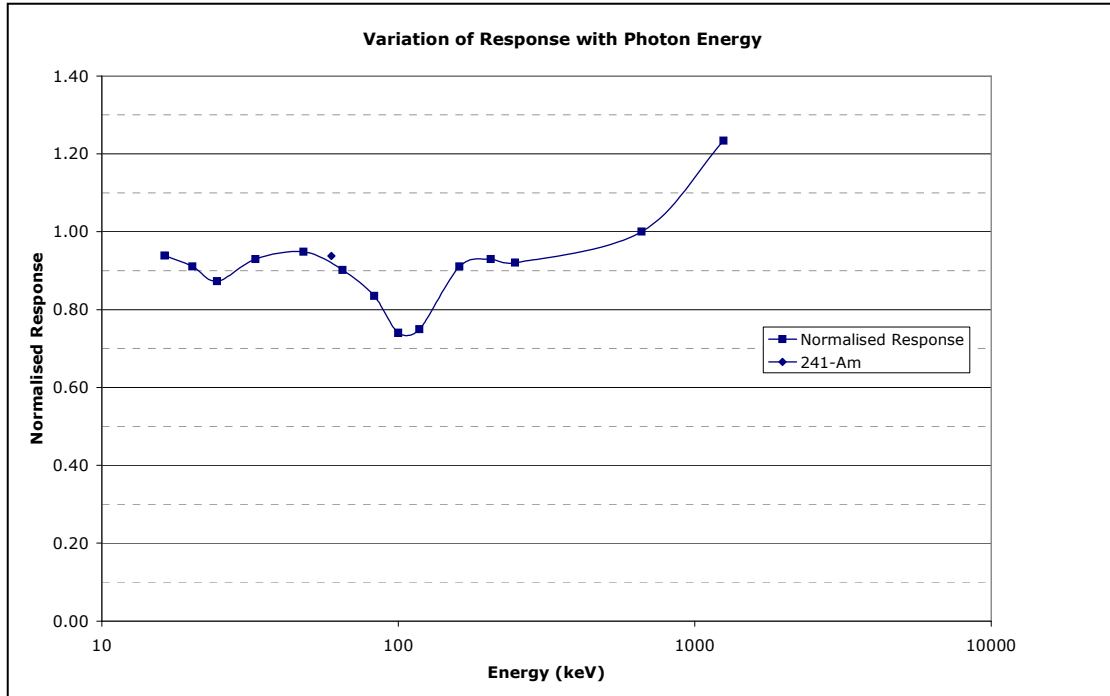
Test Result

All responses are within $\pm 20\%$ and therefore the instrument meets the standards set out in IEC 60846 s6.1.

5.2. Variation of Response with Photon Radiation Energy and Angle of Incidence

Test Procedure

Using an indicated dose rate of approximately 2.5 mSv h⁻¹, the instrument’s energy response was determined over the energy range 16.3 keV to 1.25 MeV. For energies 16.3 keV to 248 keV, x-radiation qualities were selected from the reference radiations recommended by the International Standards Organizations, i.e. the ISO Narrow and Low series of filtered x-radiations. Gamma radiation emitted from ²⁴¹Am, ¹³⁷Cs and ⁶⁰Co sources provided the response to energies 60 keV, 662 keV and 1.25 MeV respectively; in the case of the latter two, the sources were highly collimated sources. The response is defined as the ratio of the indicated dose equivalent rate to the ambient dose equivalent rate at the centre of the detector. The response is normalized to unity for ¹³⁷Cs (662 keV). This data is presented in Figure 1, full results are provided in Appendix 1. All responses, normalized to ¹³⁷Cs are within ±30%, the polar response measurements were therefore performed at the lowest mean photon energy (16.3 keV), the mean energy with the lowest normalized response (100 keV), the energy with the highest normalized response, (⁶⁰Co at 1.25 MeV) as well as ¹³⁷Cs and ²⁴¹Am. Measurements were performed at normal angle of incidence 0° ±15°, ±30° and ±45°. The results are represented graphically in



Figures 2 and 3 with the full results provided in Appendix 2.

