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Intercomparison of ^{111}In solution sources in UK Hospitals, 1997

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ABSTRACT

As part of an ongoing programme aimed at supporting the quality of radioactivity measurements in UK hospitals, an intercomparison exercise was conducted, using solution sources of ^{111}In, between the National Physical Laboratory, Amersham International plc and the UK hospital physics community.

The conduct of that intercomparison is described here, additional experimental results are presented, the results are discussed and recommendations made.

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CONTENTS

TABLES

ILLUSTRATIONS

APPENDICES

1 INTRODUCTION

Radioactive materials are widely used in hospitals for diagnostic and therapeutic purposes. The activity assay has an important role in the correct administration of a radionuclide and it should be determined to a relatively high degree of accuracy; the most common instruments used for this purpose are radionuclide calibrators. Their principle of operation is relatively simple and, used correctly via a quality assurance system, they can achieve the levels of accuracy required for diagnostic, and even therapeutic, purposes. Such a protocol for establishing and maintaining a suitable quality assurance system has been recommended for use in UK hospitals[1].

As part of an ongoing programme, supported by the National Measurement System Policy Unit of the Department of Trade and Industry, the National Physical Laboratory has been conducting a series of intercomparisons and workshops. These initiatives have the objectives of determining current levels of performance, identifying problem areas and encouraging a dialogue and exchange of information between hospital physicists.

The first two exercises examined the results obtained with ^{67}Ga[2] and ^{123}I[3]. The first exercise was based on ^{67}Ga, which had been chosen following some concerns that had been expressed about the accuracy of the assays obtained using a particular calibrator. The results of that intercomparison demonstrated that those concerns were well-founded and that significant errors in measurement could be expected. For the second exercise, ^{123}I was selected because of the significant quantity of low energy photons emitted which could produce unacceptably high variations between calibrator responses. These effects had already been recognised and some proposals had been made[4] within the hospital community to alleviate this effect. Again, the intercomparison was highly successful in confirming the extent of the problem and, in particular, it highlighted the caution that needed to be used if applying recommended correction factors when syringes were used. In addition, the exercise also raised similar concerns, as seen in the first exercise, about the quality of the calibration figures for a particular calibrator.

It was decided that the third exercise would concentrate on ^{111}In. This is a popular radionuclide in the practice of nuclear medicine and the energies of the photons emitted during its decay are between those of ^{67}Ga and ^{123}I. An intercomparison exercise, therefore, was conducted between the National Physical Laboratory (NPL), Amersham International plc (AI) and the UK hospital physics community. In addition, using a typical commercial radionuclide calibrator, some simple comparisons were made to determine the potential magnitude of the variations caused by using different container types.

2 PARTICIPANTS

Participation was open to all UK hospitals and the exercise was publicised via the contact mailing lists of AI and NPL.

Several participants took the opportunity to share their sample by circulating it amongst several hospital departments in their region.

A list of the 22 participants is given in Appendix 1.

3 INTERCOMPARISON SAMPLES

A stock solution of ^{111}In was supplied and accurately sub-divided, by Amersham International, into a series of 4 ml aliquots in P6 vials. These samples were made available to users. Two aliquots, of 3 ml each, from the same stock solution were also despatched to NPL in flame-sealed 5 ml glass ampoules for activity determinations.

At midday on the date of receipt of the samples, the activity concentration in each vial was approximately 35 MBq/g. The samples comprised ^{111}In as an aqueous solution with a chemistry of 0.1 mg g^{-1} In in 0.1M HCl.

4 NPL MEASUREMENTS AND INTERNATIONAL EQUIVALENCE

The samples sent to NPL were assayed using a sealed, high-pressure, re-entrant ionisation chamber. This chamber had been previously calibrated for ^{111}In using solutions which had been standardised absolutely using the primary standardisation facilities and techniques available at NPL.

As confirmation of the accuracy of NPL's primary standardisation, ampoules of ^{111}In have been submitted to the International Reference System of the International Bureau of Weights and Measures in Paris. This system allows comparisons to be made between the primary standards of national standards laboratories across the world. To date, samples of ^{111}In have been received from the national laboratories of Canada, Czechoslovakia, France, Denmark, U.K. and U.S.A. The NPL value agreed to within 0.3% of the mean of all the submitted values.

The solutions were also examined by gamma spectrometry. This identified the presence, at the reference time, of ^{114m}In at an activity level of about 0.015% of the ^{111}In activity level. Because of the relative photon energies and emission probabilities, the response factor of the contaminant is about 4 times lower than that of the ^{111}In. Over the period of the measurements, therefore, the effect of the contaminant was taken to be negligible when determining the ^{111}In activity concentrations.

The standard uncertainty on the NPL measurements of activity were ± 0.7% at the 68% confidence level.

In addition, a stock solution of ^{111}In was dispensed accurately to a range of containers, in particular syringes, and then assayed in a typical radionuclide calibrator, a Capintec model ARC120. For each measurement, the same calibration factor was used, namely a setting of 303. For each container, a minimal volume was initially dispensed and then subsequently topped up in stages, using inactive carrier solution, to the nominal total volume of the syringe. At each stage the syringe was assayed in the Capintec calibrator.

As before, the effect of the ^{114m}In was considered to be negligible in relation to the other uncertainties in these measurements.

Details of the containers, their nominal volumes and wall thicknesses are given in Table 1. The activities indicated by the Capintec system were compared with the known activity and these are plotted against volume in Figure 1.

5 MEASUREMENT AND REPORTING PROTOCOL

Participants were invited to assay their P6 vial in each of their radionuclide calibrators and to report their results directly to NPL. Subsequently participants were informed of the traceable activity content of their sample based on the NPL standardisation. They were encouraged to derive as much useful information as possible from this exercise by making measurements using both pre-set facilities and manual settings, where available, and additionally by transferring activity to other containers (such as syringes) and reporting measurements on these. Estimates of measurement uncertainties were also sought. A standard reporting form, as reproduced in Appendix 2, was provided.

6 CONFIDENTIALITY

All results were reported directly to NPL. Each reported calibrator was given a Code Number by NPL and the results in this Report are tabulated against those Code Numbers. The correlation between Code Number and calibrator (and hence participant) remains confidential to NPL.

7 ANALYSIS OF RESULTS

At the date of this report, 22 of the 24 possible participants had reported results. The total of 279 results represented measurements on some 109 calibrators in 38 hospitals. Each result has been decayed to the same reference time of 1200 GMT on 4 June 1997 using a half-life of 2.8047 d. Some of the participants sent their results already decayed to the above reference time.

For each original sample, the activity content was determined from the activity concentration measurements made by NPL together with the masses of solution dispensed by AI. For those samples which were subsequently dispensed by the participants (e.g. syringes), the activities were determined on the basis of the participants declared dispensings. The reported results were then compared to these NPL calculations.

None of the participants reported any evidence of contaminants and, as explained above, the effect of the contaminant on the participants results was disregarded.

The results have been tabulated as ratios of reported activity to the NPL-determined value and are presented in Table 2. Summarised breakdowns by container and chamber type are given in Table 3. In these breakdowns, the results from syringes and residue vials have been separated from the original vial results. The results are also selectively displayed in histogram form in Figures 2 to 3.

