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Second IRMF Intercomparison of Calibrations of Portable Gamma-ray Dose-rate Monitors 1995 - 1996

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ABSTRACT

The Ionising Radiations Metrology Forum (IRMF) organised a second intercomparison of calibrations of gamma-ray dose-rate monitors in which sixteen establishments in the UK participated. The exercise involved the circulation of four gamma-ray monitors for calibration in the fields produced using ^{137}Cs, ^{60}Co and ^{241}Am. The instruments used were an NE Technology PDM1B, a Mini-Instruments Mini-Rad (1000R), a Mini-Instruments Mini-900 with 44A Probe and a Siemens Electronic Personal Dosemeter.

All results were submitted to the authors for analysis. Responses relative to 'true' air-kerma rate, as stated by the individual participants, were calculated. The results, reported anonymously, are compared and demonstrate generally satisfactory agreement between establishments.

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CONTENTS

		Page
1	INTRODUCTION	1
2	PARTICIPANTS	1
3	PROTOCOL	2
4	RADIATION FIELDS	2
5	INSTRUMENTATION	2
6	MEASUREMENTS	4
7	INFORMATION REPORTED BY PARTICIPANTS	4
8	ANALYSIS OF RESULTS	5
9	OBSERVATIONS	6
10	CONCLUSIONS	7
11	ACKNOWLEDGEMENTS	7
12	REFERENCES	8

APPENDICES

APPENDIX 1:	PARTICIPANTS	9

TABLES

Table 1	Check source and background measurements	10
Table 2	Measurement of integrated dose	11
Figure 1	Results for ^{137}Cs calibrations of PDM1B	12
Figure 2	Results for ^{60}Co calibrations of PDM1B	13
Figure 3	Results for ^{241}Am calibrations of PDM1B	14
Figure 4	Results for ^{137}Cs calibrations of Mini-Rad (1000R)	15

Figure 5	Results for ^{60}Co calibrations of Mini-Rad (1000R)	16
Figure 6	Results for ^{241}Am calibrations of Mini-Rad (1000R)	17
Figure 7	Results for ^{137}Cs calibrations of Mini 900/44A	18
Figure 8	Results for ^{137}Cs calibrations of EPD; free-in-air	19
Figure 9	Results for ^{137}Cs calibrations of EPD; on-phantom	20

ANNEXES

ANNEX 1	**PROTOCOL**	21

1. INTRODUCTION

One of the main aims of the Ionising Radiations Metrology Forum (IRMF) is to encourage good practice in radiological measurements, including the need for traceability to the national standards, through the organisation of regular intercomparisons. Following the completion of the first IRMF intercomparison of calibrations of hand-held gamma-ray dose-rate monitors [1] (McClure and Hunt, 1994) the IRMF organised a second intercomparison which was carried out during 1995 and 1996. As before, the main objective was to assess the ability of calibration laboratories to perform routine calibrations of survey instruments in pursuance of Regulation 24 of the Ionising Radiations Regulations 1985 [2].

The intercomparison involved the circulation of four radiation protection monitors for participants to calibrate at three gamma-ray energies and at a number of dose rates. The participants restricted their measurements to the gamma fields and dose-rates normally used for routine instrument calibrations, employing the same methods to calibrate the four transfer instruments as were routinely used within their organisation. Three of the monitors were area survey monitors; the fourth was an electronic personal dosemeter.

The calibration quantity for this intercomparison was **air kerma**. Participants still using exposure as the quantity of interest were asked to include the value(s) of the factor(s) used to convert exposure to air kerma. All results were reported to the authors on a standard form for analysis and collation.

The intercomparison was planned by D R McClure (NRPB) and the then Secretary of the IRMF (J B Hunt, NPL) in consultation with the participants. The bulk of the analysis was undertaken by the present Secretary of the IRMF (V E Lewis, NPL), who was not involved in any of the calibrations carried out at NPL. Instrumentation matters were referred to and dealt with by D R McClure at NRPB.

With more instruments, more participants and a greater range of measurements than in the first IRMF intercomparison the programme took correspondingly longer to complete. The exercise started in May 1995 and took about a year for all measurements to be completed. The analysis, consultation and discussion of results took a further six months.

2. PARTICIPANTS

The sixteen establishments participating in the intercomparison are listed in Appendix 1 in alphabetical order.

Prior to the intercomparison it had been decided that participants would not be allowed to withdraw results, but the policy on confidentiality for publication of the report had not been agreed. The issue of whether or not to reveal which calibration results belonged to which participants was discussed by IRMF members later.

On one hand, it was felt that participants would be discouraged from taking part in future exercises and those who were seen to be out of line with the general consensus would suffer a commercial disadvantage; the IRMF intercomparisons should not be seen as measures of performance or being meant to show who gave the "right" result, but as a way of improving the performance of individual laboratories. On the other hand, there were strong views that participants should be prepared to stand by their results and prove that they were competent; potential clients should be allowed to judge this for themselves. Since there were objections by some participants it was agreed that the ownership of the reported results in the intercomparison should not be identified in any published report.

3. PROTOCOL

A comprehensive protocol for the comparison was produced by D R McClure and J B Hunt, in consultation with the participants. This provided guidance and included pro forma for reporting various information and the results of measurements to the organisers. The main text along with the diagrams showing the orientations of the monitors and examples of the pro-forma for reporting results are reproduced in Annex 1.

Instructions are given for mounting and operating the instruments correctly. Deviation from the preferred orientation was discouraged unless if it was physically impossible to achieve such an orientation in the facility used.

The preferred ("target") dose-rates, stated in terms of the reading to be achieved by each instrument for a given monitor range, are given for each instrument for each gamma-field.

4. RADIATION FIELDS

Three types of gamma-ray fields, based on ^{60}Co, ^{137}Cs and ^{241}Am sources, were used by participants. In all, a range of gamma-ray air kerma rates from about 1 μGy h^{-1} to 70 mGy h^{-1} was covered. There were several selected rates for each radionuclide/monitor combination; the minimum and maximum specified rates varied from one to another (see Section 5 below). The use of ^{241}Am was normally restricted to lower dose rates.

All sixteen participants reported results based on ^{137}Cs fields. Ten participants also used ^{60}Co fields. All ^{137}Cs and ^{60}Co sources were capsular. Twelve of the ^{137}Cs and ten of the ^{60}Co sources were collimated. The collimated beams were very similar geometrically; the beam diameter at one metre distance was generally in the range 16 cm to 22 cm and the minimum and maximum beam diameters at this distance were 14 cm and 38 cm respectively.

All sixteen participants reported results based on ^{241}Am fields. Twelve of the ^{241}Am sources were planar and four were capsular. All but five (four planar and one capsular) were collimated. The collimated beams varied considerably geometrically; the beam diameter at one metre distance ranged from 14 cm to 133 cm.

All participants reported traceability of their air kerma rates to national standards. Some establishments had used transfer instruments calibrated by other participants to achieve traceability.

Most calibration room sizes were fairly similar; the average dimensions being about 7 m (length) x 3 m (width) x 3 m (height). The smallest room was 5 m x 1.5 m x 3 m and the largest was 9 m x 4 m x 8 m.

5. INSTRUMENTATION

Four fundamentally different types of routinely-used gamma-ray dose monitor, described below, were used as transfer instruments. The electronics were in some cases deliberately off-set so that their readings did not necessarily correspond to the true value of the incident radiation field, to prevent the prediction of results at higher dose rates.

In order to have a realistic and meaningful exercise, the participants were asked to employ the same methods to calibrate the four transfer instruments as were routinely used within their organisation.

5.1 Gamma monitor PDM1B

The model PDM1B had been used in the first IRMF intercomparison and would provide a link between that and the present exercise. It is a portable ionisation chamber manufactured by NE Technology†. This is open to the air and therefore required relatively small pressure and temperature corrections. The build-up shutter had to be closed for the ^{60}Co and ^{137}Cs sources and opened for the lower energy ^{241}Am source. In addition to a linear scale and five dose-rate ranges, it has two dose ranges that facilitate its operation in an integrating mode.

The preferred dose-rates for the comparison were 2.5 μSv h^{-1}, 7.5 μSv h^{-1} and 70 μSv h^{-1} for ^{241}Am; and ranged from 2.5 μSv h^{-1} to 70 mSv h^{-1} for ^{137}Cs and ^{60}Co. In addition, an integrated measurement to an instrument reading of about 4 μSv was specified at an air kerma rate of about 70 μSv h^{-1}, with the instrument set on the 0 - 5 μSv range.

5.2 Gamma monitor Mini-Rad (1000R).

The Mini-Rad (1000R) monitor was chosen because it was a widely-used type of dosemeter and had been used in an IPEM intercomparison involving hospitals. It is manufactured by Mini-Instruments Ltd††, and is based on an energy-compensated Geiger-Müller counter. This has a different energy response characteristic from that of the PDM1B below about 60 keV.

The preferred dose-rates were 2.5 μSv h^{-1}, 7.5 μSv h^{-1} and 30 μSv h^{-1} for ^{241}Am; and ranged from 2.5 μSv h^{-1} to 300 μSv h^{-1} for ^{137}Cs and ^{60}Co. In addition, two further dose rates in the instrument ranges 10 - 100 μSv h^{-1} and 100 - 1K μSv h^{-1} were selected by individual participants with a view to providing useful calibration data.

5.3 Gamma monitor Mini-900 with 44A probe.

The Mini-900/44A, also manufactured by Mini-Instruments Ltd, was included because it has an enhanced response to lower-energy gammas and would therefore be sensitive to scattered photons in the fields used by participants.

Calibrations were carried out using ^{137}Cs sources only, with air kerma rates ranging from 0.3 μGy h^{-1} to 30 μGy h^{-1}.

5.4 Electronic personal dosemeter (EPD).

The EPD, manufactured by Siemens†††, had been introduced in order to include calibrations of personal dosemeters on- and off-phantom. The EPD displayed the total integrated dose in μSv (H_p). Before use, the EPD was tested by each participant by placing it in the test jig with the check source and measuring the time taken to increment an indicated H_p dose of 50 μSv.

Calibrations were carried out in ^{137}Cs fields at a target incident air kerma rate of 70 μGy h^{-1} and at a second air kerma rate set by the participant to a dosemeter incremental dose equivalent reading of 200 μSv.

Participants were able to choose whether to irradiate the dosemeter on or off the face of a suitable water-filled phantom.

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† NE Technology Ltd, Bath Road, Reading, Berkshire

†† Mini-Instruments Ltd, 15 Burnham Business Park, Springfield Road, Burnham-on-Crouch, Essex

††† Siemens Environmental Systems Ltd, Sopers Lane, Poole, Dorset

6. MEASUREMENTS

The transfer instruments, together with their check source jigs, were collected and packaged at NRPB and sent first to AEA Technology, Winfrith for calibration. This exercise was used to check the suitability of the protocol.

Participants were asked to immediately confirm the correct operation of each instrument by making measurements using the check source and positioning jig provided. This was repeated upon completion of the intercomparison measurements. The measured values were compared with the expected readings as provided in the Protocol by the organisers and suspected malfunctions were reported back to NRPB.

Participants were asked to measure the background response for each monitor in each field before any calibration measurements were carried out.

For the calibration measurements participants were asked to record instrument readings uncorrected for background on the Pro-forma provided.

7. INFORMATION REPORTED BY PARTICIPANTS

7.1 Check source and background measurements

Participants supplied details of check source measurements for each instrument. Results of the background measurements were also reported.

7.2 Calibration measurements

The measured data, uncorrected for background, temperature and pressure corrections, were reported together with details of the uncertainties. Two uncertainties were reported; the first was the uncertainty associated with the derivation of the true air kerma rates used for the calibration measurements, and the second was that associated with the recorded instrument readings.

7.3 Ambient conditions

The ambient conditions, i.e., temperature and pressure during measurements, were reported in order to enable the organisers to apply a correction factor to the results for the PDM1B monitor.

7.4 Participant's facilities

Participants were asked to supply the following details of their facilities -

7.4.1 Sources and traceability;

- sources geometries,
- basis of the calibration,
- traceability to national standards.

7.4.2 Collimation;

- primary beam diameter at one metre from the source,
- minimum beam diameter used in the measurements,
- associated minimum source-to-instrument separation distance.

Details of the sources and their collimation are given in Section 4 above.

7.4.3 Exposure room;

approximate dimensions of the exposure room,
source height above floor and distance from walls,
source - instrument separation distance,
wall material.

7.5 Ambient dose equivalent conversion factors

Participants were asked to state the values used for the air kerma to ambient dose equivalent conversion factors for each source, if the calibration factor was to be expressed in terms of ambient dose equivalent. All quoted a conversion coefficient of 1.74 Sv Gy^{-1} for ^{241}Am and 1.20 Sv Gy^{-1} for ^{137}Cs, as recommended by ICRU 47 [3], BCRU [4] and UKAS [5]. For ^{60}Co most participants used a value of 1.15 Sv Gy^{-1} as recommended by UKAS [5]; three participants used 1.16 Sv Gy^{-1} as recommended by BCRU [4] and ICRU 47.

The EPD report asked in addition for details of the quantity in which results would normally be reported for a personal dosemeter, together with the conversion factor used to convert from air kerma to that calibration quantity for ^{137}Cs gamma-rays. Some participants did not calibrate personal dosemeters routinely, others used ambient dose equivalent with a conversion factor of 1.20 Sv Gy^{-1} whilst others used personal dose equivalent with a conversion factor of 1.21 Sv Gy^{-1}.

8. ANALYSIS OF RESULTS

Participants were asked to send copies of the completed pro-forma report forms, including the additional information, to both co-ordinators within four weeks from completion of their measurements. The results were analysed at NPL and tables of calibration factors produced.

Some obvious discrepancies were found and investigated by the NPL co-ordinator and most were found to be due to misunderstandings, omissions or careless reporting on the part of the participants concerned, rather than to experimental techniques. Examples included -

a) a participant quoted kerma rate as being in $\mu Sv.h^{-1}$ when the units used were $\mu Gy.h^{-1}$;
b) two participants quoted kerma rate in terms of $\mu Sv.h^{-1}$;
c) several participants did not indicate what units they had used for kerma rate;
d) a participant quoted the value of the ^{137}Cs kerma to dose equivalent conversion factor as that for ^{60}Co and vice versa;
e) a participant quoted the results for one monitor in place of those for another.

