Centre for Radiation, Chemical and Environmental Hazards

Report 62556 & 59910

Type Test of Sarax Systems RM100/RM2000

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1 INTRODUCTION

The Sarax Systems RM100/RM2000 is a portable survey meter designed to measure x and gamma radiation over an energy range of 16.3 keV to 1.3 MeV in terms of the quantity ambient dose equivalent. The instrument contains a compensated end window Geiger Muller tube powered by two AA batteries with an analogue display. The RM100 is capable of measuring up to 100 µSv h^{-1} and the RM2000 is capable of measuring up to 2000 µSv h^{-1}, this being the only difference between the two models. Below the analogue display are four buttons; on/off, mute/lamp, peak dose, and accrued dose. On start up the instrument will display full scale whilst performing an intelligent battery test and will then give an indication of the battery level; this test takes no longer than 8 seconds to complete and the instrument will then begin operating. For the majority of these tests the RM2000 was used. The serial number of the RM2000 supplied was 008-1110. The serial number of the RM100 supplied was PR002.

Traceability: All the radiation quantities and sources used for the measurements performed in this report conform to the relevant ISO Standards. All the equipment associated with the measurements performed in this report have calibrations directly traceable to national standards via the National Physical Laboratory, PTB or UKAS Accredited calibration facilities

Uncertainties: The uncertainties associated with the measurements performed in this report are expressed at the 95% confidence level. Where applicable, all uncertainties are summed in quadrature.

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Signature of Qualified Person:	Mrs J C McClure
Date:	24 August 2011

2 RELATIVE INTRINSIC ERROR

The instrument's relative intrinsic error was determined over the entire indicated dose equivalent rate range using ^{137}Cs gamma radiation. The instrument indication is the mean of five statistically independent readings. The response factor, defined as the ratio of the indicated dose equivalent rate to the true ambient dose equivalent rate is given in tables 1 and 2.

Table 1. Relative Intrinsic Error- RM2000 s/n 008-1110

Ambient Dose Equivalent Rate	Instrument Indication	Response Factor	Uncertainty
Background	0.00 µSv h^{-1}	---	±30 %
6.173 µSv h^{-1}	5.70 µSv h^{-1}	0.92	±10 %
51.69 µSv h^{-1}	53.0 µSv h^{-1}	1.03	±10 %
556.3 µSv h^{-1}	600 µSv h^{-1}	1.08	±10 %
1033 µSv h^{-1}	1200 µSv h^{-1}	1.16	±10 %

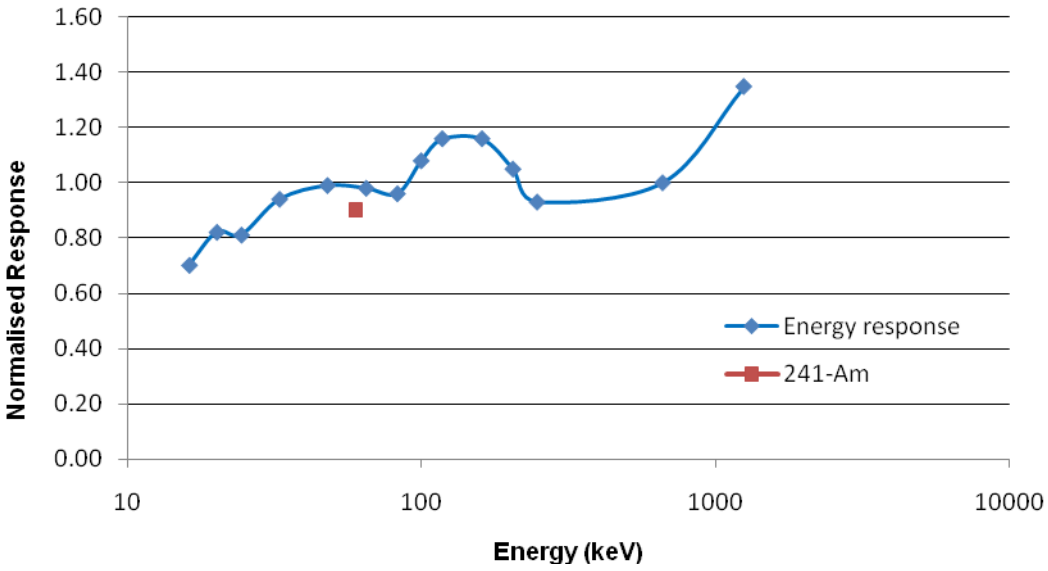
Table 2. Relative Intrinsic Error- RM100 s/n PR002