In some cases, participants had redetermined the preferred calibration factor for their calibrator: where this has occurred, it is evident from the entry in the dial factor column of Table 2 (recorded as "factor applied").

The reported uncertainties are presented in Table 4.

8 DISCUSSION

The principal objective of the intercomparison was to investigate the accuracy of measurements of ^{111}In using typical radionuclide calibrators and containers. In particular, in the light of the findings of the two previous exercises, special attention needed to be given to the accuracy of the calibration figures of some calibrators and also to the quality of recommended syringe correction factors.

Some of the residue measurements need to be regarded with some reservation. It is clear from the results that the estimation of the mass remaining after transfer is not always particularly accurate and this could lead to a distortion of the related results. The discussion, as it relates to containers, is confined to those results for the original P6 vials and for syringes.

8.1 CAPINTEC ARC 120 MEASUREMENTS AT NPL

It is useful to discuss these results first in that they provide some insight which may provide some explanations for the observed results (and discrepancies). To put these results into context, the User Manual[5] for this calibrator makes two significant statements, namely:

(a) the Calibration Setting Numbers are given for approximately 5 grams of radioactive solution in a standard source ampoule made of about 0.6 mm thick borosilicate glass. The standard radioactive source in the ampoule is, however, a good approximation for a radiopharmaceutical in a plastic syringe or a glass syringe (wall thickness of about 1.2 mm) for most radioisotopes;

(b) the anticipated syringe correction factor for ^{111}In is 10%.

It will be seen from the results in Figure 1, that none of the syringes used in the NPL measurements described above will provide a correct assay using the recommended Calibration Setting Number and correction factor. For these, correction factors of between 15% to 30% are required compared with the suggested value of 10%.

8.2 P6 VIAL DATA

The overall data, Figure 2, shows that the results are *on average* relatively good with the mean value being virtually identical with the NPL value.

Although some hospitals had noticed differences between the "dial" and "preset" ^{123}I results, this does not appear to be the case here. There are a few more outliers for the "dial" results but the numbers are not sufficient large to suggest that there is any systematic difference occurring.

A comparison with previous exercises is useful and raises some interesting points. This is discussed more fully in Section 8.5.

When the results are differentiated between individual calibrator systems, the results identify some interesting variations.

8.2.1 CAPINTEC Systems

Capintec chambers provide results which are very acceptable. Only about 5% of these results are more than 5% different from the NPL value and of these none are more than 15% in error.

8.2.2 ISOCAL IV Systems

The ISOCAL IV is the NPL secondary standard radionuclide calibrator. This has the advantages that it was calibrated by NPL using P6 vials and that the design tolerances are sufficiently strict to ensure that the variation in response between chambers is minimised. This is evidenced by the results which are within 3.5% of the NPL value.

8.2.3 ISOCAL II/PITMAN 238 systems

These systems had shown problems in previous exercises: the most reasonable explanation for those problems was that there had been errors in the calibration procedure. The results this time group about the NPL value and suggest that the calibration factor is correct. However, there are two outliers and these deserve some attention.

8.2.4 PITMAN 270 systems

The results for these systems are displayed in Figure 3 in comparison with those from the overall data set. It is clear that the majority of these results are unacceptably high and indicate that the calibration figure is in error. The reason for this is not known; obviously, users of these systems would be well advised to check their calibrations for ^{111}In against traceable, national standards.

8.2.5 Other systems

The other systems used, with the exception of a single extreme outlier result, also seem to perform reasonably well.

8.3 SYRINGE DATA

In Figure 4, the syringe results have been displayed pictorially. No distinction is made between those results which have been obtained using the "normal" calibration factors as supplied by the manufacturers and those using factors resulting from user-recalibrations.

It will be seen that there is a very wide spread of results, of the order of 40%. On the basis of accepted practice and comparison with the P6 vial data, this spread is of the order of 2 to 3 times too high. In addition, the median value is of the order of 20 to 25% in error (higher than the NPL value). The reported data reflects and confirms the findings from the work performed at NPL and described above in Section 8.1.

The CAPINTEC User Manual states that its recommended syringe correction factor should only be regarded as a guide. The evidence here suggests that not only does the recommended value underestimate the effect but also that it does not take account of the variation to be expected between syringes. Users need to determine their own correction factors if they are to have confidence in their measurements.

Syringe calibration factors have not yet been established for the NPL secondary standard radionuclide calibrator. This decision was taken initially because of the large variation in syringe types and the User Manual recommends the user should determine their own factors and provides advice on how to do this. However, it may now be appropriate to review that decision and to seek to determine syringe factors for a range of nuclides and syringes.

The authors have no knowledge of manufacturers guidance on use of syringes for other systems.

8.4 UNCERTAINTIES

The response to the request for estimates of uncertainty produced more contributions than the previous exercises but the same comments apply as before: the methods of estimation and combination of individual contributions shows no consistency. As a first attempt to remedy this situation, the question of uncertainties will be addressed at the next radionuclide calibrator workshop.

8.5 COMPARISON WITH PREVIOUS EXERCISES

Since 1980, six radionuclides have been intercompared prior to this exercise, namely, ^{57}Co[6], ^{125}I[6], ^{99m}Tc[7], ^{131}I[7], ^{67}Ga[2] and ^{123}I[3]. In the recent series of exercises, the ^{67}Ga intercomparison had suggested that there had continued to be an improvement in the overall accuracy of measurements as demonstrated by the number of results falling within both ± 5% and ± 10% of the NPL value. That position, as shown in Table 5, had then been reversed quite dramatically with ^{123}I.

It was recognised, however, that there are particular problems associated with the assay of ^{123}I. On that basis, it was felt that it would be unreasonable to assume that the results of that intercomparison were a reflection of the measurement performance to be expected with other radionuclides.

From the results of this exercise, it could be argued that there appears to have been a slight lowering of performance. However, the number and mix of calibrators varies between exercises and it may be difficult to justify such a conclusion either statistically or unless a more detailed comparison is made.

An additional consideration is the mean energy of the photon emissions involved. Taking the last five exercises, there is scope to argue that there is a general trend whereby the spread of results increases with decreasing mean photon energy. This would support the argument that the spread is a reflection of the variation in chamber wall thickness that results from manufacturing specifications. Further support for this view arises from the results for the NPL secondary standard radionuclide calibrator (the ISOCAL IV). This chamber is manufactured to very strict tolerances and manufactured chambers are not accepted for inclusion in the ISOCAL IV system unless they have been checked at NPL and it has been verified that all responses are within, at least, 3% of the master chamber at NPL. It will be seen for each of the last three exercises that all the results are within 5% of the NPL value.

Without a deeper inspection of the data, of the chamber specifications and of production quality controls, it is difficult to draw hard conclusions.

9 CONCLUSIONS

This exercise, as part of an ongoing programme, has again proved beneficial. It has identified at least one system where the accuracy of the calibration figures appear to be significantly in error. In addition, it supports the evidence seen in previous intercomparisons that recommended syringe correction factors are probably underestimating administered doses.

It would be useful to conduct more work in this area and to investigate the potential relationship between spread of results and mean photon energy. The benefits of continuing these exercises is also clear.

In summary, therefore, the authors would propose the following conclusions.