The above are not necessarily indicative of errors that occur in routine calibration work.

Furthermore, several sets of results for measurements made for the integrating mode were incomplete (either the time taken to acquire integrated dose or the value of the integrated dose was omitted). In addition, several participants operated at some air kerma rates that were in the region of the values quoted for the target instrument reading instead of operating the instruments at positions that gave the target instrument readings. The co-ordinators included all the results after verifying what the participants had actually meant to report.

A summary of the results in graphical form was distributed to all participants prior to holding a wash-up meeting, attended by eleven participants, to discuss the results, make observations and agree conclusions to be drawn from the comparison. No values were changed and no results were withdrawn - those shown in the present report are the original. Participants agreed that no further work on this exercise would be carried out. The results were discussed at a full meeting of the IRMF in April 1997.

9. OBSERVATIONS

The check source and background measurement results are given in table 1. The standard deviations (given in parentheses) of the check source values are generally reasonable; there are two or three values outside two standard deviations.

The results for the dose rate measurements are summarised in figures 1 to 9 in which response, expressed in Sv Gy^{-1} (except for Mini 900/44A), is plotted against instrument reading. For improved clarity, the participants are divided into two groups of eight for most of the figures. The results are identified by letters. These do not correspond to the same order as the list of participants given in Appendix 1. Uncertainties are not shown, partly for reasons of clarity, but also because some are considered to be unrealistic. The scales used for the plots have been chosen to give optimum clarity and vary considerably from one monitor to another.

For reasons of clarity the figures do not contain the results for the PDM1B integrated dose measurements; these are given in table 2.

9.1 PDM1B

Good consistency was obtained with ^{137}Cs apart from a problem at low dose rate experienced by one participant (measurements for higher rates, made using another facility, were consistent with the norm) and low results reported by a participant who had of necessity used the monitor upside down because of geometrical limitations. (Further tests carried out at NRPB did not account for all of the apparent difference.) Otherwise the consistency was about ±16%. Apart from one unexplained value, the results from the integrated dose measurements are consistent with the dose rate measurements.

The better consistency observed for the ^{60}Co (about ±10%) is due partly to the lesser number of participants. These laboratories also had better consistency for ^{137}Cs than the other participants whose results showed greater variation. An outlying value was traced to a source problem.

The ^{241}Am results show much greater variation. The high values observed by one participant might be due to their being made using a higher range than used by other laboratories, but this seems unlikely. The results observed by the participant who used the monitor upside down are again low, but the magnitude of this effect is considered to be insufficient to explain why those values were much lower than the norm.

These results do not appear to be quite as close as in the previous intercomparison. It was suggested that this was possibly due to the longer time that the PDM1B was in circulation, but measurements made at NRPB at the beginning, during and at the end of the intercomparison demonstrated good stability and performance. If there is a greater spread, this is probably due to the greater number of participants.

9.2 Mini-Rad 1000R

Although there is a change of response with dose rate due to the non-linearity artificially introduced which complicates comparison, the results for the MiniRad 1000R appear to be generally consistent. The ^{137}Cs calibrations have good consistency (about ±16%) except for one outlier. Consistency is slightly better for the calibrations made with ^{60}Co, due perhaps to there being fewer participants. There is no difference in the shapes of the characteristics for ^{137}Cs and ^{60}Co over the common range of dose rate.

The variations seen with ^{241}Am calibrations (a factor of two between maximum and minimum response values) are larger than expected. These trends are common to both the MiniRad 1000R and the PDMB1.

9.3 Mini-900 / 44A

The large variation in the values obtained for the Mini-900/44A (calibrated using only ^{137}Cs) was expected on account of its sensitivity to lower energy photons and is was an indication of the different scattering conditions, from one laboratory to another due, for example, to collimation effects. It has been suggested that the use of lead absorbers to vary the dose rate could also have had an effect, but only one participant recorded the use of such absorbers. Some step changes in the results of individual establishments were known to be due to source changes. There was general consistency within the uncertainties estimated by most participants.

9.4 EPD

The EPD was calibrated with ^{137}Cs both on-phantom and (mainly) off-phantom. Water-filled Perspex phantoms were generally used; the type of phantom appeared to have little effect.

The consistency was good. The measurement made for an unsuitably low dose was affected by the nature of the integer display and the measurement technique used, and should be disregarded. The mean difference of 5% between the on- and off-phantom results is what was expected due to the effect of backscatter.

10. CONCLUSIONS

Although some of the results look fairly dramatic, the overall accuracy is generally satisfactory and shows that users could meet the requirements of HS(G)49. Some of the observed inconsistencies are known to be due to low energy radiation produced by scattering effects.

It was felt that some of the reported uncertainties were unrealistically good.

Participants agreed that the intercomparison was useful and that it is desirable to hold such exercises about every three years. These should be as wide-ranging as possible regarding participation, but simpler regarding the range of measurements to be carried out.

As a separate exercise, it is planned to circulate an EPD continuously. A summary of results would be maintained by the co-ordinator on a rolling basis.

11 ACKNOWLEDGEMENTS

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The organisers and participants are grateful to NE Technology, Mini-Instruments and Siemens for the loan of the instruments.

The authors wish to thank Tim Daniels (NRPB) for producing the figures.

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APPENDIX 1: PARTICIPANTS

(In alphabetical order)

AEA Technology (Harwell Laboratory),	Harwell	R Bosley
AEA Technology (Winfrith Laboratory),	Winfrith	J Simpson
British Nuclear Fuels plc,	Sellafield	A P Dalton
Defence Radiological Protection Service,	Gosport	J T B Bennett
Defence Radiological Standards Centre,	AWE Aldermaston	J Wardle
Johnson Controls (Procord),	Dounreay	D Mackensie
Magnox Electric plc,	Berkeley	M Pottinger
NE Technology Ltd,	Beenham	M Renouf
National Physical Laboratory,	Teddington	T T Williams
National Radiological Protection Board,	Chilton	D R McClure
Northern Ireland Radiation Protection Service,	Belfast	P Loan
Radiation Protection Service, University of Leeds,	Leeds	A G Richards
Radiation Protection Service, Velindre Hospital,	Cardiff	D W Thomas
Regional Radiation Physics & Protection Service,	Birmingham	D Peach
Royal Naval College,	Greenwich	R Manson
St Thomas' Hospital,	London	S Batchelor

Table 1 **Check source and background measurements**

	PDM1B			Mini-RAD		Mini-900			EPD
	Source ($mSv.h^{-1}$)	Bkgd ($mSv.h^{-1}$)	Source corrected	Source ($mSv.h^{-1}$)	Bkgd ($mSv.h^{-1}$)	Source (s^{-1})	Bkgd (s^{-1})	Source corrected	Time for 50 mSv (s)
A	7.9	0.25	7.65	47	0.3	180	35	145	943
B	9.0	0.8	8.2	45	0.2	200	10	190	912
C	8.25	0.35	7.9	45.5	0.2	172	5	167	929
D	7.9	0.5	7.4	45	0.2	190	4	186	912
E	8.25	0.25	8.0	45	0.2	180	6	174	1042
F	8.4	0.25	8.15	43	0.2	190	9	181	935
G	8.2	0.0	8.2	45	0.1	200	13	187	931
H	8.25	0.2	8.05	45	0.3	186	5	181	926
J	8.3	0.2	8.1	49	0.3	190	6	184	1000
K	8.25	0.25	8.0	47	0.25	200	13	187	933
L	8.85	1.0	7.85	45	0.3	190	17	173	904
M	8.1	0.05	8.05	47	0.2	182	8	174	904
N	8.1	0.6	7.5	45	0.2	182	6	176	1000
P	8.1	0.1	8.0	49.4	0.15	190	8	182	935
Q	8.3	0.2	8.1	45	0.2	190	8	182	935
R	8.25	0.25	8.0	45	0.5	180	6	174	971
MEAN	-----	-----	7.95 (25)	45.8 (1.7)	-----	-----	-----	178 (11)	945 (39)

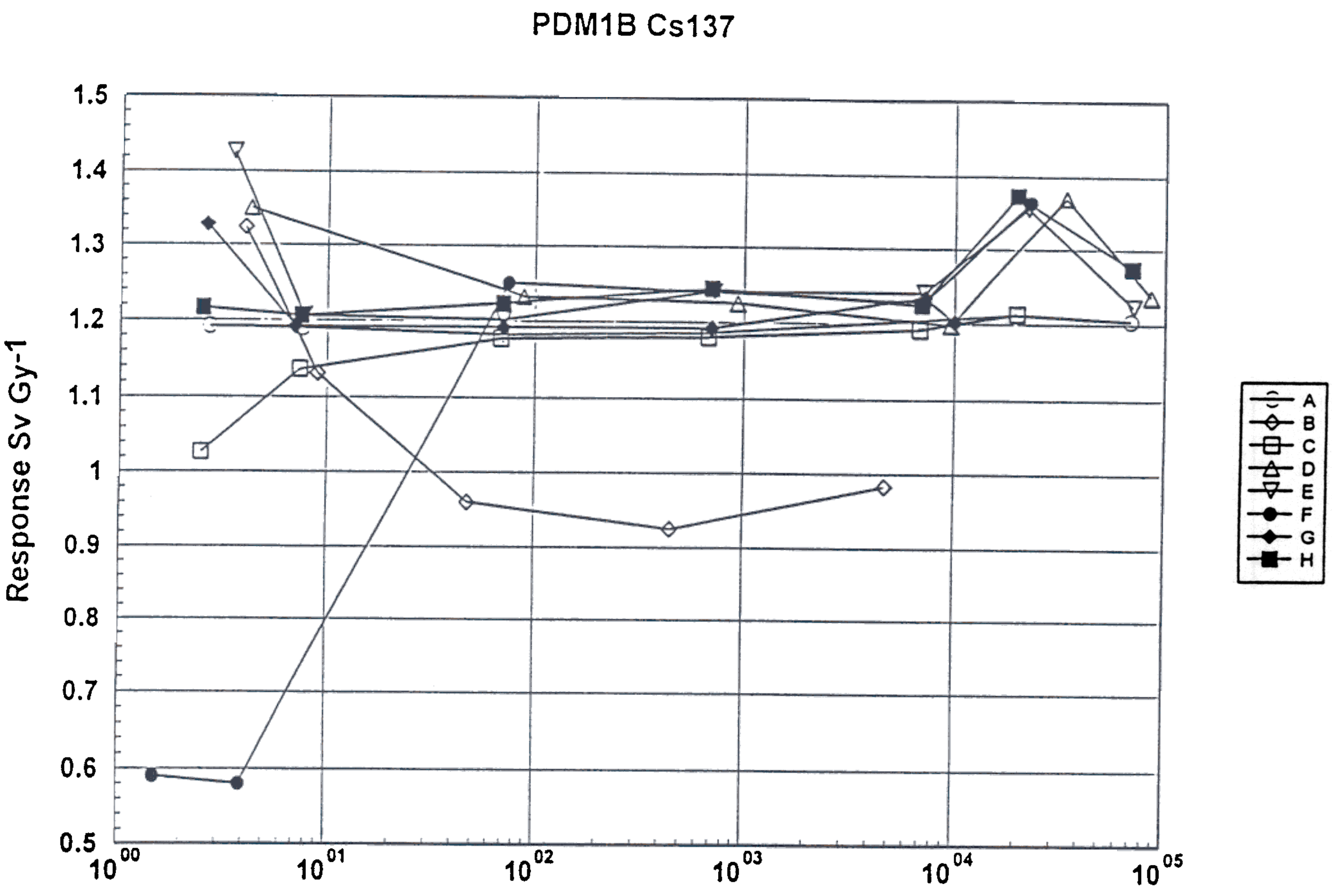
Table 2 **PDM1B calibrations from measurements of integrated dose**

	Cs-137			Co-60			Am-241		
Participant	True rate (μGy.h^{-1})	Response (dose)	Response (dose rate)	True rate (μGy.h^{-1})	Response (dose)	Response (dose rate)	True rate (μGy.h^{-1})	Response (dose)	Response (dose rate)
A	58	1.31	1.18	217	1.40	1.20	40	1.89	1.73
B	48	(2.25)	(0.96)	---	---	---	50	1.21	1.02
C	58	1.25	1.18	---	---	---	---	---	---
D	70	1.32	1.23	71.1	1.27	1.19	64	1.68	1.35
E	58	1.43	1.20	---	---	---	40	1.83	1.49
F	58	1.30	1.25	61	1.24	1.20	40	1.77	1.71
G	70	1.33	1.19	---	---	---	70	1.29	1.66
H	58	1.26	1.22	---	---	---	40	1.72	1.64
J	58	1.23	1.20	---	---	---	40	1.61	1.56
K	59	1.27	1.21	61	1.25	1.18	43	1.93	1.65
L	40	1.40	1.17	---	---	---	47	1.61	1.47
M	70	1.34	1.22	70	1.40	1.26	70	1.43	1.33
N	78	1.22	1.22	---	---	---	---	---	---
P	55	1.29	1.25	60	1.26	1.21	39	1.71	1.61
Q	70	1.32	1.21	70	1.26	1.18	70	1.39	1.37
R	58	1.28	1.22	---	---	---	97	1.65	1.49
MEAN		1.30 ± 0.06	1.21 ± 0.03		1.30 ± 0.07	1.20 ± 0.03		1.62 ± 0.22	1.51 ± 0.19

Response quoted in Sv.Gy^{-1}

Values in parentheses are excluded from calculation of means and standard deviations

Response (dose) - value obtained from measurement of integrated dose
Response (dose rate) - value obtained from measurement of dose rate