Ambient Dose Equivalent Rate	Instrument Indication	Response Factor	Uncertainty
Background	0.00 µSv h^{-1}	---	±30 %
2.5 µSv h^{-1}	2.7 µSv h^{-1}	1.08	±10 %
7.5 µSv h^{-1}	8.3 µSv h^{-1}	1.11	±10 %
20 µSv h^{-1}	22 µSv h^{-1}	1.10	±10 %
50 µSv h^{-1}	55 µSv h^{-1}	1.10	±10 %
75 µSv h^{-1}	80 µSv h^{-1}	1.07	±10 %

3 VARIATION OF RESPONSE WITH PHOTON RADIATION ENERGY AND ANGLE OF INCIDENCE

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 Organisation for Standardisation, i.e. the ISO Narrow series of filtered x-radiations. Gamma radiation emitted from ^{241}Am, ^{137}Cs and ^{60}Co sources provided the response to energies 60 keV, 662 keV and 1.25 MeV respectively. 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 normalised to unity for ^{137}Cs (662 keV). This test was performed on the RM2000. The data is presented in Figure 1, full results are provided in Appendix A.

Figure 1. Variation of response with photon radiation energy- Ambient dose equivalent H*(10)



Measurements were performed on the RM2000 to determine the variation of response with angle of incidence using ^{137}Cs, ^{241}Am and 33 keV x radiation. The measurements were performed at angles of incidence up to $\pm 90^{o}$ in two perpendicular planes. Plane 1 being in the normal functional use position, and plane 2, turning the instrument 90° on its side so the radiation is travelling through the instrument's display at positive angles, and through the speaker at negative angles. This data is presented in figure 2 and 3, full measurement results are provided in Appendix B. See Appendix C for diagrams of plane 1 and 2.