Figure 1. Variation of Response with Photon Energy

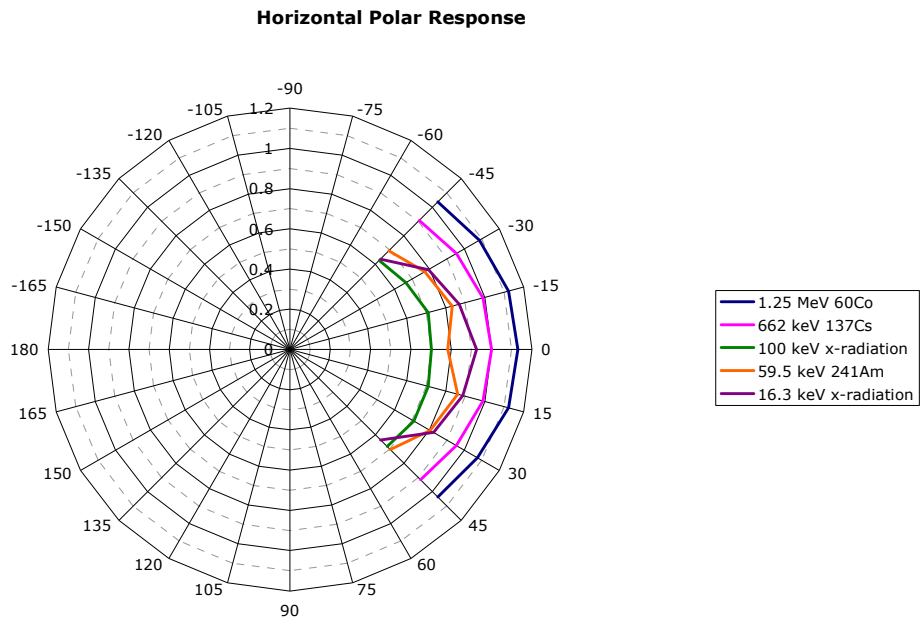


Figure 2. Horizontal Polar Response

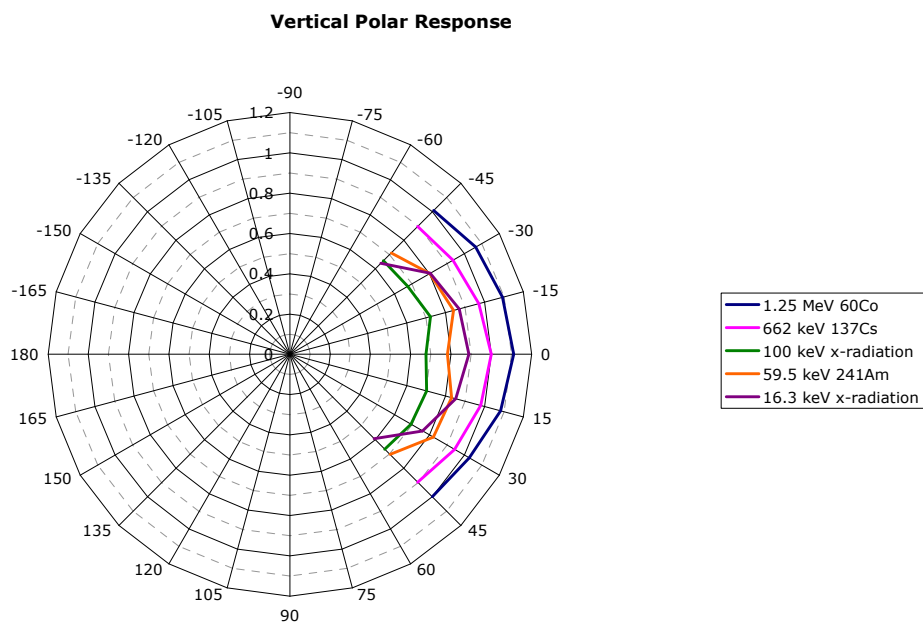


Figure 3. Vertical Polar Response

Test Result

All responses for the measurements performed fall within $\pm 40\%$ of the response obtained to ^{137}Cs at normal angle of incidence and therefore the requirements specified in IEC 60846 s6.2 are considered to be met. The minimum rated photon energy is 16.3 keV.

5.3. Response Time

Test Procedure

The response time is the time taken for the instrument to display a value of 90% of the final expected indication for a step increase or decrease in dose equivalent rate. The initial and final dose equivalent rates shall differ by a factor of 10 or more. For the measurements performed, the response time of the instrument was less than three seconds for all measurements and in many cases was instantaneous. At higher dose rates, the response time was increased with the intermittent display of the alarm signal. With a maximum dose rate range of less than 10 mSv h^{-1} ,

Test Result

The instrument meets the required ten second response time prescribed under IEC 60846 s5.8. A full record of the results obtained is located in Appendix 3.

5.4. Overload performance

Test Procedure

The instrument was exposed to an approximate dose equivalent rate of 700 mSv h^{-1} for a period of five minutes. During the test, the instrument provided a satisfactory overload indication and on subsequent reduction of dose rate, the instrument function immediately returned to normal.

Test Result

This instrument satisfies the requirements outlined in IEC 60846 s6.3.