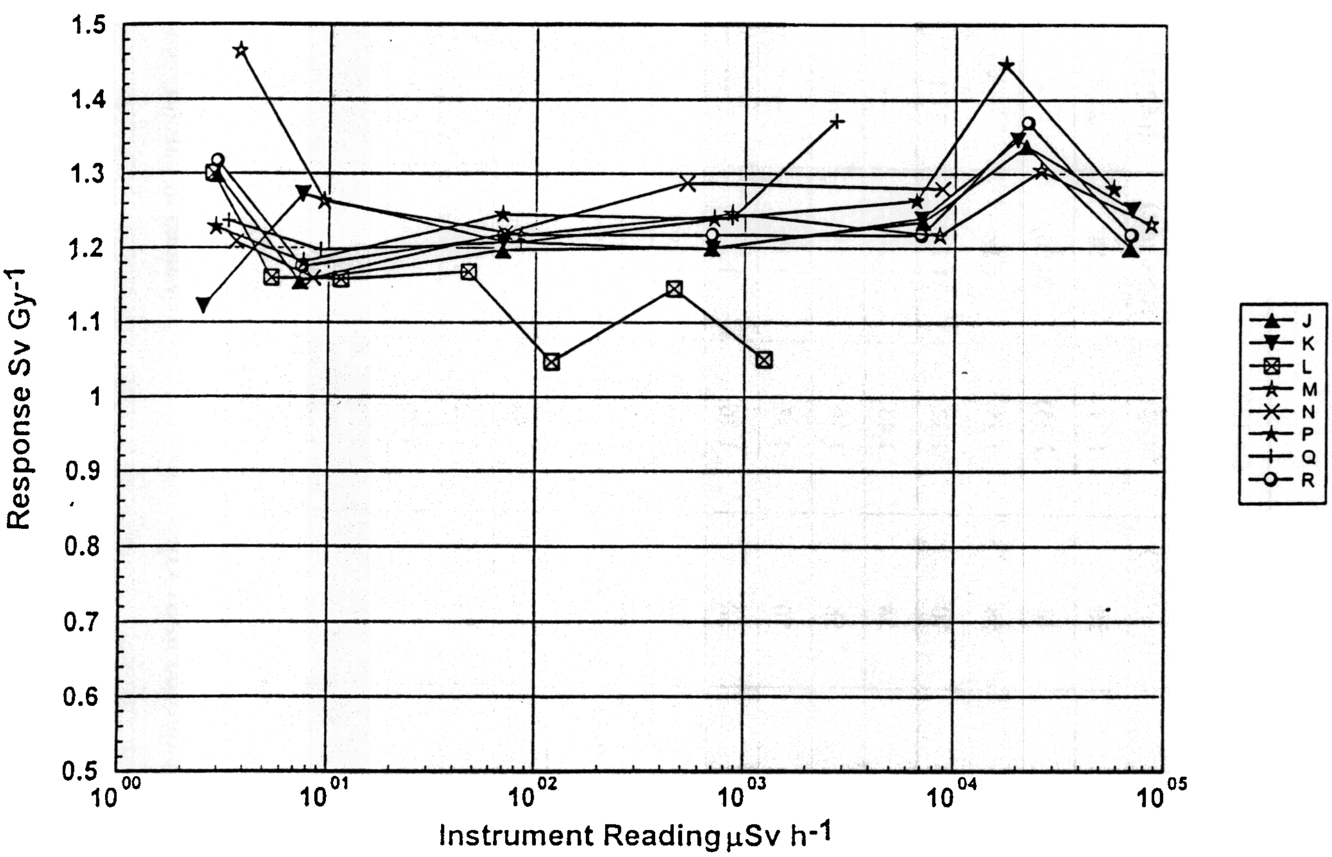


Figure 1 **Results for ^{137}Cs calibrations of PDM1B**

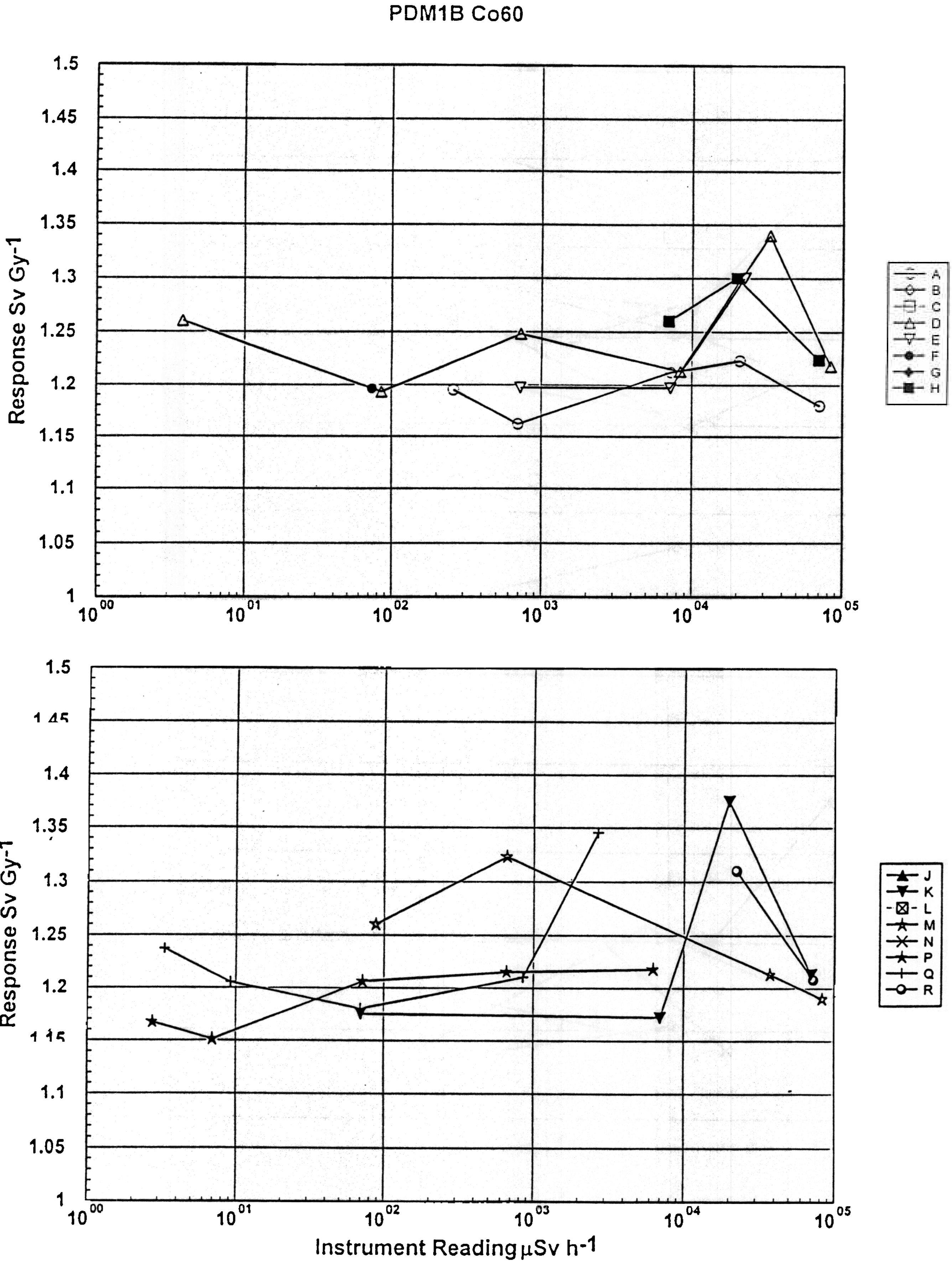


Figure 2 **Results for ^{60}Co calibrations of PDM1B**

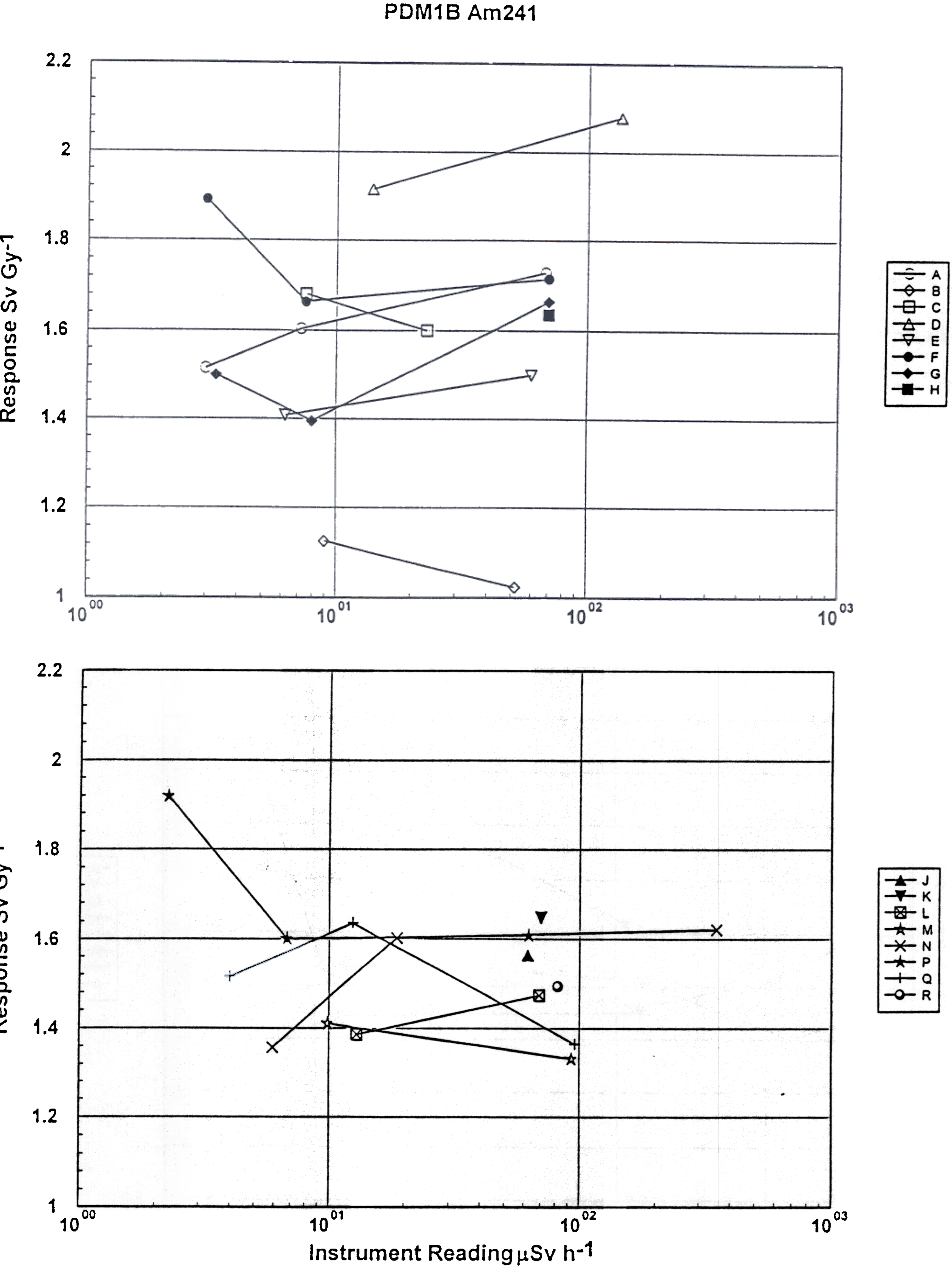


Figure 3 **Results for ^{241}Am calibrations of PDM1B**