Figure 2. Variation of Response with Angle of Incidence- Plane 1

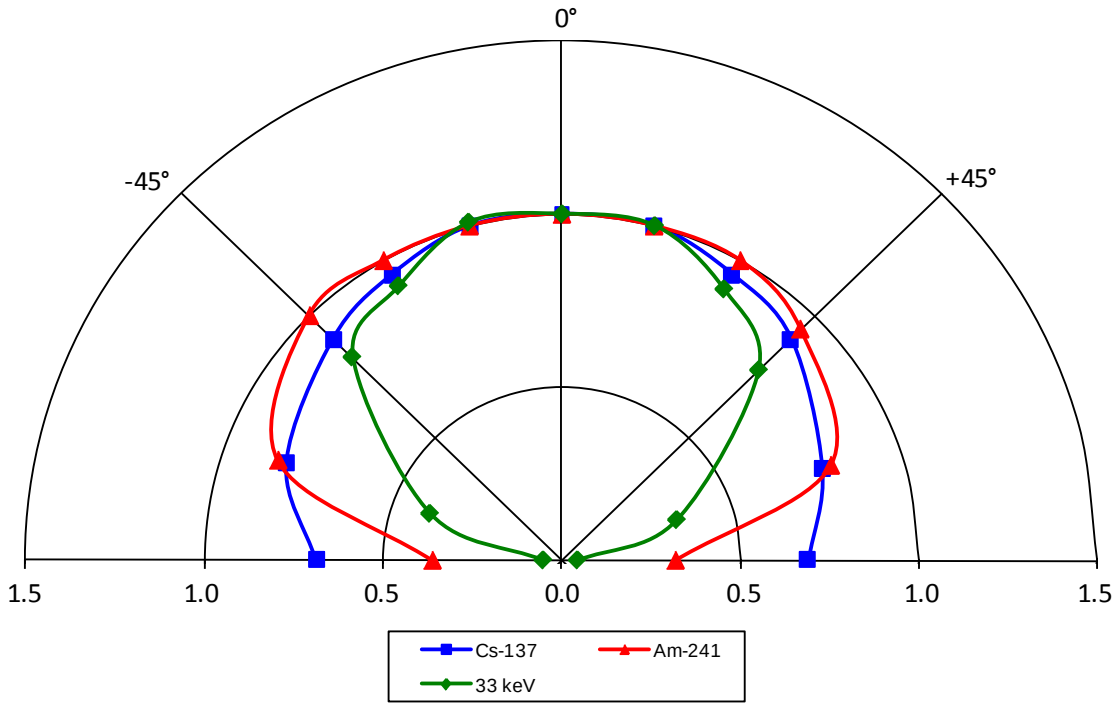
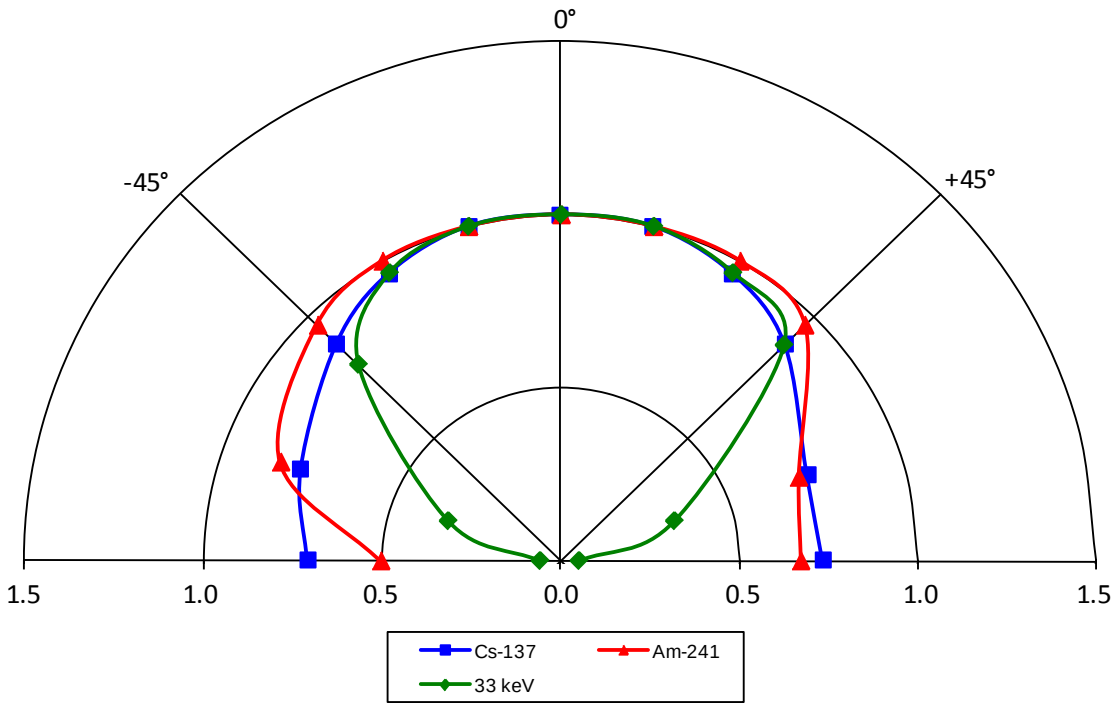


Figure 3. Variation of Response with Angle of Incidence- Plane 2



4 OVERLOAD PERFORMANCE

The RM100 and the RM2000 were exposed to a dose rate field one hundred times the operational range maximum i.e. approximately 10 mSv h^{-1} and 0.2 Sv h^{-1}, where both instruments were exposed for a period of five minutes. Both instruments returned to normal operation immediately after ceasing the overload exposure.

5 RESPONSE TIME

The instrument was firstly exposed to a small ^{137}Cs source to give an instrument indication in each decade, and was then exposed to a greater ^{137}Cs source. The response time was the time taken to indicate 90% of a factor of 10 change in dose rate. This test was repeated five times at the different dose rates to get an average time. This procedure was repeated for decreasing dose rates by a factor of 10, and timing how long it took for the instrument indication to indicate a 10% change in dose rate. This test was performed on the RM2000, see tables 3 and 4 for results.