(a) Users of PITMAN 270 systems should check the calibrations of their systems using traceable standards.

(b) The spreads of results for syringes are unacceptably large.

(c) These spreads may be due to the production tolerances on the wall thicknesses of particular calibrators and further data should be sought.

(d) Recommended syringe correction factors may be significantly in error and recalibrations using traceable solutions should be made, recognising that calibration factors may vary significantly between syringe types and volumes.

(e) Syringe factors should be determined for the NPL secondary standard radionuclide calibrator.

(d) Attention should be given by all users to the accuracy and traceability of calibration factors for nuclides which emit a significant proportion of low energy photons.

(e) Users should ensure that quality assurance procedures are in place.

(f) Further intercomparisons should be held.

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Thanks are also due to the participants for their cooperation and openness in reporting.

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Table

Details of containers used in experimental work at NPL

Container	Nominal volume (ml)	Wall thickness (mm)
BS glass ampoule	2	0.45
BS glass ampoule	5	0.55
NBS glass ampoule	5	0.6
P6 glass vial	10	1.2
Plastic syringe (Sabre)	1	1.27
Plastic syringe (Gillette)	2	1
Plastic syringe (Sabre)	2	1
Plastic syringe (Gillette)	5	1.30
Plastic syringe (Sabre)	5	1.25
Plastic syringe (Sabre)	10	1.50

Table 2. Reported results.

Code	Calibrator Manufacturer	Model	Dial setting	Reported activity (MBq)		NPL activity (MBq)	Reported values	
				Preset	Dial		Preset/NPL	Dial/NPL
1	SIEL	BIC-1	342	147.62	147.13	138.31	1.067	1.064
2	CAPINTEC	CRC-15R		137.71		138.40	0.995	
3	VINTEN	ISOCAL II		141.69		138.40	1.024	
4a	CAPINTEC	CRC-15R	303	134.63	135.26	137.65	0.978	0.983
4b	"	10ml syringe		156.20		129.54	1.206	
4c	"	residue		7.86		8.11	0.970	
5	SIEL	BIC-1	342	144.80	144.20	138.31	1.047	1.043
6a	VINTEN	ISOCAL II	2244		149.84	139.50		1.074
6b	"	10ml in P6 vial	2244		144.62	139.50		1.037
7	VINTEN	ISOCAL II	2244	130.58	130.55	140.53	0.929	0.929
8a	VINTEN	ISOCAL II	2244		143.54	138.92		1.033
8b	"	5ml syringe	2064		41.34	32.72		1.263
8c	"	5ml syringe	2064		41.79	33.17		1.260
8d	"	5ml syringe	2064		40.86	32.48		1.258
8e	"	0.5ml syringe	2042		2.84	2.21		1.285
8f	"	1ml syringe	2042		9.86	7.76		1.271
8g	"	20ml syringe	1997		9.44	7.59		1.244
8h	"	10ml syringe	1997		23.04	17.72		1.300
9	CAPINTEC	ARC-120R	303	139.17 *	139.17 *	138.04	1.008 *	1.008 *
10	VINTEN (3" Pb wall)	ISOCAL III	1226		140.54	139.04		1.011
11a	CAPINTEC	CRC-15R	260		159.04	139.05		1.144
11b	"	"	303		143.04	139.05		1.029
12	CAPINTEC	CRC-15R	303	139.71	139.71	138.04	1.012 *	1.012 *
13a	VINTEN	ISOCAL II	2244		144.38	140.76		1.026
13b	"	5ml syringe	2244		107.05	103.44		1.035
13c	"	residue	2244		42.27	37.32		1.133
14a	CAPINTEC	CRC-15R	303		143.88	140.76		1.022
14b	"	5ml syringe	303		128.13	103.44		1.239
14c	"	residue	303		41.86	37.32		1.122
15	VEENSTRA	VDC 304	676		147.77	138.88		1.064
16	CAPINTEC	CRC-15R	303		141.40	139.27		1.015
17a	CAPINTEC	CRCR-15R		140.91		138.57	1.017	
17b	"	0.5ml syringe	cal 400		3.55	3.448		1.030
17c	"	residue 1		137.38		135.122	1.017	
17d	"	5ml syringe	cal 400		76.07	74.477		1.021
17e	"	residue 2		61.44		60.645	1.013	

Code	Calibrator Manufacturer	Model	Dial setting	Reported activity (MBq)		NPL activity (MBq)	Reported values	
				Preset	Dial		Preset/NPL	Dial/NPL
18	CAPINTEC	CRC-15R		141.56		138.40	1.023	
19	SIEL	BIC-1	342	136.97	135.91	138.31	0.990	0.983
20a	NE	ISOCAL III	1226	135.11	134.94	137.65	0.982	0.980
20b	"	10ml syringe		130.72		129.54	1.009	
20c	"	residue		8.02		8.11	0.989	
21a	CAPINTEC	ARC-120R	303	139.49	140.53	139.04	1.003	1.011
21b	"	2ml syringe	303	47.0	47.62	37.60	1.250	1.266
21c	"	2ml syringe	303	86.10	86.72	69.05	1.247	1.256
21d	"	residue		32.90		32.39	1.016	
21e	"	glass vial	303	34.64	34.75	36.11	0.959	0.962
21f	"	syringe residue		1.87		1.49	1.255	
21g	"	glass vial	303	69.51	69.72	67.30	1.033	1.036
21h	"	syringe residue		2.18		1.75	1.246	
21i	"	2ml syringe	303	37.17	37.17	29.38	1.265	1.265
21j	"	residue		2.84		3.01	0.944	
22	VINTEN	ISOCAL II	2244		140.52	140.76		0.998
23a	CAPINTEC	CRC-15R	260		159.51	139.05		1.147
23b	"	"	303		143.48	139.05		1.032
24	VINTEN	ISOCAL IV	1226	134.40	134.45	139.04	0.967	0.967
25	ATOMLAB	ATOM 100	cal 13.8	129.99	141.66	139.55	0.931	1.015
26	VINTEN	ISOCAL II	2467		144.72	139.50		1.037
27a	VINTEN	ISOCAL II	2244		135.74	137.73		0.986
27b	"	20ml syringe	2244		119.34	125.10		0.954
27c	"	residue	2244		12.21	12.63		0.967
28a	CAPINTEC	ARC-120	303	138.14	138.84	138.14	1.000	1.005
28b	"	"		139.81		138.14	1.012	
28c	"	10ml syringe		86.59		69.00	1.255	
28d	"	residue		70.41		69.14	1.018	
29a	CAPINTEC (2" Pb wall)	CRC-15R	303	142.16	142.28	139.33	1.020	1.021
29b	"	10ml syringe	395	175.46	141.42	131.02	1.339	1.079
29c	"	residue		4.26		8.31	0.513	
29d	"	P6 vial	265	140.17	155.78	139.33	1.006	1.118
30	SIEL	BIC		147.61		138.40	1.067	
31	CAPINTEC	CRCR-15R		137.54		140.55	0.979	
32	CAPINTEC	CRCR-15R	303		141.77	139.27		1.018
33a	CAPINTEC	CRC-15R	303	139.96	140.05	138.31	1.012	1.013
33b	"	"	46111		139.98	138.31		1.012