6. Contamination Mode Tests

6.1. Relative Intrinsic Error and Statistical Fluctuation

Test Procedure

The instrument indication is the mean of ten statistically independent readings. The instrument's relative intrinsic error was determined over the entire indicated count rate range using ¹³⁷Cs gamma radiation. The response factor, defined as the ratio of the indicated count rate to the true ambient dose equivalent rate, above background, is provided in Table 1. The statistical fluctuation is given as the standard deviation of the indicated count rate over the mean indicated dose equivalent rate, multiplied by one hundred. Where the statistical fluctuation is recorded '—', the measurements were all identical.

Ambient Dose Equivalent Rate ($\mu\text{Sv h}^{-1}$)	Instrument indication (counts s^{-1})	Response Factor	Statistical Fluctuation	Uncertainty
Background	0	--	--	$\pm 10\%$
2.29	13.7	5.99	7.7%	$\pm 10\%$
6.14	39.3	6.40	4.0%	$\pm 10\%$
19.5	122	6.27	5.1%	$\pm 10\%$
65.2	428	6.56	2.0%	$\pm 10\%$
209	1334	6.38	0.9%	$\pm 10\%$
604	3782	6.26	1.8%	$\pm 10\%$
979	6130	6.26	1.4%	$\pm 10\%$
1462	9570	6.55	1.6%	$\pm 10\%$
2339	13.9E	5.96	0.8%	$\pm 10\%$
4584	28.1E	6.14	--	$\pm 10\%$
5659	34.9E	6.17	--	$\pm 10\%$

Table 2. Relative Intrinsic Error

Test Result

The results for the relative intrinsic error do not exceed $\pm 25\%$ over the effective range and consequently, the instrument meets the requirements outlined under IEC 60325 s9.4.

6.2. Variation of Response with Particle Energy

Test Procedure

The instrument's response was determined to various radionuclides with a range of particle energies. The response factor is defined as the ratio of the indicated count rate to the surface activity rate of the source in terms of becquerels per square centimeter. Full results are provided in Table 3. For alpha emitters, the reference radionuclide used was ²⁴¹Am and ³⁶Cl for beta emitters. IEC 60325 requires the instrument's efficiency to be determined in three beta energy bands, the energy bands and the radionuclides utilized are as follows:

- $E_{max} < 0.2 \text{ MeV}$ – ¹⁴C
- E_{max} between 0.2 MeV and 0.5 MeV – ¹⁴⁷Pm and ⁶⁰Co
- $E_{max} > 0.5 \text{ MeV}$ - ³⁶Cl and ⁹⁰Sr/⁹⁰Y

Nuclide	Activity (Bq cm ⁻²)	Instrument Indication (counts s ⁻¹)	Response Factor	Uncertainty
⁹⁰ Sr + ⁹⁰ Y	70.55	277	3.92	±10%
³⁶ Cl	35.84	135	3.78	±10%
⁶⁰ Co	34.62	56	1.63	±10%
¹⁴⁷ Pm	18.65	19.6	1.05	±10%
¹⁴ C	142.64	143	1.00	±10%
²⁴¹ Am	21.57	27.2	1.26	±10%
²³⁸ Pu	21.54	27.9	1.30	±10%

Table 3. Variation of Response with Particle Energy

In addition, the instrument was tested for possible response to ⁵⁵Fe and ¹²⁵I contamination. There was no measurable increase in instrument indication above background for these radionuclides with activities of 86.1 Bq cm⁻² and 25.9 Bq cm⁻² respectively.

6.3. Overload performance

Test Procedure

The instrument was exposed to an approximate equivalent count rate of 400,000 counts s⁻¹ for a period of five minutes. During the test, the instrument provided a satisfactory overload indication and on subsequent reduction of dose rate, the instrument function immediately returned to normal. The overload indication was provided within five seconds of the indication returned on-scale on removal of the activity well within thirty seconds.

Test Result

This instrument satisfies the requirements outlined in IEC 60325 s 5.4.

7. Environmental Tests

7.1. Ambient temperature (IEC 13.5 and 15.1)

Test Procedure

The RAM GENE-1 was inserted into a temperature chamber, from -10 °C to 50°C and the display was monitored throughout the test

Test Result

The RAM GENE-1 displayed the radiation readings throughout the test procedure with results within 10% of the referenced reading at 25°C.

7.2. Battery dependence test

Test Procedure

The RAM GENE-1 was operated with a new 9V alkaline battery and monitored. The instrument was then connected to an external power supply and the voltage was decreased until 6.3VDC.

Test Result

The RAM GENE-1 operated properly for more than 50h under battery power.