Table 3. Increasing dose rate response times

Start Dose Rate	End Dose Rate	90% of indicated reading	Average time taken (seconds)
BG	10 µSv h^{-1}	9 µSv h^{-1}	4
10 µSv h^{-1}	100 µSv h^{-1}	90 µSv h^{-1}	3
100 µSv h^{-1}	1000 µSv h^{-1}	900 µSv h^{-}	3

Table 4. Decreasing dose rate response times

Start Dose Rate	End Dose Rate	10% of indicated reading	Average time taken (seconds)
10 µSv h^{-1}	BG	1 µSv h^{-1}	4
100 µSv h^{-1}	10 µSv h^{-1}	10 µSv h^{-1}	4
1000 µSv h^{-1}	100 µSv h^{-1}	100 µSv h^{-}	4

6 POWER SUPPLY

6.1 Battery test function

The RM100 and the RM2000 both use two ‘AA’ cells, IEC type LR6, connected in series to power the instrument. There is no manual battery test function; however on start up the instrument performs an intelligent battery check. If the battery indication is outside the green zone the on/off button light will flash, and the instrument will alarm to warn the user the batteries require replacing.

6.2 Variation in open circuit voltage

This test was conducted with the RM2000 exposed to a radiation field sufficient to cause the instrument to indicate 35 µSv h^{-1}. With a reduction in the supply voltage the instrument continues to operate as normal, until the voltage is reduced to 2.5 volts, where the instrument sounds the low battery warning on start up.

Table 5. Fall in open circuit voltage

Supply Potential (Volts)	Current Drawn (mA)	Radiation Present	Indication (µSv h^{-1})	Comments
3.0	33	Yes	35	Instrument operates as normal.
2.9	33	Yes	35	Instrument operates as normal.
2.8	33	Yes	35	Instrument operates as normal.
2.7	30	Yes	35	Instrument operates as normal.
2.6	30	Yes	35	Instrument operates as normal.
2.5	25	Yes	35	Instrument sounded the low battery warning on start up.
2.4	20	Yes	35	Instrument sounded the low battery warning on start up.

6.3 Variation in series resistance

Similar tests were performed using a supply potential of 3.0 volts, but varying the series resistance. This would occur in the case of poor battery contact or contact corrosion.

Table 6. Rise in series resistance

Series Resistance (Ohms)	Supply Potential (Volts)	Radiation Present	Indication ($\mu Sv\ h^{-1}$)	Comments
0	3.0	Yes	35	Instrument operates as normal.
1	3.0	Yes	35	Instrument operates as normal.
2	3.0	Yes	35	Instrument operates as normal.
3	3.0	Yes	--	Instrument fails to turn on.

APPENDIX A

Variation of response with photon radiation energy

Variation of response with photon radiation energy:

Radiation Quantity	Energy (keV)	Normalised Response	Uncertainty
^{60}Co γ-radiation	1250	1.35	±10 %
^{137}Cs γ-radiation	662	1.00	±10 %
ISO Narrow series x-radiation	248	0.93	±10 %
ISO Narrow series x-radiation	205	1.05	±10 %
ISO Narrow series x-radiation	161	1.16	±10 %
ISO Narrow series x-radiation	118	1.16	±10 %
ISO Narrow series x-radiation	100	1.08	±10 %
ISO Narrow series x-radiation	83	0.96	±10 %
ISO Narrow series x-radiation	65	0.98	±10 %
^{241}Am γ-radiation	59.5	0.90	±10 %
ISO Narrow series x-radiation	48	0.99	±10 %
ISO Narrow series x-radiation	33	0.94	±10 %
ISO Narrow series x-radiation	24.5	0.81	±10 %
ISO Narrow series x-radiation	20.2	0.82	±10 %
ISO Narrow series x-radiation	16.3	0.70	±10 %

APPENDIX B

Variation of response with incident angle

Variation of response with incident angle:

Radiation Quality	Angle of Incidence	Normalised Response	Uncertainty
^{137}Cs (662 keV)	0° Plane 1	1.00	±10%
^{137}Cs (662 keV)	+15° Plane 1	1.00	±10%
^{137}Cs (662 keV)	-15° Plane 1	1.00	±10%
^{137}Cs (662 keV)	+30° Plane 1	0.95	±10%
^{137}Cs (662 keV)	-30° Plane 1	0.95	±10%
^{137}Cs (662 keV)	+45° Plane 1	0.91	±10%
^{137}Cs (662 keV)	-45° Plane 1	0.91	±10%
^{137}Cs (662 keV)	+70 ° Plane 1	0.77	±10%
^{137}Cs (662 keV)	-70 ° Plane 1	0.82	±10%
^{137}Cs (662 keV)	+90 ° Plane 1	0.69	±10%
^{137}Cs (662 keV)	-90 ° Plane 1	0.69	±10%
^{137}Cs (662 keV)	0° Plane 2	1.00	±10%
^{137}Cs (662 keV)	+15° Plane 2	1.00	±10%
^{137}Cs (662 keV)	-15° Plane 2	1.00	±10%
^{137}Cs (662 keV)	+30° Plane 2	0.96	±10%
^{137}Cs (662 keV)	-30° Plane 2	0.96	±10%
^{137}Cs (662 keV)	+45° Plane 2	0.89	±10%
^{137}Cs (662 keV)	-45° Plane 2	0.89	±10%
^{137}Cs (662 keV)	+70 ° Plane 2	0.74	±10%
^{137}Cs (662 keV)	-70 ° Plane 2	0.77	±10%
^{137}Cs (662 keV)	+90 ° Plane 2	0.74	±10%
^{137}Cs (662 keV)	-90 ° Plane 2	0.71	±10%

Variation of response with incident angle continued:

Radiation Quality	Angle of Incidence	Normalised Response	Uncertainty
^{241}Am (59.5 keV)	0° Plane 1	1.00	±10%
^{241}Am (59.5 keV)	+15° Plane 1	1.00	±10%
^{241}Am (59.5 keV)	-15° Plane 1	1.00	±10%
^{241}Am (59.5 keV)	+30° Plane 1	1.00	±10%
^{241}Am (59.5 keV)	-30° Plane 1	1.00	±10%
^{241}Am (59.5 keV)	+45° Plane 1	0.95	±10%
^{241}Am (59.5 keV)	-45° Plane 1	1.00	±10%
^{241}Am (59.5 keV)	+70 ° Plane 1	0.80	±10%
^{241}Am (59.5 keV)	-70 ° Plane 1	0.85	±10%
^{241}Am (59.5 keV)	+90 ° Plane 1	0.32	±10%
^{241}Am (59.5 keV)	-90 ° Plane 1	0.36	±10%
^{241}Am (59.5 keV)	0° Plane 2	1.00	±10%
^{241}Am (59.5 keV)	+15° Plane 2	1.00	±10%
^{241}Am (59.5 keV)	-15° Plane 2	1.00	±10%
^{241}Am (59.5 keV)	+30° Plane 2	1.00	±10%
^{241}Am (59.5 keV)	-30° Plane 2	1.00	±10%
^{241}Am (59.5 keV)	+45° Plane 2	0.96	±10%
^{241}Am (59.5 keV)	-45° Plane 2	0.96	±10%
^{241}Am (59.5 keV)	+70 ° Plane 2	0.71	±10%
^{241}Am (59.5 keV)	-70 ° Plane 2	0.83	±10%
^{241}Am (59.5 keV)	+90 ° Plane 2	0.67	±10%
^{241}Am (59.5 keV)	-90 ° Plane 2	0.50	±10%

Variation of response with incident angle continued:

Radiation Quality	Angle of Incidence	Normalised Response	Uncertainty
33 keV	0° Plane 1	1.00	±10%
33 keV	+15° Plane 1	1.00	±10%
33 keV	-15° Plane 1	1.01	±10%
33 keV	+30° Plane 1	0.90	±10%
33 keV	-30° Plane 1	0.91	±10%
33 keV	+45° Plane 1	0.78	±10%
33 keV	-45° Plane 1	0.83	±10%
33 keV	+70 ° Plane 1	0.34	±10%
33 keV	-70 ° Plane 1	0.39	±10%
33 keV	+90 ° Plane 1	0.04	±10%
33 keV	-90 ° Plane 1	0.05	±10%
33 keV	0° Plane 2	1.00	±10%
33 keV	+15° Plane 2	1.00	±10%
33 keV	-15° Plane 2	1.00	±10%
33 keV	+30° Plane 2	0.96	±10%
33 keV	-30° Plane 2	0.96	±10%
33 keV	+45° Plane 2	0.88	±10%
33 keV	-45° Plane 2	0.80	±10%
33 keV	+70 ° Plane 2	0.34	±10%
33 keV	-70 ° Plane 2	0.34	±10%
33 keV	+90 ° Plane 2	0.05	±10%
33 keV	-90 ° Plane 2	0.06	±10%