Code	Calibrator Manufacturer	Model	Dial setting	Reported activity (MBq)		NPL activity (MBq)	Reported values	
				Preset	Dial		Preset/NPL	Dial/NPL
34	SIEL	BIC-3A		141.26		139.55	1.012	
35a	VINTEN	ISOCAL II	2244		142.58	138.92		1.026
35b	"	5ml syringe	2064		40.43	32.72		1.236
35c	"	5ml syringe	2064		40.82	33.17		1.231
35d	"	5ml syringe	2064		40.0	32.48		1.232
35e	"	0.5ml syringe	2042		2.82	2.21		1.276
35f	"	1ml syringe	2042		9.97	7.76		1.285
35g	"	20ml syringe	1997		9.43	7.59		1.242
35h	"	10ml syringe	1997		22.44	17.72		1.266
36	CAPINTEC	ARC-120R	303	138.44	138.72	138.04	1.003	1.005
37	CAPINTEC	CRC-15R	303		143.75	140.76		1.021
38	PITMAN	238	0361		162.67	138.88		1.171
39	PITMAN	238	0362		126.09	140.48		0.898
40	VINTEN	ISOCAL II		140.60		140.55	1.0004	
41a	PITMAN	270	10803	160.03	163.04	137.65	1.163	1.184
41b	"	10ml syringe	10803	163.19	163.70	129.54	1.260	1.264
41c	"	residue		9.43		8.11	1.163	
42a	VINTEN	ISOCAL II	2244		138.59	137.19		1.010
42b	"	"	0.96 vial factor applied		133.0	137.19		0.969
43	CAPINTEC	CRC-15R	303		139.54	139.60		0.999
44	AMERSHAM	ARC-120	303	142.74	142.39	140.53	1.016	1.013
45	CAPINTEC	CRC-120	303	135.79	137.07	140.53	0.966	0.975
46a	VINTEN	ISOCAL II	2244		142.07	138.92		1.023
46b	"	5ml syringe	2064		37.68	32.72		1.152
46c	"	5ml syringe	2064		37.40	33.17		1.128
46d	"	5ml syringe	2064		36.95	32.48		1.138
46e	"	0.5ml syringe	2042		2.78	2.21		1.260
46f	"	1ml syringe	2042		9.75	7.76		1.256
46g	"	20ml syringe	1997		8.63	7.59		1.137
46h	"	10ml syringe	1997		20.28	17.72		1.144
47	CAPINTEC	CRC-10BC	303	140.56	139.67	138.04	1.018	1.012
48	PITMAN	270	10803		158.52	139.05		1.140
49	CAPINTEC	CRCR-15R	303	139.16	139.28	138.95	1.002	1.002
50	SIEL	BIC-1	342	139.91	138.58	138.31	1.012	1.002
51	CAPINTEC	CRC-15R	303		141.35	139.27		1.015
52a	NE	ISOCAL III	1226	137.37	137.32	137.65	0.998	0.998
52b	"	10ml syringe		130.56		129.54	1.008	

Code	Calibrator Manufacturer	Model	Dial setting	Reported activity (MBq)		NPL activity (MBq)	Reported values	
				Preset	Dial		Preset/NPL	Dial/NPL
52c	"	residue		7.88		8.11	0.972	
53a	VINTEN	ISOCAL II	2244		131.40	137.65		0.955
53b	"	10ml syringe	2244		133.76	129.54		1.033
53c	"	residue	2244		7.62	8.11		0.940
54a	VINTEN	ISOCAL II	2244		131.79	137.19		0.961
54b	"	"	0.99 vial factor applied		130.43	137.19		0.951
55a	VINTEN	ISOCAL II	2244		134.65	137.73		0.978
55b	"	20ml syringe	2244		119.9	125.10		0.958
55c	"	residue	2244		12.01	12.63		0.951
56	AMERSHAM (CAPINTEC)	ARC-120	303	142.48	142.51	140.53	1.014	1.014
57	CAPINTEC	CRC-35R		141.34		139.55	1.013	
58	CAPINTEC	CRC-35R		137.51		139.55	0.985	
59a	CAPINTEC	CRC-10RB	303	142.53	142.55	139.04	1.025	1.025
59b	"	2ml syringe	303	49.82	49.82	37.60	1.325	1.325
59c	"	residue		103.69		101.44	1.022	
59d	"	2ml syringe	303	91.16	91.17	69.05	1.320	1.320
59e	"	residue		32.89		32.39	1.015	
59f	"	glass vial	303	34.90	34.91	36.11	0.966	0.967
59g	"	syringe residue		1.97		1.49	1.322	
59h	"	glass vial	303	69.63	69.63	67.30	1.035	1.035
59i	"	syringe residue		2.32		1.75	1.326	
59j	"	2ml syringe	303	39.07	39.08	29.38	1.330	1.330
59k	"	residue		2.86		3.01	0.950	
60	CAPINTEC	CRC-15R	303		141.77	140.76		1.007
61a	PITMAN	270	1083		160.80	139.05		1.156
61b	"	"	10930		139.01	139.05		0.9997
62	CAPINTEC	CRC-15R	303	140.15	140.07	140.53	0.997	0.997
63	CAPINTEC	CRCR-15R	303	139.57	139.52	138.95	1.004	1.004
64	CAPINTEC	CRCR-15R		141.91		140.55	1.0096	
65a	VINTEN	ISOCAL II	1226	140.19	139.99	138.45	1.013	1.011
65b	"	2.5ml syringe	1226	37.21	37.22	33.79	1.101	1.101
65c	"	residue		103.79		104.66	0.992	
66	SIEL	BIC-1	342	136.62	136.34	138.31	0.988	0.986
67	CAPINTEC (6mm Pb wall)	CRC-15R	303	135.87	136.0	139.33	0.975	0.976
68	CAPINTEC	CRC-15R	303		142.30	139.60		1.019
69	AMERSHAM	ARC-120	303	141.70	141.72	140.53	1.008	1.008