With external power supply connected, when the voltage fell below 6.3VDC the instrument initiated a low voltage alarm.

Notes - When operated by battery following the first low voltage alarm the instrument continued working properly for 8 more hours after the first low voltage alarm.

7.3. Drop Test

Requirement

To withstand damage, and continue to operate if dropped from a height of 1 meter onto a hard wooden surface

Test Procedure

The RAM GENE-1 was positioned so that each of the six sides was exposed to the surface, and released from a height of 1 meter onto a hard wooden surface 3 times for each side. The pancake detector was covered with the plastic casing during the test.

Test Result

The RAM GENE-1 continued to work following the drop tests and no damage was observed to the outer casing or inner components of the instrument.

7.4. IP Protection Classification

The RAM GENE-1 is classified as IP-54 with the plastic cap mounted on the pancake detector and IP- 53 with the cap removed from the pancake detector.

7.5. CE Complaint

The RAM GENE-1 is classified as being CE Compliant following tests done at the Israeli Bureau of Standards. A separate report has been supplied.

8. Appendix 1

Full Energy Response Data

Radiation Quantity	Energy (keV)	Normalized Response	Uncertainty
⁶⁰ Co γ -radiation	1250	1.17	$\pm 10\%$
¹³⁷ Cs γ -radiation	662	1.00	$\pm 10\%$
ISO Low series x-radiation	248	0.92	$\pm 10\%$
ISO Low series x-radiation	205	0.93	$\pm 10\%$
ISO Low series x-radiation	161	0.91	$\pm 10\%$
ISO Low series x-radiation	118	0.75	$\pm 10\%$
ISO Low series x-radiation	100	0.74	$\pm 10\%$
ISO Low series x-radiation	83	0.83	$\pm 10\%$
ISO Low series x-radiation	65	0.90	$\pm 10\%$
²⁴¹ Am γ -radiation	59.5	0.94	$\pm 10\%$
ISO Low series x-radiation	48	0.95	$\pm 10\%$
ISO Low series x-radiation	33	0.93	$\pm 10\%$
ISO Low series x-radiation	24.5	0.87	$\pm 10\%$
ISO Low series x-radiation	20.2	0.91	$\pm 10\%$
ISO Low series x-radiation	16.3	0.94	$\pm 10\%$

Appendix 2

Horizontal Polar Response Data, Normalised Responses

Angle	⁶⁰ Co	¹³⁷ Cs	100 keV	²⁴¹ Am	16.3 keV
-45	1.04	0.91	0.63	0.69	0.64
-30	1.08	0.95	0.66	0.77	0.79
-15	1.12	0.99	0.71	0.83	0.87
0	1.13	1.00	0.70	0.78	0.93
+15	1.12	0.99	0.71	0.86	0.89
+30	1.07	0.95	0.71	0.80	0.82
+45	1.04	0.92	0.68	0.70	0.64

Vertical Polar Response Data, Normalized Responses

Angle	⁶⁰ Co	¹³⁷ Cs	100 keV	²⁴¹ Am	16.3 keV
-45	1.01	0.90	0.66	0.71	0.64
-30	1.06	0.94	0.68	0.80	0.81
-15	1.09	0.97	0.72	0.84	0.87
0	1.11	1.00	0.68	0.78	0.89
+15	1.08	0.98	0.70	0.83	0.85
+30	1.03	0.94	0.69	0.82	0.76
+45	1.00	0.90	0.67	0.70	0.59

Appendix 3

Response time results.

Initial Indication	Final Indication	90% Indication	Response Time
BG (<0.2 μSv h ⁻¹)	55.6 μSv h ⁻¹	50.1 μSv h ⁻¹	~ 1 second
BG (<0.2 μSv h ⁻¹)	433 μSv h ⁻¹	390 μSv h ⁻¹	< 2 seconds
BG (<0.2 μSv h ⁻¹)	2668 μSv h ⁻¹	2401 μSv h ⁻¹	< 2 seconds
2668 μSv h ⁻¹	BG (<0.2 μSv h ⁻¹)	266.8 μSv h ⁻¹	< 2 seconds
433 μSv h ⁻¹	BG (<0.2 μSv h ⁻¹)	43.3 μSv h ⁻¹	< 3 seconds
55.6 μSv h ⁻¹	BG (<0.2 μSv h ⁻¹)	5.56 μSv h ⁻¹	< 2 seconds
165 μSv h ⁻¹	1980 μSv h ⁻¹	1799 μSv h ⁻¹	< 2 seconds
1980 μSv h ⁻¹	165 μSv h ⁻¹	346.5 μSv h ⁻¹	< 2 seconds