APPENDIX C

Diagram of plane 1

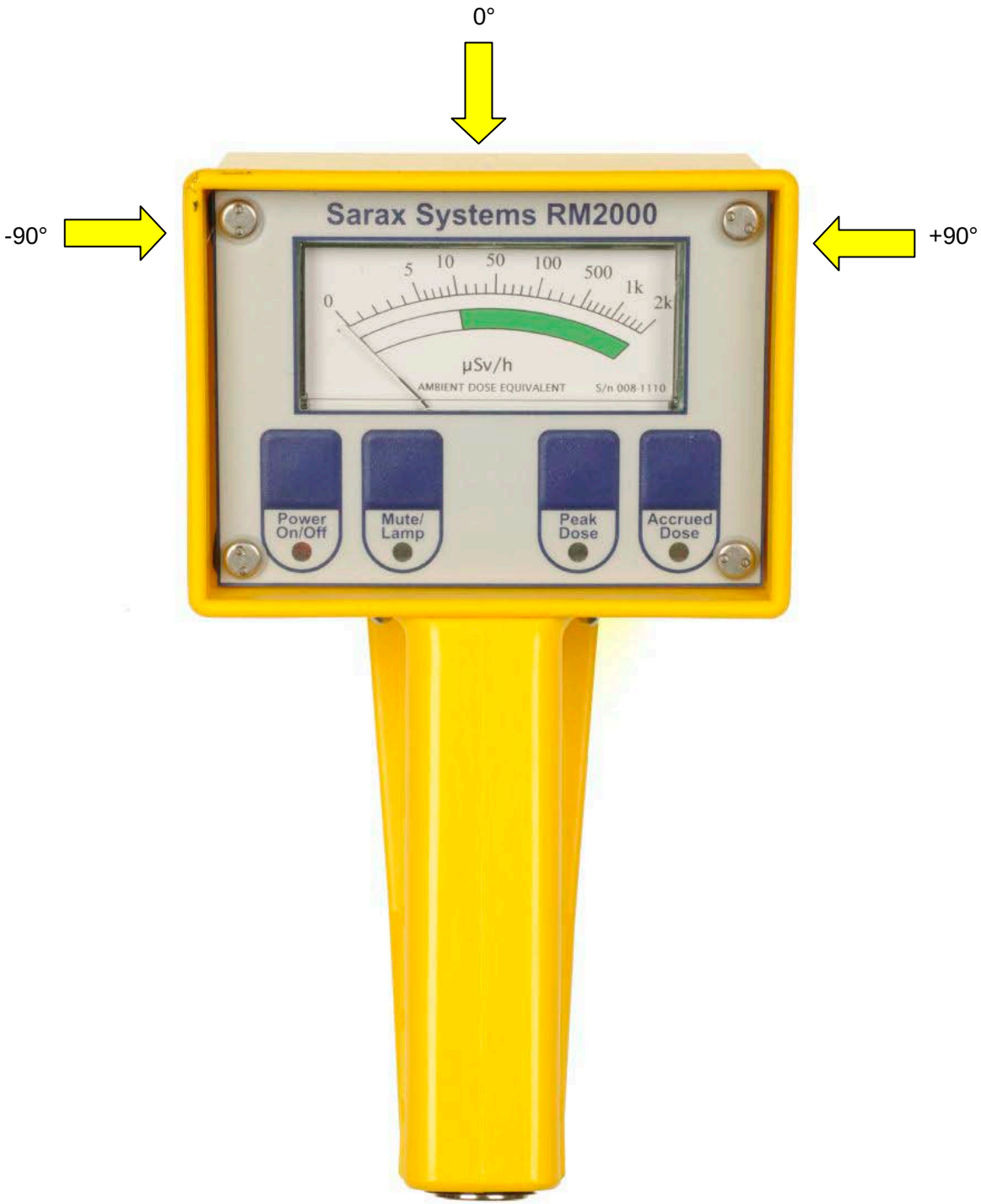


Diagram of plane 2