Code	Calibrator Manufacturer	Model	Dial setting	Reported activity (MBq)		NPL activity (MBq)	Reported values	
				Preset	Dial		Preset/NPL	Dial/NPL
70	CAPINTEC	CRC-15R	303	141.04	140.94	140.53	1.004	1.003
71a	CAPINTEC	CRC-15R	303	136.82	136.95	139.04	0.984	0.985
71b	"	2ml syringe	303	44.14	44.15	37.60	1.174	1.174
71c	"	2ml syringe	303	80.21	80.21	69.05	1.162	1.162
71d	"	residue		31.64		32.39	0.977	
71e	"	glass vial	303	33.83	33.83	36.11	0.937	0.937
71f	"	syringe residue		1.75		1.49	1.174	
71g	"	glass vial	303	66.73	66.73	67.30	0.992	0.992
71h	"	syringe residue		2.06		1.75	1.177	
71i	"	2ml syringe	303	34.68	34.68	29.38	1.180	1.180
71j	"	residue		2.75		3.01	0.914	
72	CAPINTEC	ARC-120R	303	138.84	139.73	138.04	1.006 *	1.012 *
73a	CAPINTEC	CRC-15R	260		158.69	139.05		1.141
73b	"	"	303		141.10	139.05		1.015
74	CAPINTEC	CRC-15R	303	137.64	137.58	138.95	0.991	0.990
75a	VINTEN	ISOCAL II		141.66		140.55	1.008	
75b	"	syringe		74.36		70.14	1.060	
75c	"	residue		71.42		70.41	1.014	
76	SIEL	BIC		145.04		138.40	1.048	
77a	NE	ISOCAL III	1226	138.95	138.90	137.65	1.009	1.009
77b	"	10ml syringe		131.55		129.54	1.016	
77c	"	residue		8.21		8.11	1.012	
78	CAPINTEC	CRC-15R		139.61		138.14	1.011	
79	PITMAN	270	10803		155.68	139.60		1.115
80a	VINTEN	ISOCAL II	2244		147.59	140.55		1.050
80b	"	"	2308		143.43	140.55		1.020
81	CAPINTEC	CRC-15R		142.98		140.48	1.018	
82a	VINTEN	ISOCAL II	1226	148.08	148.11	138.45	1.070	1.070
82b	"	2.5ml syringe	1226	36.4	36.4	33.79	1.077	1.077
82c	"	residue		110.14		104.66	1.052	
83	SIEL	BIC-1	342	138.91	134.49	138.31	1.004	0.972
84	CAPINTEC	ARC-120	303	139.75	140.76	138.31	1.010	1.018
85a	CAPINTEC	CRC-15R	303		139.81	137.19		1.019
85b	"	3ml syringe	303		65.61	53.13		1.235
85c	"	"	0.83 syringe factor applied		54.38	53.13		1.024
85d	"	residue	303		85.93	84.06		1.022
86	CAPINTEC	CRC-15R	303	143.43	143.43	140.53	1.021	1.021

Code	Calibrator Manufacturer	Model	Dial setting	Reported activity (MBq)		NPL activity (MBq)	Reported values	
				Preset	Dial		Preset/NPL	Dial/NPL
87	CAPINTEC	CRC-10BC		143.46		139.55	1.028	
88	CAPINTEC	CRC-15R	303	138.36	138.36	138.04	1.002	1.002
89a	VINTEN	ISOCAL III	2250		159.71	139.05		1.149
89b	"	"	2467		145.35	139.05		1.045
90a	CAPINTEC	CRC-30	303		138.13	138.45		0.998
90b	"	2.5ml syringe	303		44.16	33.79		1.307
90c	"	residue	303		102.10	104.66		0.976
91	PTW	CURIEMENTOR E	4.50		125.94	138.40		0.910
92	VINTEN	ISOCAL IV	11083		138.71	138.31		1.003
93	CAPINTEC unshielded	CRC-15R	303	135.50	135.50	139.33	0.973	0.973
94	CAPINTEC	CRC-15R (non-standard liner)		135.43		138.14	0.980	
95a	VINTEN	ISOCAL II	2244		140.89	139.50		1.010
95b	"	10ml in P6 vial	2244		140.64	139.50		1.008
96	CAPINTEC	CRC-15R	303	141.17	141.22	140.53	1.005	1.005
97	SIEL	D CAL 1		141.55		140.48	1.008	
98	CAPINTEC	CRC-15R		139.40		138.40	1.007	
99a	CAPINTEC	CRC-10B	303		144.68	137.19		1.055
99b	"	"	0.89 vial factor applied		128.83	137.19		0.939
99c	"	3ml syringe	303		72.86	53.13		1.371
99d	"	"	0.72 syringe factor applied		52.44	53.13		0.987
99e	"	residue	0.89 vial factor applied		79.57	84.06		0.947
100	VEENSTRA	VDC 202	652	139.28	138.32	138.31	1.007	1.0001
101	PTW	CURIEMENTOR 2	357		182.81	138.40		1.320
102	PITMAN	270	10803		162.35	139.60		1.163
103	CAPINTEC	CRC-712M	303		146.6	140.53		1.043
104	CAPINTEC	CRC-35R		137.23		139.55	0.983	
105	VINTEN	ISOCAL II	2276		141.67	140.48		1.008
106	VEENSTRA	VDC 202	645	138.39	139.00	138.31	1.001	1.005
107	CAPINTEC unshielded	CRC-15R	303	138.82	138.69	139.33	0.996	0.995
108	AMERSHAM	ARC-120	303	133.52	134.56	140.53	0.950	0.950
109	VINTEN	ISOCAL II	2244		140.55	139.05		1.011

Table 3. Results summarised by calibrator and container

DATA GROUPS		0.85 to 0.90	0.90 to 0.95	0.95 to 1.00	1.00 to 1.05	1.05 to 1.10	1.10 to 1.15	1.15 to 1.20	1.20 to 1.25	1.25 to 1.30	1.30 to 1.37
ALL DATA	(total: 279 results)	1	11	62	119	14	15	15	10	19	13
P-6 VIAL DATA (4ml solution only)		1	5	44	97	9	6	5	-	-	1
	PRESET DATA	-	2	25	55	6	-	1	-	-	-
	DIAL DATA	1	3	19	42	3	6	4	-	-	1
RESIDUE DATA		-	4	9	9	1	2	1	-	-	-
SYRINGE DATA		-	-	3	8	4	6	9	10	19	12
OTHER CONTAINERS		-	2	6	5	-	1	-	-	-	-
CHAMBER DATA (4ml solution only)											
	CAPINTEC 10	-	1	-	5	1	-	-	-	-	-
	CAPINTEC 15	-	-	18	36	-	3	-	-	-	-
	CAPINTEC 30	-	-	1	-	-	-	-	-	-	-
	CAPINTEC 35	-	-	2	1	-	-	-	-	-	-
	CAPINTEC 120	-	-	4	19	-	-	-	-	-	-
	CAPINTEC 712	-	-	-	1	-	-	-	-	-	-
	ISOCAL II/PITMAN 238	1	2	7	17	4	-	1	-	-	-
	ISOCAL III	-	-	4	4	-	1	-	-	-	-
	ISOCAL IV	-	-	2	1	-	-	-	-	-	-
	PITMAN 270	-	-	1	-	-	2	4	-	-	-
	PITMAN 238	1	-	-	-	-	-	1	-	-	-
	SIEL	-	-	5	8	3	-	-	-	-	-
	PTW	-	1	-	-	-	-	-	-	-	1
	VEENSTRA	-	-	-	4	1	-	-	-	-	-
	ATOMLAB	-	1	-	1	-	-	-	-	-	-

Table 4. Reported uncertainties

Participants	Type A uncertainty (random)	Type B uncertainty (non-random)	Overall uncertainty
a1	1%	3.1%	3.3%
a2	1%	3.1%	3.3%
a3	1%	3.1%	3.3%
b1	0.04%	not quoted	0.04%
b2	0.09%	not quoted	0.09%
b3	0.003%	not quoted	0.003%
c1	0.3%	not quoted	not quoted
c2	0.3%	not quoted	not quoted
c3	0.6%	not quoted	not quoted
c4	0.43%	not quoted	not quoted
d1	0.2%	2.0%	2.0%
d2	0.2%	2.0%	2.0%
d3	0.12%	not quoted	not quoted
e1	0.183%	not quoted	not quoted
e2	0.158%	not quoted	not quoted
e3	0.195%	not quoted	not quoted
e4	0.109%	not quoted	not quoted
f1	0.06%	not quoted	not quoted
f2	0.07%	not quoted	not quoted
f3	0.06%	not quoted	not quoted
f4	0.4%	not quoted	not quoted
f5	0.05%	not quoted	not quoted
g1	0.04%	2 1%	2.1%
g2	0.04%	2.1%	2.1%
g3	0.04%	2.1%	2.1%
h1	0.3%	not quoted	5.0%
h2	0.3%	3.1%	5.0%
h3	0.3%	0.1%	5.0%
h4	0.3%	2.0%	5.0%