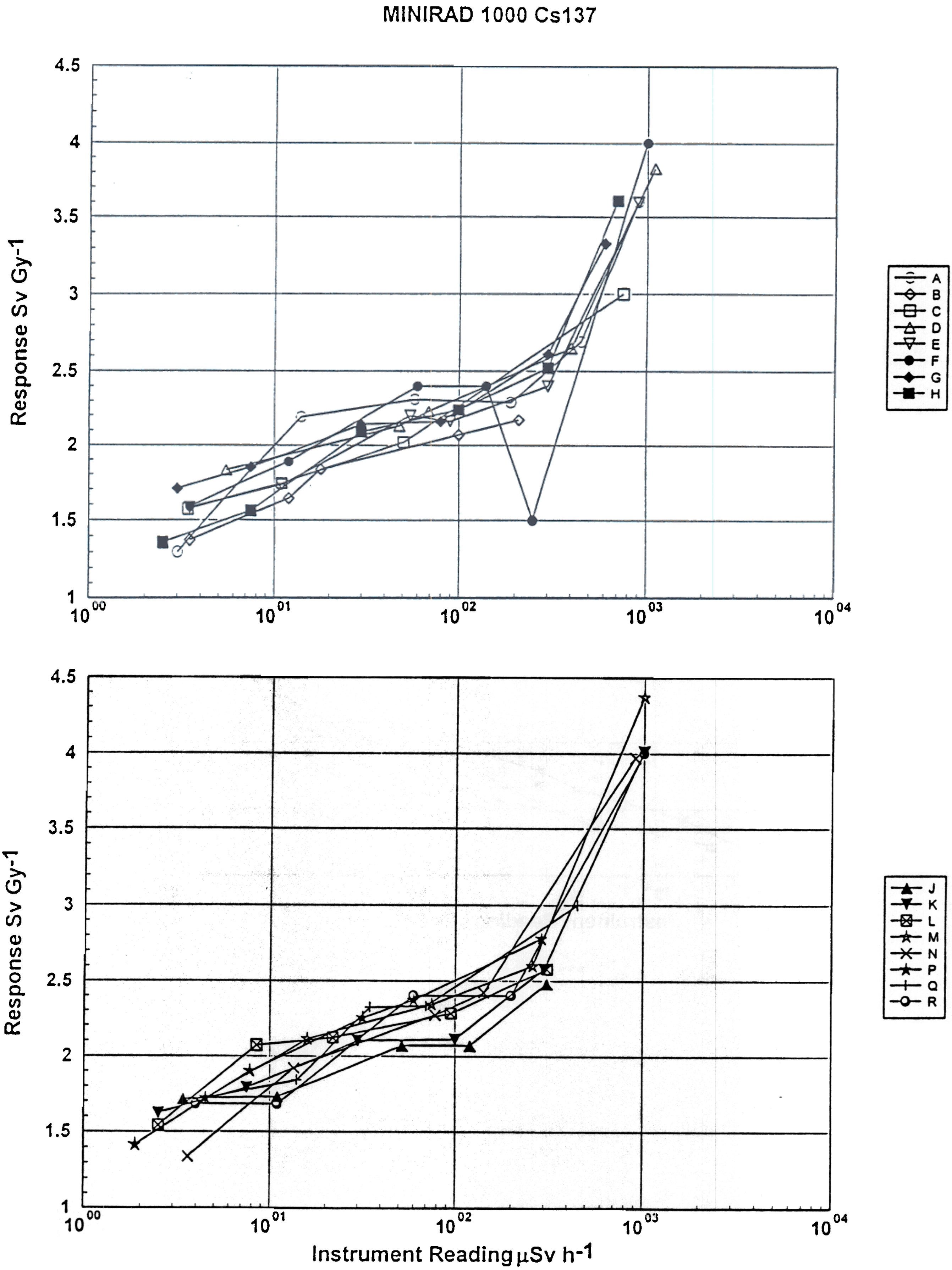


Figure 4 **Results for ^{137}Cs calibrations of Mini-Rad (1000R)**

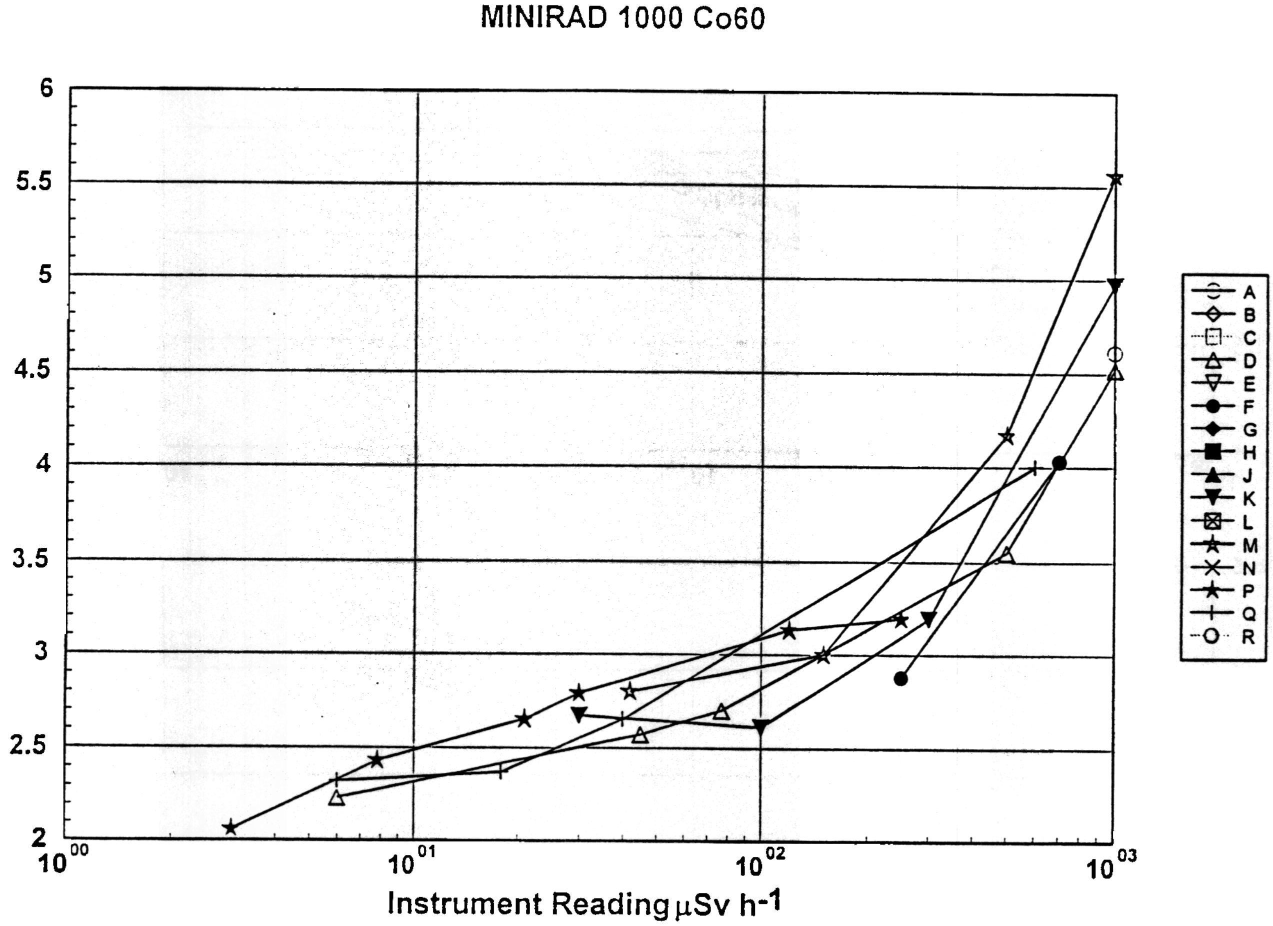


Figure 5 Results for ^{60}Co calibrations of Mini-Rad (1000R)

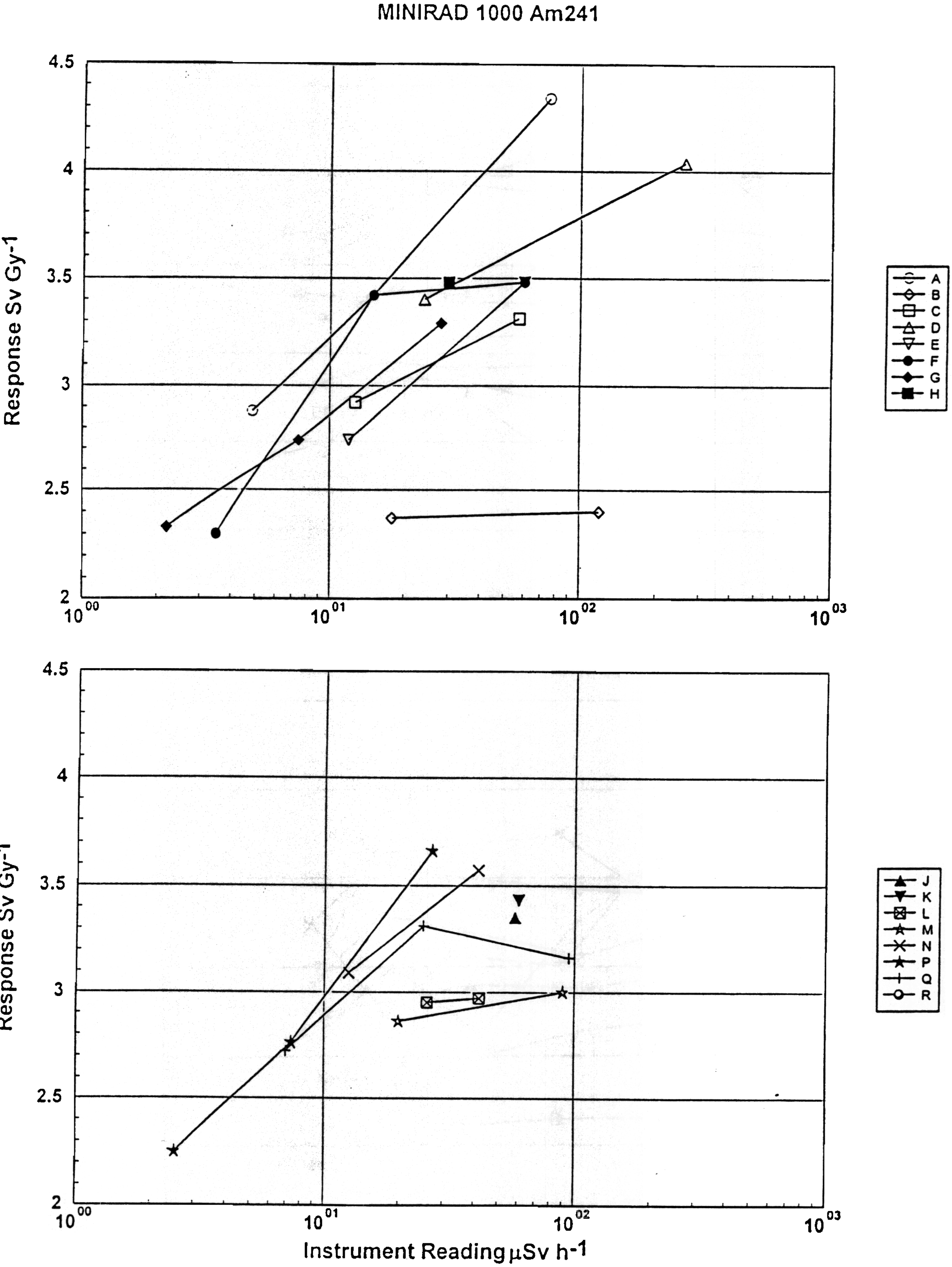
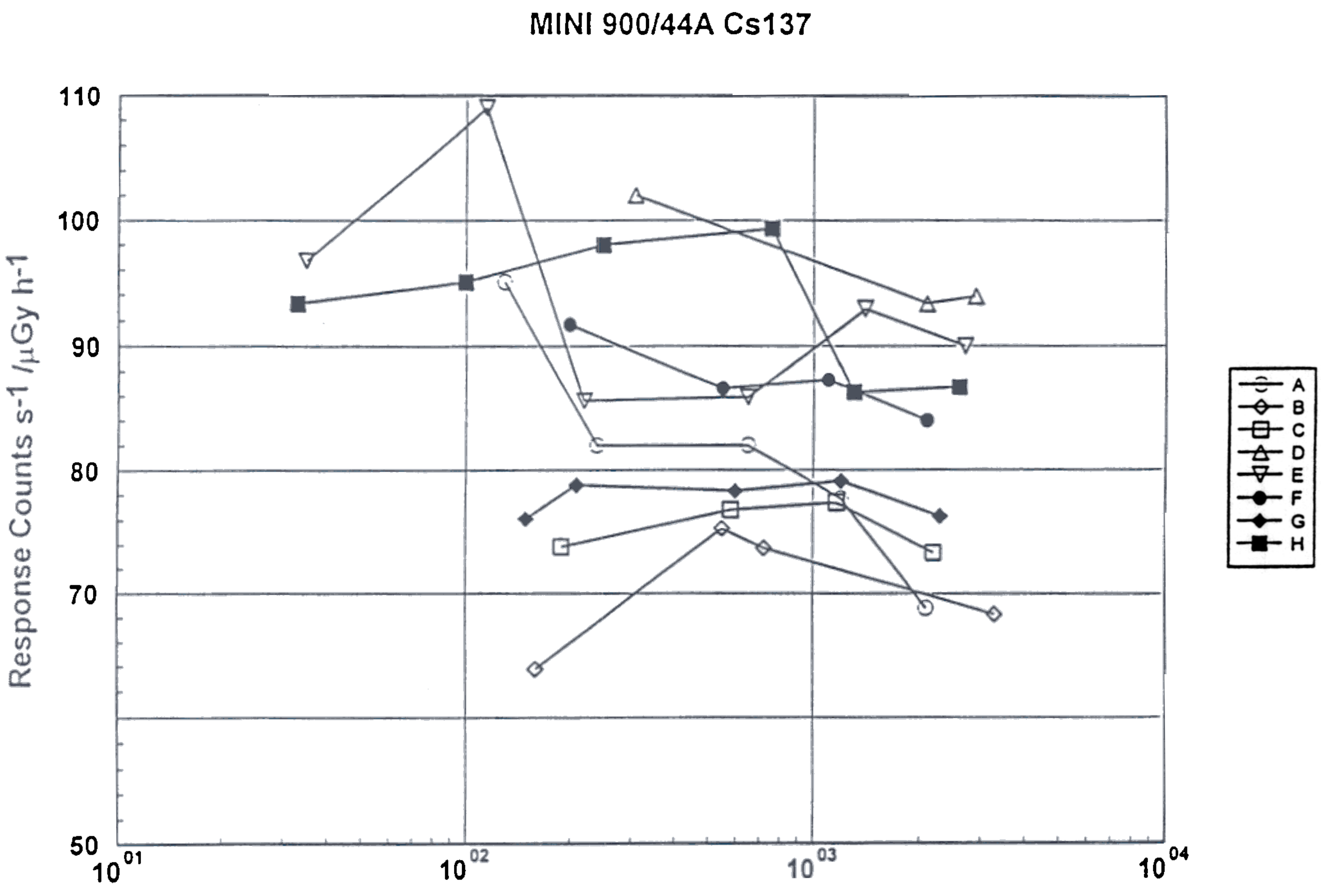