Participants	Type A uncertainty (random)	Type B uncertainty (non-random)	Overall uncertainty
i1	0.4%	not quoted	not quoted
i2	0.7%	not quoted	not quoted
j1	0.01%	1.36%	1.36%
j2	0.01%	3.0%	3.0%
j3	0.01%	1.36%	1.36%
j4	0.01%	3.0%	3.0%
k1	1.0%	3.7%	3.8%
k2	1.3%	0.5%	1.4%
k3	0.2%	1.3%	1.3%
k4	0.6%	2.7%	2.8%
k5	0.5%	3.4%	3.4%
k6	0.5%	0.5%	0.7%
l1	0.78%	1.0%	1.0%
l2	0.2%	1.0%	1.04%
l3	0.32%	1.0%	1.04%
l4	0.28%	1.0%	1.04%
l5	0.23%	1.0%	1.03%
l6	not quoted	1.0%	1.0%
m1	1.6%	5.8%	6.0%
m2	2.1%	5.8%	6.2%
n1	not quoted	not quoted	10.0%
n2	not quoted	not quoted	10.0%
n3	not quoted	not quoted	10.0%

Letters (e.g. f) indicate individual participants.
Numbered subsets (e.g. e1, e2) indicate different calibrators for the same participant.

Table 5. Distributions of results from past and present intercomparisons (expressed as percentage of results within given range of NPL value)

Year	Nuclide	Range	
		0.95 - 1.05	0.90 - 1.10
1981	^{125}I	13%	26%
1981	^{57}Co	52%	76%
1986	^{99m}Tc	73%	94%
1986	^{131}I	88%	95%
1996	^{67}Ga	91%	95%
1996	^{123}I	28%	62%
1997	^{111}In	84%	92%

Note: Based on "routine" containers for 1981 and 1986, and P6 vial data for 1996 and 1997

Figure 1 Variation of response with container in Capintec ARC 120

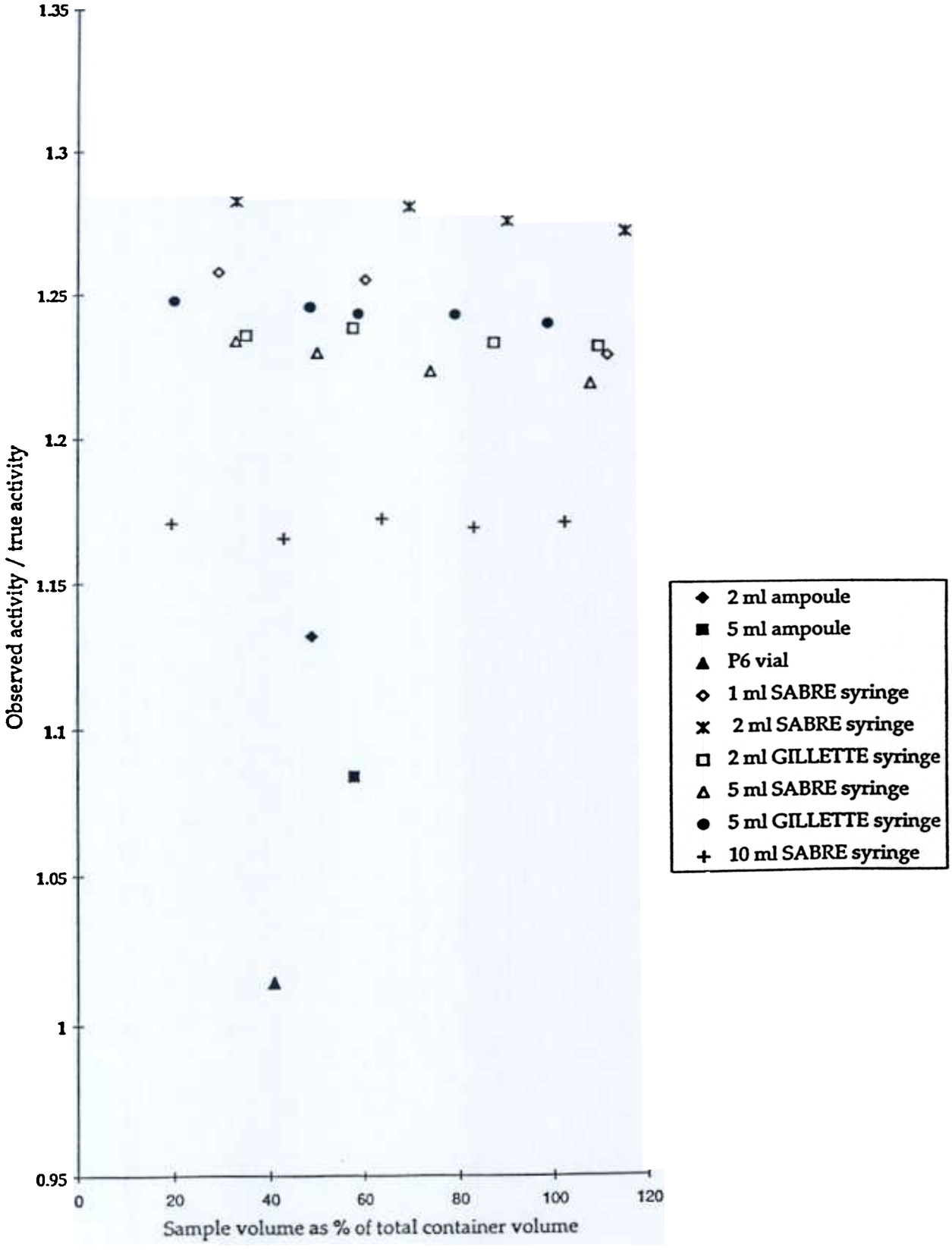


Figure 2. Distribution of results - all systems (4 ml in P6 vials)

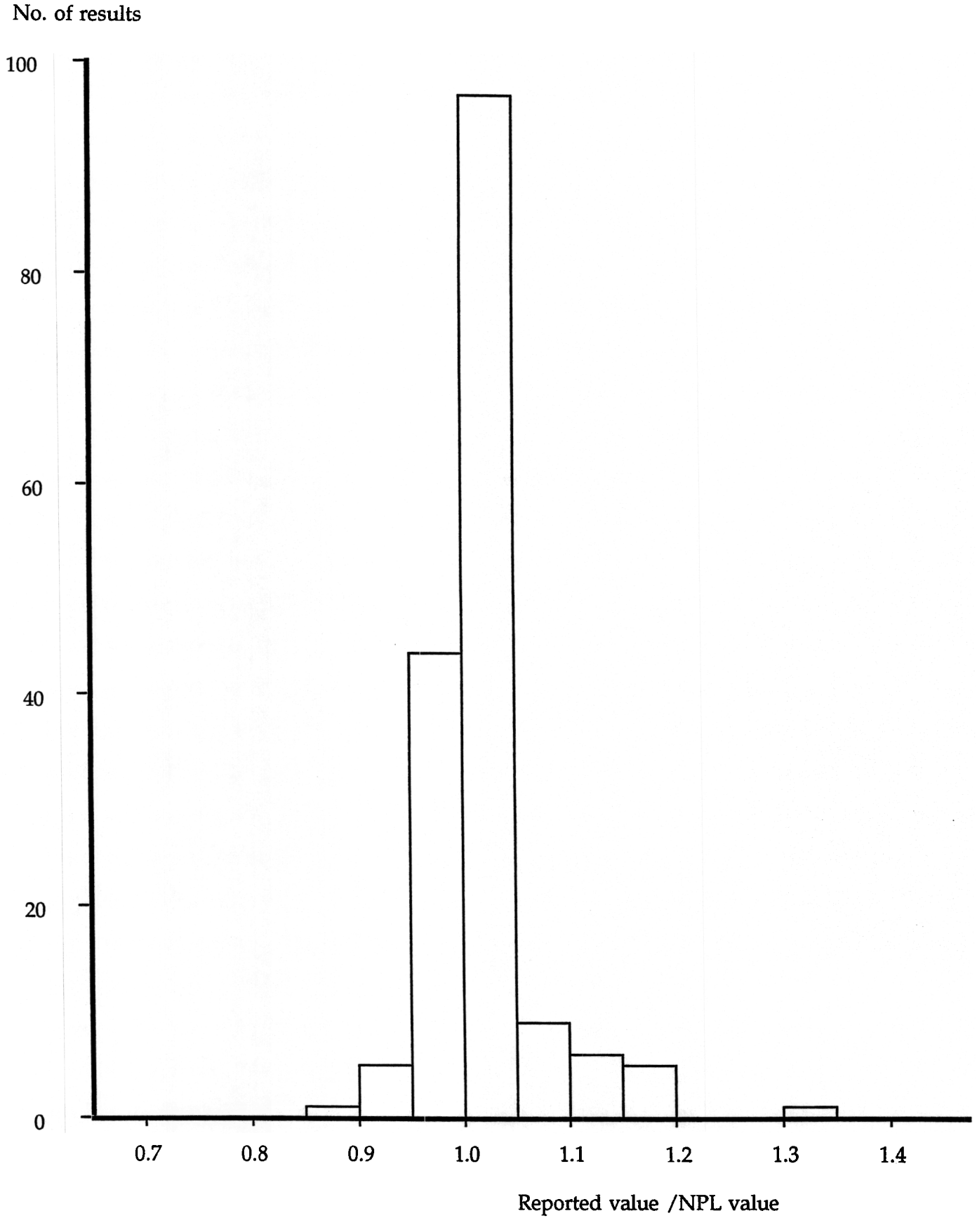


Figure 3. Distribution of results - PITMAN 270 systems (4 ml in P6 vials)

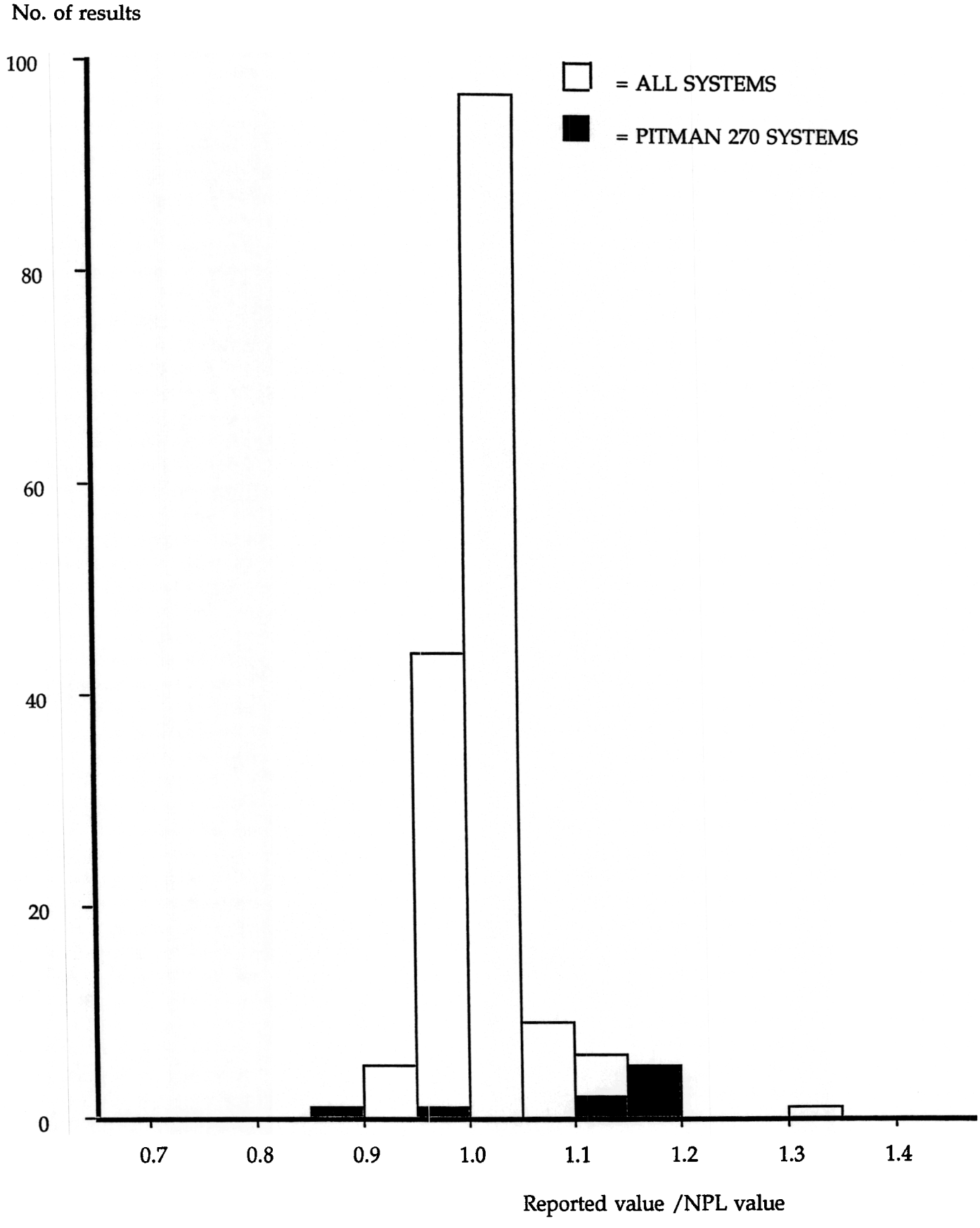
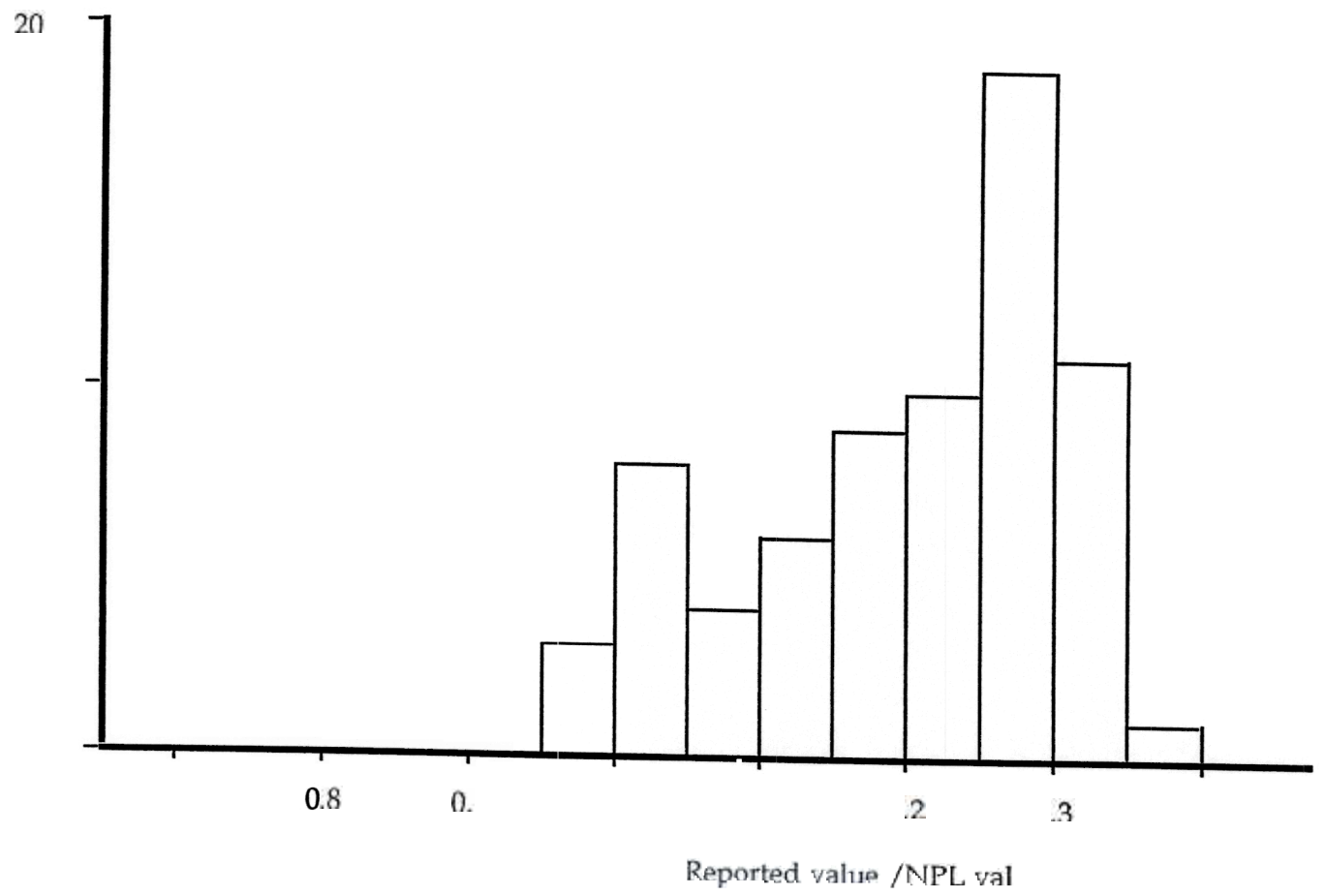