Figure 6 **Results for ^{241}Am calibrations of Mini-Rad (1000R)**



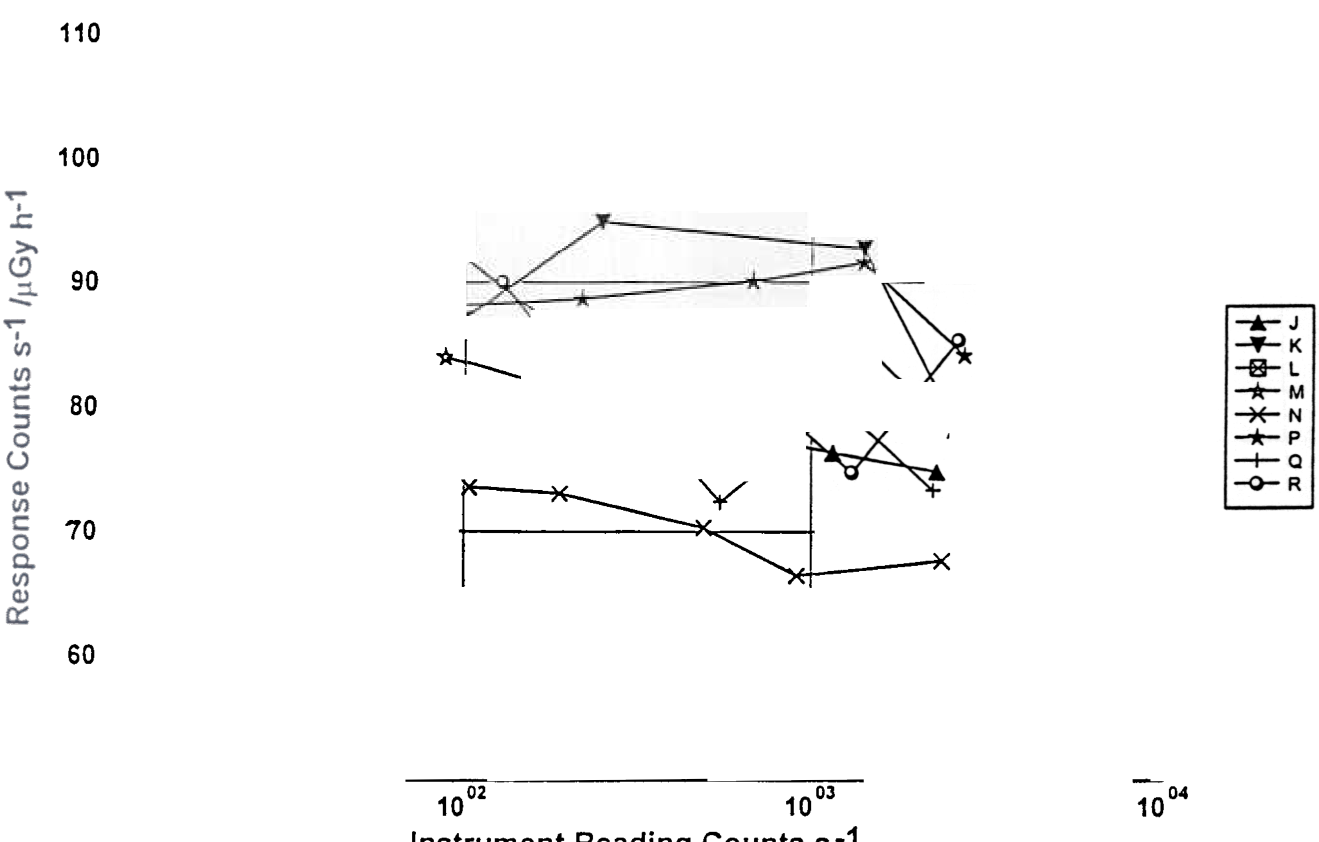


Figure 7 **Results for ^{137}Cs calibrations of Mini 900 / 44A**

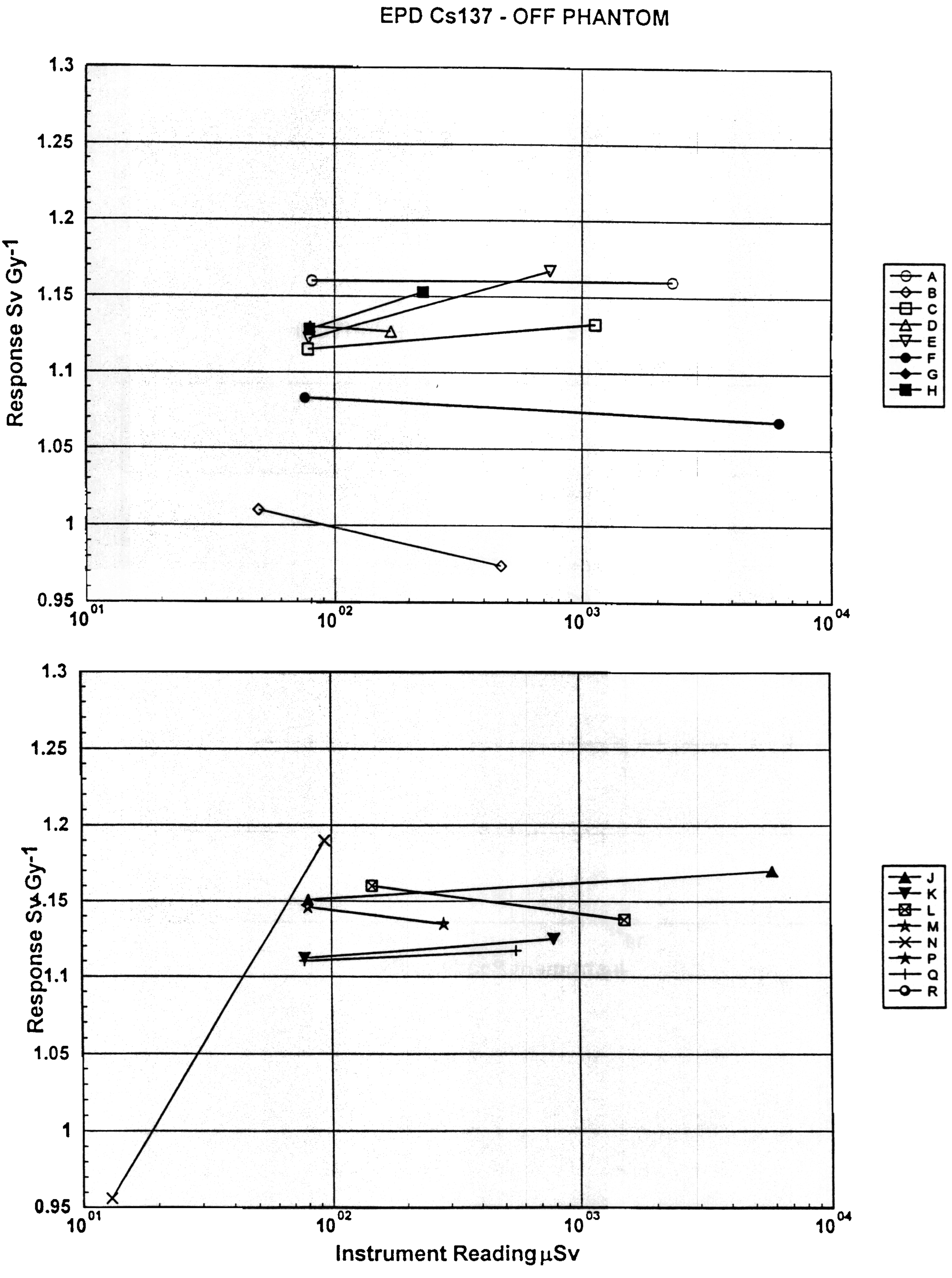


Figure 8 **Results for ^{137}Cs calibrations of EPD free-in-air**

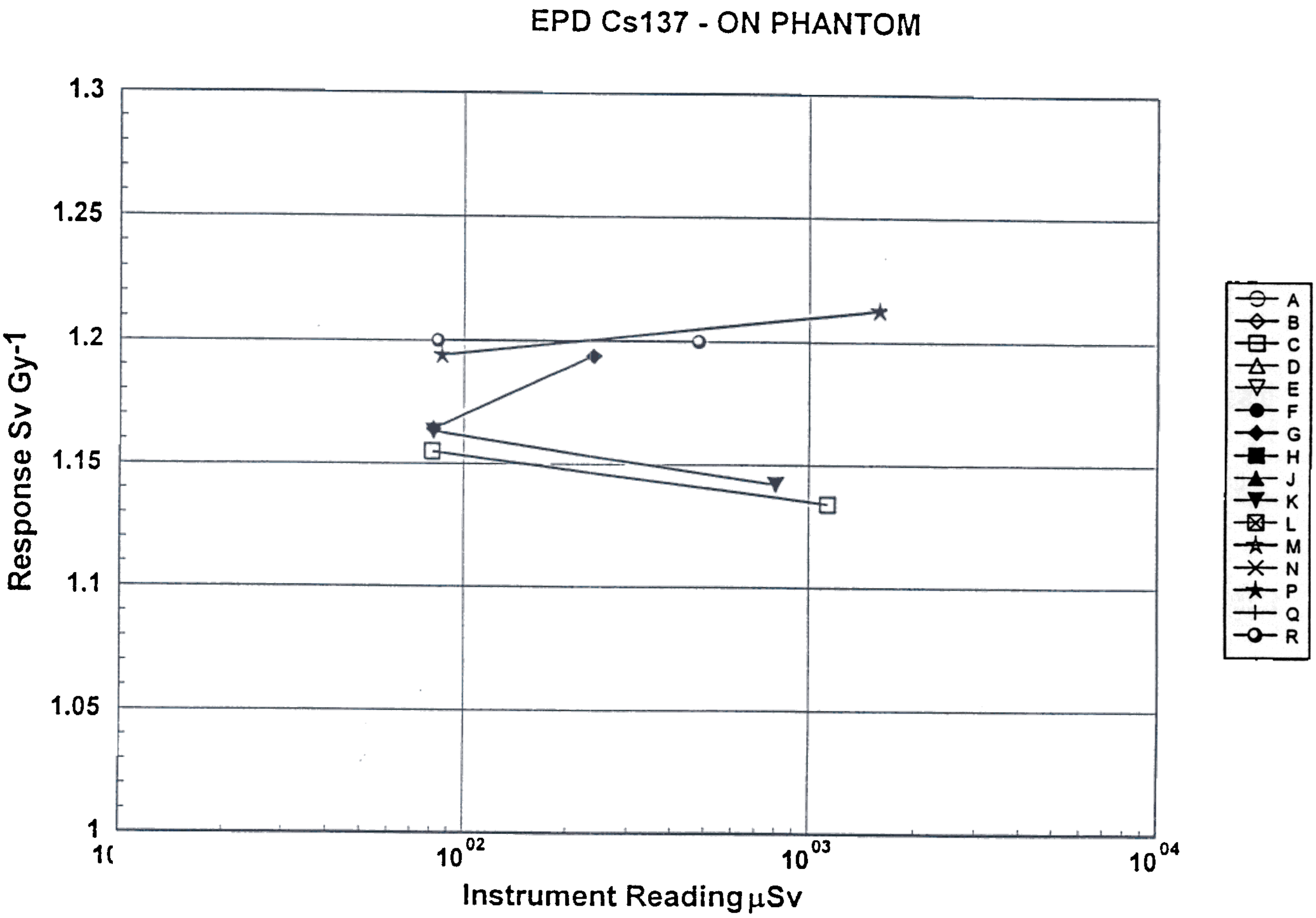


Figure 9 **Results for ^{137}Cs calibrations of EPD on-phantom**

ANNEX PROTOCOL

The following extracts of the Protocol are shown overleaf -

a) Introduction, notes and questionnaire

b) Diagrams showing calibration orientations for all instruments

c) Samples of results pro forma

SECOND IRMF INTERCOMPARISON OF CALIBRATIONS OF PORTABLE GAMMA-RAY DOSE-RATE MONITORS USED FOR AREA MONITORING

1. Introduction

Following the successful completion of the first Ionising Radiations Metrology Forum (IRMF) intercomparison of calibrations of hand-held gamma-ray dose-rate monitors it has been agreed that the IRMF will organise a second intercomparison to be carried out during 1995 and early 1996. As before, the aim of the intercomparison is to increase confidence in the ability of the participants to perform such calibrations and to highlight the need for traceability of such measurements to the national primary standard of air kerma.

The intercomparison involves the circulation of four radiation protection monitoring instruments whose electronics may have been deliberately off-set in order that their readings do not necessarily correspond to the true value of the incident radiation field. For a realistic and meaningful exercise it is essential that participants employ exactly the same techniques and methods to calibrate the four transfer instruments as routinely used within their organisation - the intercomparison is not a research project.

The protocol embraces the use of three radiation sources, ^{60}Co, ^{137}Cs and ^{241}Am gamma-ray sources. The use of ^{241}Am is normally restricted to confirming the energy response at one dose rate only; participants should make measurements as appropriate within the instrument range. The range of gamma-ray air kerma rates covered is from about 1 µGy h^{-1} to 70 mGy h^{-1}. However, it is emphasised that participants should restrict their measurements to the sources and dose-rates normally used in-house for routine instrument calibrations.

The quantity of interest for this intercomparison is **AIR KERMA**. Participants who still use the quantity exposure must include the value(s) of the conversion factor(s) used to convert exposure to air kerma, and a brief description of how the particular value(s) was derived.

2. Organisation of the intercomparison

It is intended to carry out the intercomparison during the period May to December 1995. The transfer instruments, together with their check source jigs, will be collected and packaged at NRPB (Duncan McClure) and sent first to AEA Technology, Winfrith for calibration. This exercise will also be used to check the suitability of the protocol. It is intended to send the set of transfer instruments to each participant over successive weekends, i.e., despatch Friday afternoon from one participant to the next ready for use the following Monday morning. The intention is for a minimum of three participants to complete their measurements each calendar month. Participants are advised to use the following carrier:

SECURICOR OMEGA EXPRESS
RADIAC DEPARTMENT
TECHNO 2
HUGHENDEN AVENUE
HIGH WYCOMBE
BUCKINGHAMSHIRE HP13 5SG

Telephone: 01494 472727 Extn 22
Ask for: Ron Hatcher or Steve Lloyd

and to complete the shipping form as per the attached example (obviously information such as Consignor, Consignee, telephone numbers and dates will be different each time). Participants will have to pay £50 towards the costs of the intercomparison (cheques should be paid payable to the Department of Trade and Industry, marked 'IRMF Intercomparison' on the back, and sent to Dr Julian Hunt, Division of Radiation Science and Acoustics, National Physical Laboratory, Teddington, Middlesex).

3. Transfer instruments

The following instruments are being used as transfer instruments for this intercomparison:

(a) **Gamma monitor PDM1B.** As stated above, the instrument scale readings may have been offset, so participants should not be surprised if the instrument does not indicate the incident dose equivalent rate. A user's manual is in the shipping case with the instrument. The check source jig for the instrument is also in the case.

Before use, the instrument should be tested using the check source jig supplied. It should be placed into the appropriate side of the jig (which is already labelled for each instrument) with the slide **CLOSED** and the window adjacent to the marked source position. Note the black slide guard rails are a snug fit in the sides of the jig and the front face of the instrument must be pushed in contact with the back face of the jig. The instrument should read (on the 0 - 10 μSv h^{-1} range):

8.2 μSv h^{-1} after subtracting background and applying temperature and pressure correction

If the reading is different from this value by more than ± 5%, please contact Duncan McClure (NRPB - 01235 822738 (Direct)) for advice. You will be advised to either return the instrument to the manufacturer, to NRPB or to AEA Technology, Winfrith. Check source measurements should be carried out before and upon completion of the intercomparison measurements for each gamma-ray source.

The instrument should be mounted as shown in the attached diagram, i.e., vertically with its 'base' facing the radiation source. The beam axis should be aligned with the marks on the instrument case. This is the preferred orientation and you should only deviate from it if it is physically impossible to achieve such an orientation in your facility. Any deviations should be noted on the appropriate diagram and returned with the relevant measurement Pro-forma. The build-up shutter should be **closed** for both the ^{60}Co and ^{137}Cs sources and should be **opened** for the low energy ^{241}Am source. A 'background' (BG) measurement should also be made with the instrument set on the 0 - 10 μSv h^{-1} range prior to any calibration intercomparison measurements.

Calibrations should be carried out on the following instrument ranges, using the attached Pro-forma to record your results:

^{241}Am source

0 - 10 µSv h^{-1};	target instrument reading:	≈ 2.5 µSv h^{-1}
0 - 10 µSv h^{-1};	target instrument reading:	≈ 7.5 µSv h^{-1}
0 - 100 µSv h^{-1};	target instrument reading:	≈ 70 µSv h^{-1}

^{137}Cs source

0 - 10 µSv h^{-1};	target instrument reading:	≈ 2.5 µSv h^{-1}.
0 - 10 µSv h^{-1};	target instrument reading:	≈ 7.5 µSv h^{-1}.
0 - 100 µSv h^{-1};	target instrument reading:	≈ 70 µSv h^{-1}.
0 - 1 mSv h^{-1};	target instrument reading:	≈ 0.7 mSv h^{-1}.
0 - 10 mSv h^{-1};	target instrument reading:	≈ 7 mSv h^{-1}.
0 - 100 mSv h^{-1};	target instrument reading:	≈ 20 mSv h^{-1}.
0 - 100 mSv h^{-1};	target instrument reading:	≈ 70 mSv h^{-1}.

^{60}Co source

0 - 10 µSv h^{-1};	target instrument reading:	≈ 2.5 µSv h^{-1}.
0 - 10 µSv h^{-1};	target instrument reading:	≈ 7.5 µSv h^{-1}.
0 - 100 µSv h^{-1};	target instrument reading:	≈ 70 µSv h^{-1}.
0 - 1 mSv h^{-1};	target instrument reading:	≈ 0.7 mSv h^{-1}.
0 - 10 mSv h^{-1};	target instrument reading:	≈ 7 mSv h^{-1}.
0 - 100 mSv h^{-1};	target instrument reading:	≈ 20 mSv h^{-1}.
0 - 100 mSv h^{-1};	target instrument reading:	≈ 70 mSv h^{-1}.

Instrument readings should <u>not</u> be corrected for background; participants are only required to record instrument readings on the Pro-forma. An estimate of the uncertainty associated with each reading, estimated at the 95% confidence level, should be entered in the column headed 'Un' on the Pro-forma.

An integrate measurement should be carried out at an incident air kerma rate of ≈ 70 µSv h^{-1}, to a target integrated instrument reading of ≈ 4 µSv, with the instrument set on the 0 - 5 µSv range.

The measurement Pro-forma includes all the above details, for each source respectively.

(b) **<u>Gamma monitor MINI-RAD (1000R).</u>** As stated above, the instrument scale readings may have been offset, so participants should not be surprised if the instrument does not indicate the incident dose equivalent rate. A user's manual is in the shipping case with the instrument. The check source jig for the instrument is also in the case.

Before use, the instrument should be tested using the check source jig supplied. It should be placed into the appropriate side of the jig (which is labelled). This is the same side as that used for the NE PDM1B. The front feet of the MINI-RAD fit into the two large holes in the base of the jig. The two rear feet and the rear of the instrument overhang the front of the jig. In this position the instrument sits on the three additional rubber feet fitted to the base of the jig; please take care not to disturb these rubber feet.

The instrument should read (on the 10 - 100 µSv h^{-1} decade):

<u>45 µSv h^{-1}</u>, <u>after subtracting background</u>

If the reading is different from this value by more than ± 5%, please contact Duncan McClure (NRPB - 01235 822738 (Direct)) for advice. You will be advised to either return the instrument to the manufacturer, to NRPB or to AEA Technology, Winfrith. Check source measurements should be carried out before and upon completion of the intercomparison measurements for each gamma-ray source.

The instrument should be mounted as shown in the attached diagram, i.e., horizontally with the front face facing the radiation source. The beam axis should be aligned with the instrument case. The distance should be measured between the source and the marked reference point on the side of the instrument case. This is the preferred orientation and you should only deviate from it if it is physically impossible to achieve such an orientation in your facility. Any deviations should be noted on the appropriate diagram and returned with the relevant measurement Pro-forma. A 'background' (BG) measurement should also be made with the instrument set on the 0.1 - 1 μSv h^{-1} range prior to any calibration intercomparison measurements.

Calibrations should be carried out on the following instrument decades, using the attached Pro-forma to record your results:

^{241}Am source:

1 - 10 μSv h^{-1}; target instrument reading: ≈ 2.5 μSv h^{-1}.
1 - 10 μSv h^{-1}; target instrument reading: ≈ 7.5 μSv h^{-1}.
10 - 100 μSv h^{-1}; target instrument reading: ≈ 30 μSv h^{-1}.

Cs source

1 - 10 μSv h^{-1}; target instrument reading: ≈ 2.5 μSv h^{-1}.
1 - 10 μSv h^{-1}; target instrument reading: ≈ 7.5 μSv h^{-1}.
10 - 100 μSv h^{-1}; target instrument reading: ≈ 30 μSv h^{-1}.
10 - 100 mSv h^{-1}; target instrument reading: ≈ * μSv h^{-1}.
100 - 1K mSv h^{-1}; target instrument reading: ≈ 300 μSv h^{-1}.
100 - 1K mSv h^{-1}; target instrument reading: ≈ * μSv h^{-1}.

* - Target instrument reading to be set by participant with a view to providing useful calibration data.

^{60}Co source

1 - 10 μSv h^{-1}; target instrument reading: ≈ 2.5 μSv h^{-1}.
1 - 10 μSv h^{-1}; target instrument reading: ≈ 7.5 μSv h^{-1}.
10 - 100 μSv h^{-1}; target instrument reading: ≈ 30 μSv h^{-1}.
10 - 100 mSv h^{-1}; target instrument reading: ≈ * μSv h^{-1}.
100 - 1K mSv h^{-1}; target instrument reading: ≈ 300 μSv h^{-1}.
100 - 1K mSv h^{-1}; target instrument reading: ≈ * μSv h^{-1}.

* - Target instrument reading to be set by participant with a view to providing a user of the instrument with useful calibration data.

Instrument readings should <u>not</u> be corrected for background; participants are only required to record instrument readings on the Pro-forma. An estimate of the uncertainty associated with each reading, estimated at the 95% confidence level, should be entered in the column headed 'Un' on the Pro-forma.

The measurement Pro-forma includes all the above details, for each source respectively.

(c) **<u>Gamma monitor MINI-900 with 44A probe.</u>** As stated above, the instrument scale readings may have been offset, so participants should not be surprised if the instrument count rate does not related to the manufacturers recommended response and the incident air kerma rate. A user's manual is in the shipping case with the instrument. The check source jig for the instrument is also in the case.

Before use, the instrument should be tested using the check source jig supplied. It should be placed into the appropriate side of the jig (which is labelled). This is the same side as that used for the NE PDM1B and MINI-RAD 1000. The plastic protection cap should be removed and the side of the probe body placed in contact with the left hand side and base of the jig. The probe should them slide forwards until the front of the probe (window end) is in contact with the back of the jig. The probe should then be rotated so that the join in the retaining circlip at the rear is facing upwards.

The instrument should read (on the 100 - 1000 counts s^{-1} range)

<u>185 counts per second</u> <u>after subtracting background</u>

If the reading is different from this value by more than ± 5%, please contact Duncan McClure (NRPB - 01235 822738 (Direct)) for advice. You will be advised to either return the instrument to the manufacturer, to NRPB or to AEA Technology, Winfrith. Check source measurements should be carried out before and upon completion of the intercomparison measurements for each gamma-ray source.

The 44A probe should be mounted as shown in the attached diagram, i.e., horizontal with its central axis of symmetry aligned with the incident beam axis. The beam axis should be aligned with the front edge of the white tape on the body of the probe. This is the preferred orientation and you should only deviate from it if it is physically impossible to achieve such an orientation in your facility. Any deviations should be noted on the appropriate diagram and returned with the relevant measurement Pro-forma. The distance should be measured between the source and the marked reference point on the side of the instrument case. A 'background' (BG) measurement should also be made prior to any calibration intercomparison measurements. Participants are warned that the indicated background reading of this instrument may change with the instrument position within the calibration facility. If this is significant, background readings should be performed over the range of distances used for the calibrations and reported to the organisers.

Calibrations, using the ^{137}Cs gamma-ray source only, should be carried out for the following instrument decades, using the attached Pro-forma to record your results:

^{137}Cs source:

10 - 100 counts s^{-1};	target air kerma rate:	≈ 0.3	$\mu Gy\ h^{-1}$.
10 - 100 counts s^{-1};	target air kerma rate:	≈ 1.0	$\mu Gy\ h^{-1}$.
100 - 1K counts s^{-1};	target air kerma rate:	≈ 2.5	$\mu Gy\ h^{-1}$.
100 - 1K counts s^{-1};	target air kerma rate:	≈ 7.5	$\mu Gy\ h^{-1}$.
1K - 5K counts s^{-1};	target air kerma rate:	≈ 15	$\mu Gy\ h^{-1}$.
1K - 5K counts s^{-1};	target air kerma rate:	≈ 30	$\mu Gy\ h^{-1}$.

Instrument readings should not be corrected for background; participants are only required to record instrument readings on the Pro-forma. An estimate of the uncertainty associated with each reading, estimated at the 95% confidence level, should be entered in the column headed 'Un' on the Pro-forma.

The measurement Pro-forma includes all the above details, for each source respectively.

(d) **Electronic personal dosemeter (EPD).** As stated above, the dosemeter response may have been offset, so participants should not be surprised if the dosemeter indicated incremental dose equivalent does not indicate the incident dose equivalent. The check source jig for the instrument is in the case.

As supplied, the EPD default display should be total integrated dose in μSv (H_p). If this is not the case, please see note below. Participants should not have to operate any of the controls in order to carry out measurements for the intercomparison. It also means that if a participant inadvertently operates any of the controls, the EPD will automatically return to the total integrated dose in μSv (H_p) display after a few seconds. In addition, the dose and dose rate alarms on the EPD have been set to their maximum values and should not operate during the intercomparison measurements.

The EPD contains a high energy Lithium battery. This should easily last the duration of the intercomparison. DO NOT Attempt to dismantle the unit in any way. As a precautionary measure, the battery manufacturers safety instructions are included with this documentation.

NOTE Participants should not expose the EPD to radiation for longer than is necessary for the measurements; if the total accumulated dose equivalent exceeds 9999 μSv the unit will autorange to mSv. If the recorded accumulated dose equivalent is either close to 9999 μSv or the unit reads in mSv, please contact Duncan McClure (NRPB - 01235 822738 (Direct)) for advice; you will be advised to return the instrument to NRPB in order that the dosemeter can be reset. In view of the number of participants it is very likely that the instrument will autorange sometime during the intercomparison.

Before use, the instrument should be tested using the check source jig supplied. It should be placed into the appropriate side of the jig (which is labelled). This is the opposite side to that used for the NE PDM1B, MINI-RAD 1000 and MINI 900 with 44A probe. The EPD should be placed in the perspex holder with the clip uppermost and the display facing outwards. It will only fit this way round in the jig. It is a snug fit in the holder and you must ensure that it is pushed firmly into position

Obviously, once the EPD is in place in the jig it will start incrementing dose. The check source reading is the time to increment an H_p dose of 50 µSv. It is recommended that the EPD indication is timed between readings.

The instrument should read (on the H_p Dose range - the default display):

50.0 µSv in 903 seconds

If the reading is different from this value by more than ± 5%, please contact Duncan McClure (NRPB - 01235 822738 (Direct)) for advice. You will be advised to either return the instrument to the manufacturer, to NRPB or to AEA Technology, Winfrith. Check source measurements should be carried out both before and upon completion of the intercomparison measurements for each gamma-ray source.

The EPD dosemeter should be mounted as shown in the attached diagram, i.e., dosemeter front towards the incident beam with its central axis of symmetry aligned at right angles to the incident beam axis. The dosemeter may be irradiated either on or off a suitable phantom (or both if time permits). The distance should be measured from the gamma-ray source to the reference point (the 'beta-window') on the dosemeter. This is the preferred orientation and you should only deviate from it if it is physically impossible to achieve such an orientation in your facility. Any deviations should be noted on the appropriate diagram and returned with the relevant measurement Pro-forma.

Calibrations, using the ^{137}Cs gamma-ray source only, should be carried out at two target air kerma rates, using the attached Pro-forma to record your results:

^{137}Cs source:

Target dosemeter incremental dose equivalent reading: ≈ 200 µSv.

Target incident air kerma rates of 70 µGy h^{-1} and at a second air kerma rate to be set by the participant.

Participants are only required to record instrument readings on the Pro-forma. An estimate of the uncertainty associated with each reading, estimated at the 95% confidence level, should be entered in the column headed 'Un' on the Pro-forma.

The measurement Pro-forma includes all the above details. Your attention is also drawn to a number of additional questions included on the Pro-forma for this particular instrument; please complete as fully as possible, including additional pages if necessary.

4. Collation of results

The co-ordinators of this exercise are Julian Hunt (NPL, 0181-943-6561) and Duncan McClure (NRPB, 01235 822738 (Direct)). Participants should send copies of the completed Pro-forma report forms, including the additional information (see below) to both of the co-ordinators within four weeks from completion of their measurements. A summary report will be prepared and distributed to all participants prior to the holding of a 'summary meeting' to finalise the report and agree conclusions to be drawn from the intercomparison. It is hoped to publish a brief report in the open literature.

5. Information required from participants

Please use the attached Pro-forma measurement report forms whenever possible, completing only those parts marked for participants use. Please do not apply any corrections to the reported measured data; i.e., background subtraction, temperature and pressure corrections, etc, except to the check source reading as detailed above. There are two columns for uncertainties (marked 'Un'). The first one is for the uncertainty associated with the derivation of the true air kerma rates used for the calibration measurements, and the second is for the uncertainty associated with the recorded instrument readings. Both of these should be quoted as ± at the 95% confidence level. You may use the comments section of the Pro-forma if you wish to give a more detailed explanation of how these values are obtained.

The following information should also be included, as requested, on the Pro-forma:

(a) Check source measurements for each instrument, prior to and following all the intercomparison measurements. A background measurement should also be performed and the results reported.

(b) Ambient conditions, i.e., temperature and pressure during measurements. Reference conditions assumed to be 20°C and 101.325 kPa (note that 101.325 kPa is equivalent to 1 atm (760 mm Hg), 1 bar is equivalent to 10^5 Pa and 1 torr is equivalent to 133.322 Pa). The Pro-forma includes space for a correction factor for temperature and pressure but you should **ONLY** use this when reporting check source measurements for the PDM1B instrument.

c Participants irradiation source and facilities

(i <u>SOURCES AND TRACEABILITY</u>

(a) Are the sources capsules or planar?

^{241}Am:

^{137}Cs

^{60}Co:..

(b) What is the basis of the calibration in terms of air kerma rate? Is this traceable to primary standards, and if so, how?

....
....
....
....
....
....
....
....

(ii) COLLIMATION

What is the primary beam diameter (in cm) at a distance of one metre (1 m) from the source?

^{241}Am:......

^{137}Cs

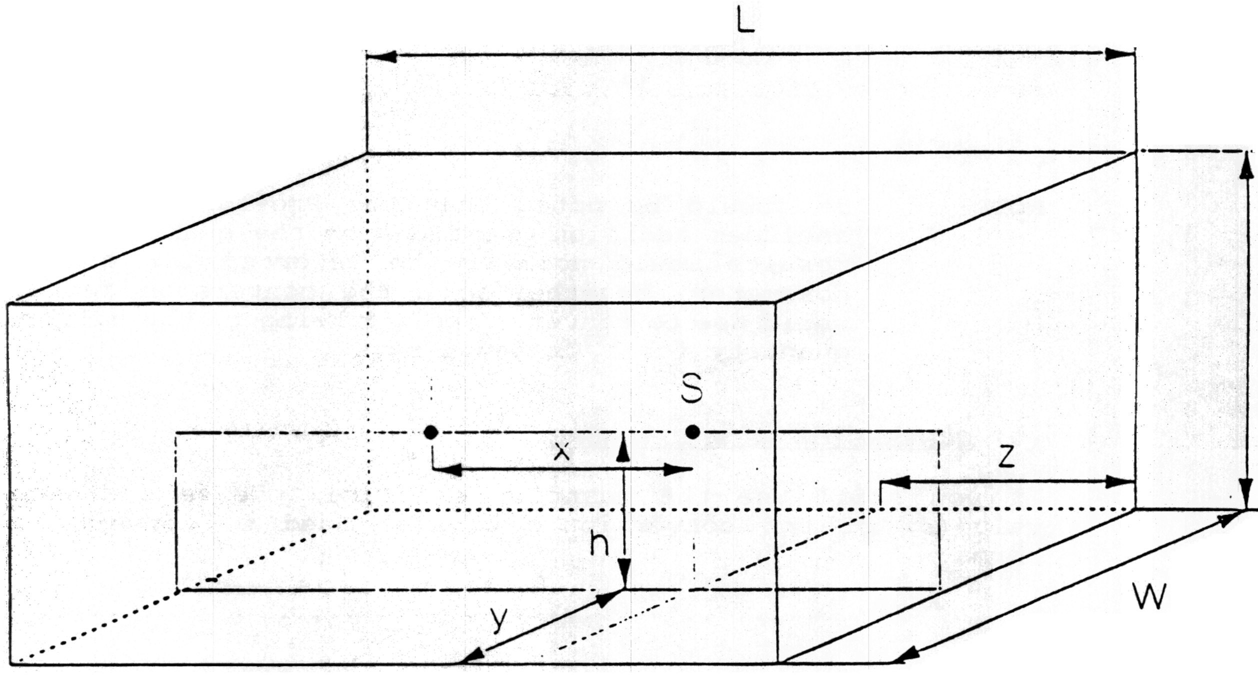
Please state for each source the minimum beam diameter used in the measurements and the associated minimum source to instrument separation distance:

^{241}Am:

^{60}Co:...

iii EXPOSURE ROOM

Please indicate the approximate dimensions of the exposure room as indicated on the following diagram.



Exposure Room Dimensions (in metres)

Length L:..............

Width W:........................

Height H:...........

What is the wall material?..

Source/Instrument Geometry (in metres):

Source - Height above floor h:

Distance from walls y:.......

z:

Source/Instrument Separation Distance (in metres):

Minimum x_{min}

Maximum x_{max}

(iv) AMBIENT DOSE EQUIVALENT

What is the value of the air kerma to ambient dose equivalent conversion factor that would be used, for each source, if the calibration factor was to be expressed in terms of ambient dose equivalent?

^{241}Am:...

^{137}Cs

^{60}Co

NOTE It should be noted that the Pro-forma for the EPD includes addition questions on the quantity in which results would normally be reported for a personal dosemeter, together with the conversion factor you would use to convert from air kerma to the calibration quantity for ^{137}Cs gamma-rays.

v CONVERSION FROM EXPOSURE

If you still use the quantity exposure, please indicate the value(s) of the conversion factor(s) used to convert to air kerma.

^{241}Am:.......

^{137}Cs

^{60}Co:

What is the basis of the above conversion factor(s)?

. . . .
. . . .
. . . .
. . . .
. . . .
. . . .
. . . .
. . . .
. . . .
. . . .

(vi <u>COMMENTS</u>

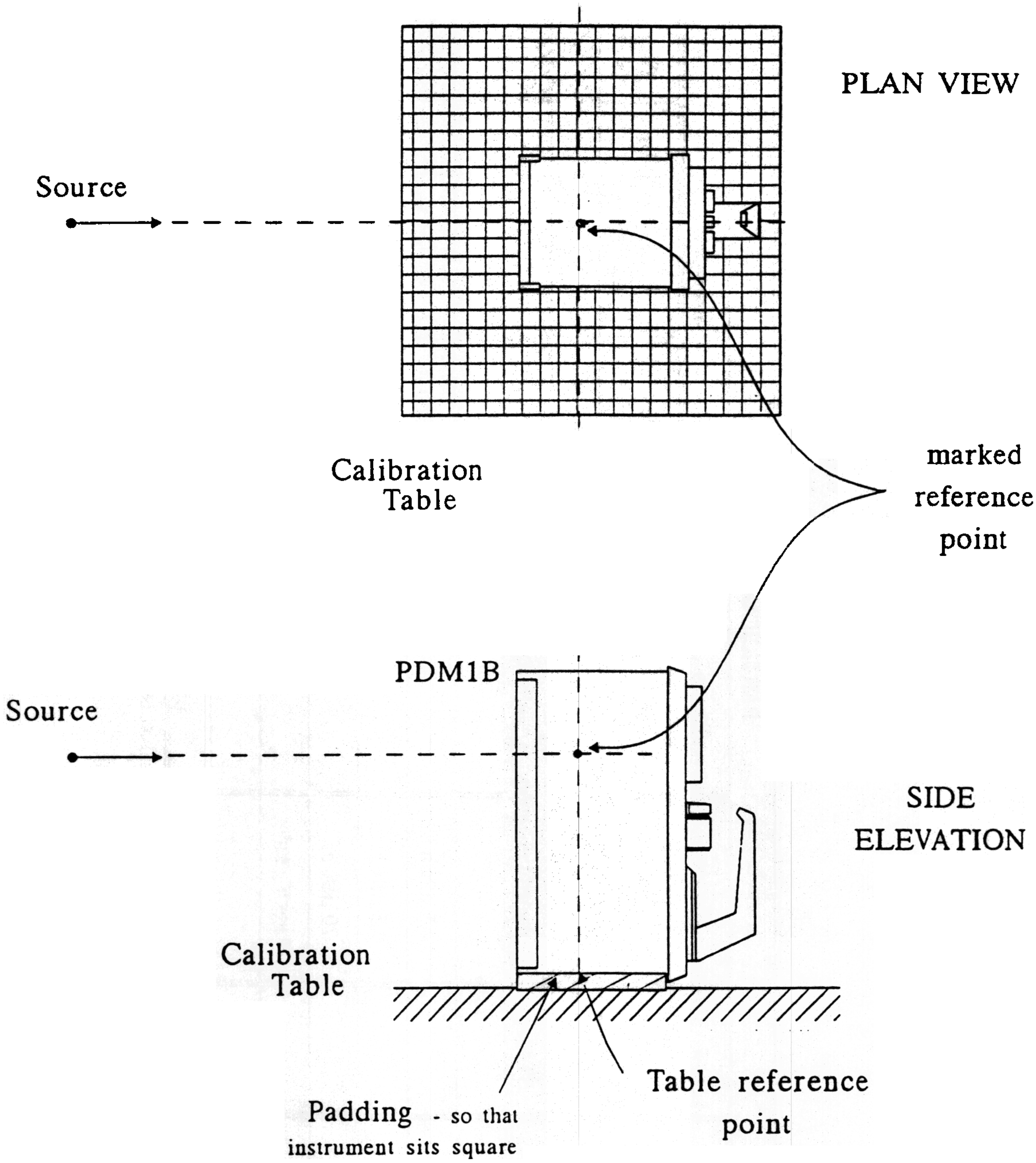
COMMENTS continued

Date Signature:.

Send copies of completed Pro-formas to the organisers:

Dr J B Hunt	Mr D McClure
Building 62	National Radiological Protection Board
Division of Radiation Science and Acoustics	Chilton
National Physical Laboratory	Didcot
Teddington	Oxfordshire
Middlesex TW11 0LW	OX11 0RA
Tel 0181 943 6561 (Direct)	01235 822738 (Direct)

CALIBRATION ORIENTATION FOR
PDM1B



<u>IRMF GAMMA-RAY CALIBRATION INTERCOMPARISON</u>

Participant ______________________ Lab. ref: ____________

nstrument type: **PDM1B** Serial No. ____________

Build Up Shutter - Open

Temperature ______ K) 760 mmHg x T

Pressure ______ mmHg P 293.2K

Nuclide - ^{241}Am

PARTICIPANTS									OFFICIAL USE ONLY		
Nuclide	Distance□	Target Air Kerma Rate	True Air Kerma Rate	Un.	Instrument: Decade	Instrument: Reading inc. BG	Instrument: Un.	Instrument: Time (sec)			
BG					0 - 10 μSv h^{-1}						
Check Source	START	Expected Indication ____ μSv h^{-1}		±5%	0 - 10 μSv h^{-1}						
^{241}Am		2.5 μSv h^{-1}			0 - 10 μSv h^{-1}						
^{241}Am		7.5 μSv h^{-1}			0 - 10 μSv h^{-1}						
^{241}Am		70 μSv h^{-1}			0 - 100 μSv h^{-1}						
^{241}Am		70 μSv h^{-1} / 4 μSv			0 - 5 μSv						
Check Source	FINISH	Expected Indication ____ μSv h^{-1}		±5%	0 - 10 μSv h^{-1}						

□ - Distance from detector reference centre to centre of source

Date / /

Comments ____

Signiture ____________

IRMF GAMMA-RAY CALIBRATION INTERCOMPARISON

Participant ______________________ Lab. ref: ____________

Instrument type: PDM1B ______________ Serial No. ____________

Build Up Shutter - Closed

Temperature ______ K) 760 mmHg x T
Pressure mmHg P 293.2K

Nuclide - ^{137}Cs

PARTICIPANTS									OFFICIAL USE ONLY		
Nuclide	Distance□	Target Instrument Reading	True Air Kerma Rate	Un.	Instrument: Decade	Reading inc. BG	Un.	Time (sec)			
BG					0 - 10 μSv h^{-1}						
Check Source	START	Expected Indication ____ μSv h^{-1}		±5%	0 - 10 μSv h^{-1}						
^{137}Cs		2.5 μSv h^{-1}			0 - 10 μSv h^{-1}						
^{137}Cs		7.5 μSv h^{-1}			0 - 10 μSv h^{-1}						
^{137}Cs		70 μSv h^{-1}			0 - 100 μSv h^{-1}						
^{137}Cs		0.7 mSv h^{-1}			0 - 1 mSv h^{-1}						
^{137}Cs		7 mSv h^{-1}			0 - 10 mSv h^{-1}						
^{137}Cs		20 mSv h^{-1}			0 - 100 mSv h^{-1}						
^{137}Cs		70 mSv h^{-1}			0 - 100 mSv h^{-1}						
^{137}Cs		70 μSv h^{-1} / 4 μSv			0 - 5 μSv						
Check Source	FINISH	Expected Indication ____ μSv h^{-1}		±5%	0 - 10 μSv h^{-1}						

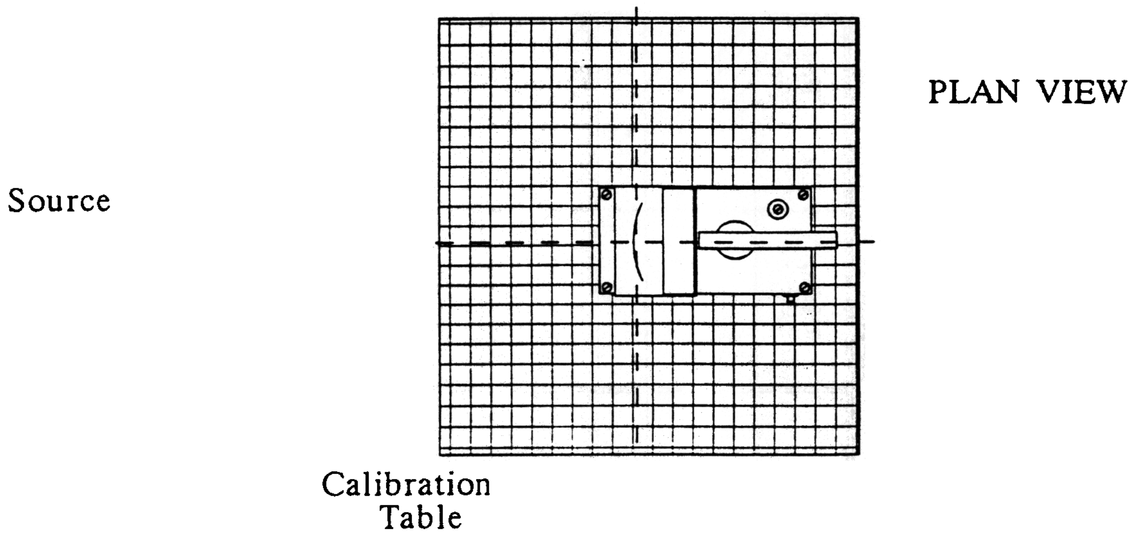
□ - Distance from detector reference centre to centre of source

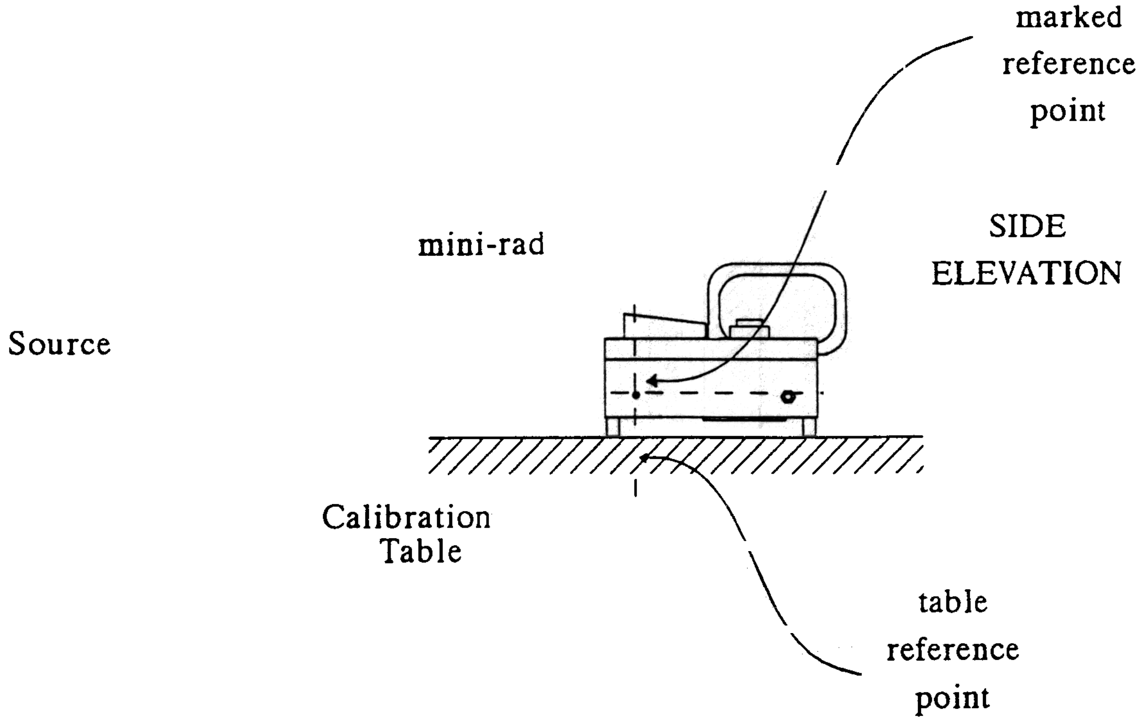
Date / /

Comments ____

Signature ____________

CALIBRATION ORIENTATION FOR MINI-RAD (1000R)





IRMF GAMMA-RAY CALIBRATION INTERCOMPARISON

Participant ______________________ Lab. ref: ______________

Instrument type: **mini-rad 1000** Serial No. ______________

Nuclide - ^{60}Co

PARTICIPANTS								OFFICIAL USE ONLY		
Nuclide	Distance□	Target Instrument Reading	True Air Kerma Rate	Un.	Instrument Decade	Instrument Reading inc. BG	Instrument Un.			
BG					0.1 - 1 μSv h^{-1}					
Check Source	START	Expected Indication ____ μSv h^{-1}		±5%	10 - 100 μSv h^{-1}					
^{60}Co		2.5 μSv h^{-1}			1 - 10 μSv h^{-1}					
^{60}Co		7.5 μSv h^{-1}			1 - 10 μSv h^{-1}					
^{60}Co		30 μSv h^{-1}			10 - 100 μSv h^{-1}					
^{60}Co		* μSv h^{-1}			10 - 100 μSv h^{-1}					
^{60}Co		300 μSv h^{-1}			100 - 1K μSv h^{-1}					
^{60}Co		* μSv h^{-1}			100 - 1K μSv h^{-1}					
Check Source	FINISH	Expected Indication ____ μSv h^{-1}		±5%	10 - 100 μSv h^{-1}					

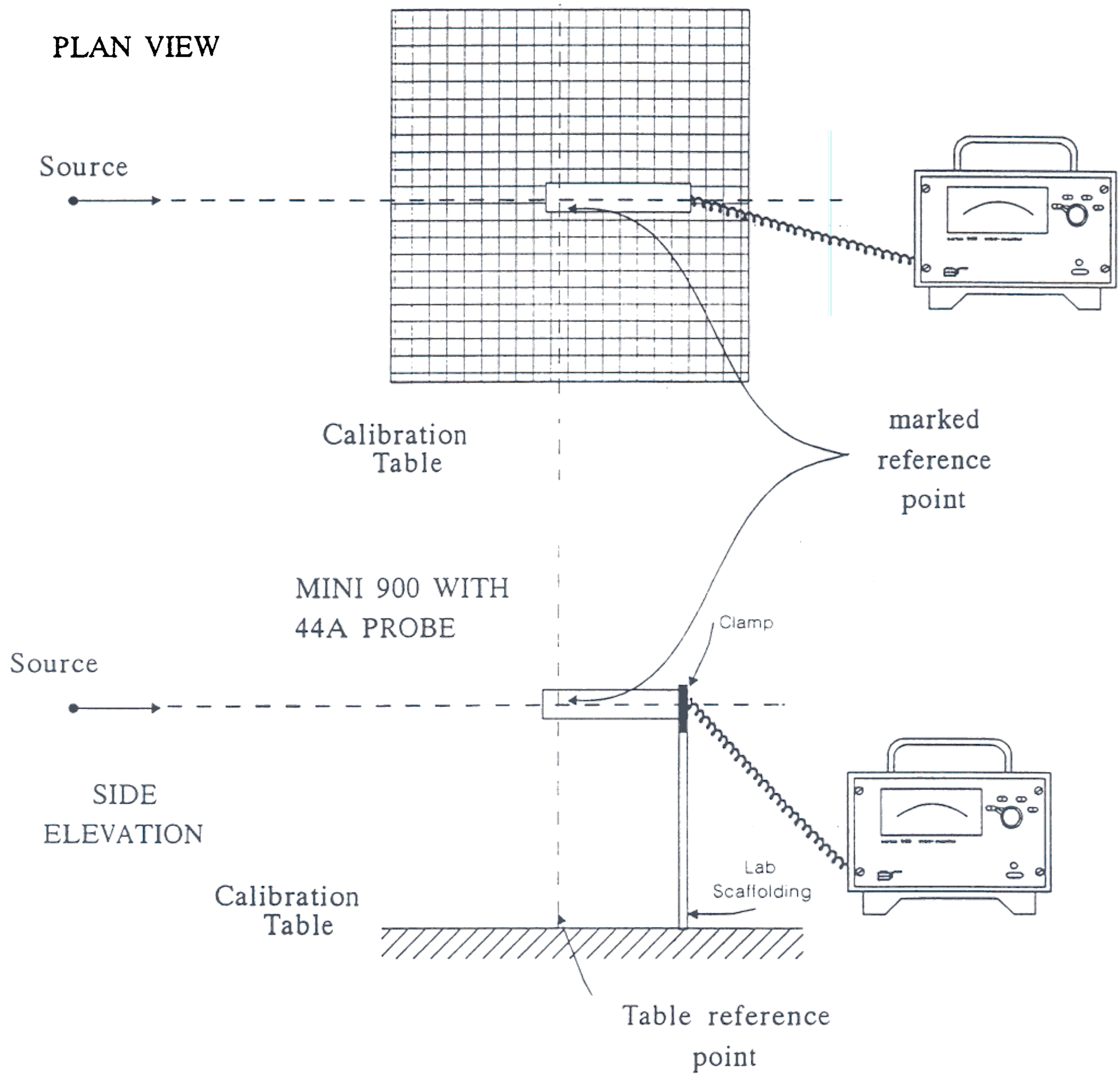
□ - Distance from detector reference centre to centre of source

* - Measurement Points to be chosen by Participant

Date / /

Comments ______________________________________ Signature ______________

CALIBRATION ORIENTATION FOR
MINI 900 / 44A



IRMF GAMMA-RAY CALIBRATION INTERCOMPARISON

Participant ______________________ Lab. ref: ______________

Instrument type: MINI 900 / 44A Serial No. ______________

Build up material & thickness if used ______________________

Nuclide - ^{137}Cs

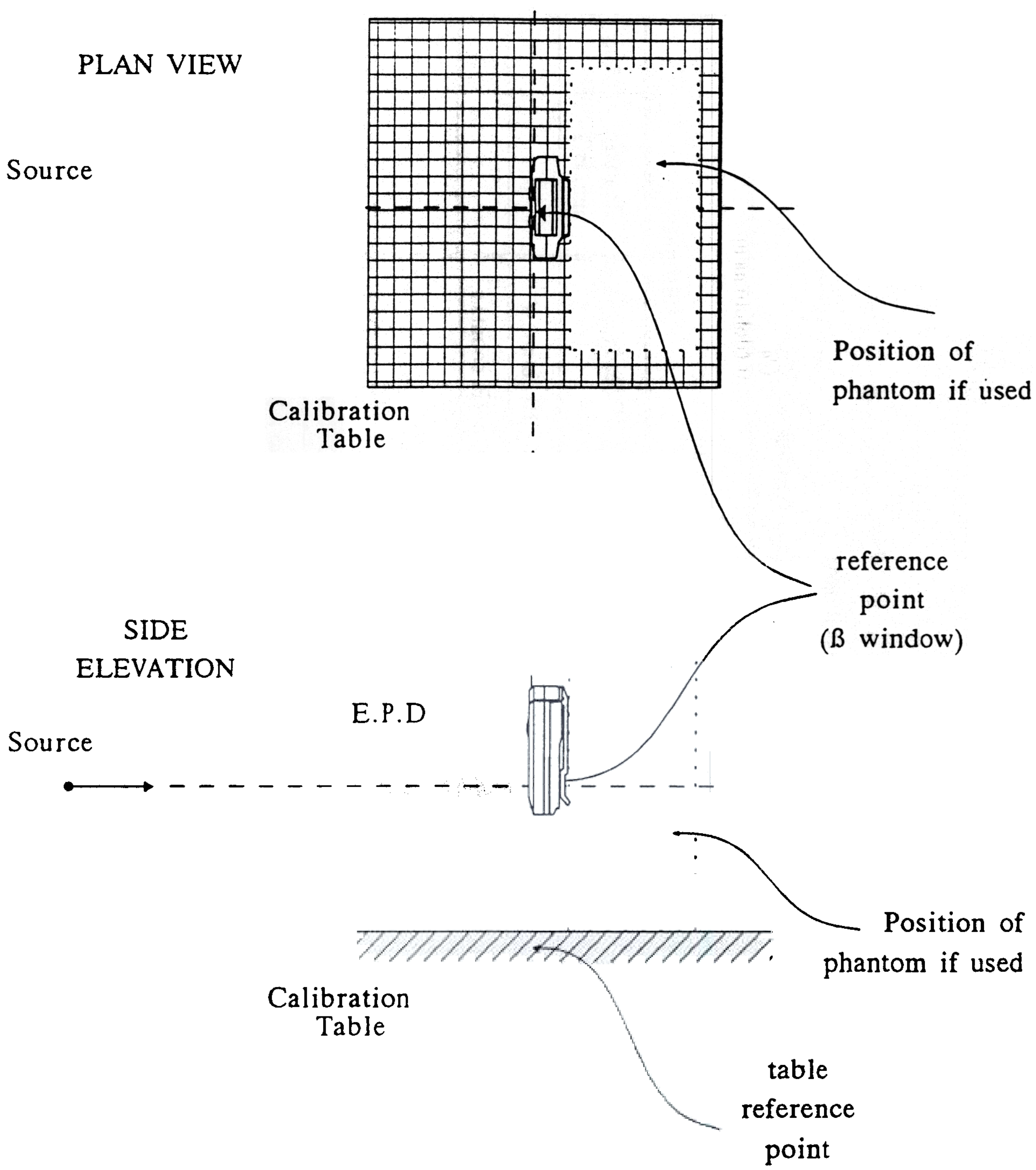
PARTICIPANTS								OFFICIAL USE ONLY		
Nuclide	Distance*	Target Air Kerma Rate	True Air Kerma Rate	Un.	Instrument					
					Decade	Reading inc. BG	Un.			
BG					1 - 10 counts s^{-1}					
Check Source	START	Expected Indication ____ counts s^{-1}		±5%	100 - 1K counts s^{-1}					
^{137}Cs		0.3 μGy h^{-1}			10 - 100 counts s^{-1}					
^{137}Cs		1.0 μGy h^{-1}			10 - 100 counts s^{-1}					
^{137}Cs		2.5 μGy h^{-1}			100 - 1K counts s^{-1}					
^{137}Cs		7.5 μGy h^{-1}			100 - 1K counts s^{-1}					
^{137}Cs		15 μGy h^{-1}			1K - 5K counts s^{-1}					
^{137}Cs		30 μGy h^{-1}			1K - 5K counts s^{-1}					
Check Source	FINISH	Expected Indication ____ counts s^{-1}		±5%	100 - 1K counts s^{-1}					

* - Distance from detector reference centre to centre of source

Date / /

Comments ______________________________ Signature ______________

CALIBRATION ORIENTATION FOR
ELECTRONIC PERSONAL DOSEMETER (E.P.D)



IRMF GAMMA-RAY CALIBRATION INTERCOMPARISON

Participant ______________________ Lab. ref: ______________

Instrument type: ____E.P.D______________ Serial No. ______________

Nuclide - ^{137}Cs

Test conducted ON / OFF phantom (delete as appropriate)

* - Measurement Points to be chosen by Participant

PARTICIPANTS									OFFICIAL USE ONLY		
Nuclide	Distance □	Target		True							
		Air Kerma Rate	Hp increment	Air Kerma Rate	Un.	Hp increment	Time (sec)	Un.			
Check Source	START	Expected Hp Increment ______ µSv			±5%		1000				
^{137}Cs		70 µGy h^{-1}	200 µSv								
^{137}Cs		*	200 µSv								
Check Source	FINISH	Expected Hp Increment ______ µSv			±5%		1000				

Details of phantom (if applicable), material & dimensions ______________________

____

Quantity in which results would normally be reported ______________________

Conversion coefficient from Air Kerma used ______________________

□ - Distance from detector reference centre to centre of source

Date / /

Comments ______________________ Signature ______________