Figure 4. Distribution of results syringes



APPENDIX 1

PARTICIPANTS

Participant	Hospital
S Allen	Guys, London
R W Barber	Addenbrookes
I Belton	Leicester Royal Infirmary
N Boyce	St Mary's, Portsmouth
A Cluckie	Kings College, London
R Gadd	North Staffordshire
E Harbottle	Gloucester Royal
	Cheltenham General
P Hillel	Royal Hallamshire
	Northern General
	Western Park
S Hooper	University Hospital of Wales
I MacDonald	Glan Clwyd
McGarvie	Crosshouse, Kilmarnock
	Ayr Hospital
J Nettleton	Manchester Royal Infirmary
C Nottage	Oldchurch, Romford
	Princess Alexandra, Harlow
	Broomfield, Chelmsford
P Ormsby	Derriford, Plymouth
B Pratt	Royal Marsden, Sutton
H Rogers	Queen Elizabeth, Birmingham
D Simpson	Kent & Canterbury
A H Smith	Leeds General Infirmary
H R Stockdale	Royal Liverpool University
D Twiss	Royal Wolverhampton
R J Ward	Royal Devon and Exeter
M Wisbey	Maidstone District
	Joyce Green, Dartford
	William Harvey, Ashford
F Zananiri	Bristol General

APPENDIX 2

AMERSHAM INTERNATIONAL/NATIONAL PHYSICAL LABORATORY

INTERCOMPARISON OF ^{111}In ACTIVITY - JUNE 1997

Organisation ..... Participant .....

Address ..... Tel No.

..... Fax No.

e-mail .....

.....

Vial identifier ..... Nominal volume: 4.0 ml

Chem. form:

DETAILS OF RADIONUCLIDE CALIBRATOR (If more than one calibrator is used, please photocopy this reporting form and use a separate form for each calibrator)

Manufacturer

Model/Type

Serial No

Measurement in original container (P6 vial)

Calibration factor/dial setting used

Time of measurement (GMT) Month ..... Day ..... Hour ..... Min .....

Measured activity (after bgd subtraction) ..... MBq

If you used a preset setting, it would help to repeat the reading on the manually adjustable setting (if available) using the figure recommended by the manufacturer. Please record below.

Calibration factor/dial setting used

Time of measurement (GMT) Month ..... Day ..... Hour ..... Min .....

Measured activity (after bgd subtraction) ..... MBq

Assays are often made in different containers (e.g. syringe). If you do this routinely, it would help to make a similar measurement here. In order to check the accuracy of such an assay, we need to know how much solution was transferred from the P6 vial to the new container. This could be determined by weighing the new container empty and then after the solution has been added. An additional check would be to remeasure the P6 vial after the transfer.

Measurement in different container (please give details .....)

Mass/volume transferred ..... g or ml

Calibration factor/dial setting used

Time of measurement (GMT) Month ..... Day ..... Hour ..... Min .....

Measured activity (after bgd subtraction) ..... MBq

If you used a preset setting, it would help to repeat the reading on the manually adjustable setting (if available) using the figure recommended by the manufacturer. Please record below.

Calibration factor/dial setting used

Time of measurement (GMT) Month ..... Day ..... Hour ..... Min .....

Measured activity (after background subtraction) ..... MBq

Remeasurement of P6 vial after removal of solution

Calibration factor/dial setting used

Time of measurement (GMT) Month..... Day.....Hour.....Min.....

Measured activity (after background subtraction) ..... MBq

Uncertainties

Please provide an estimate of the uncertainty (at the 1σ level) on your measurements

Random (Type A) ± .....%, Non-random (Type B) ± .....%, Overall ± .....%

It would be useful if you could indicate below how these values were estimated

---

Please return this form (together with any additional comments you would like to add) to:

Mike Woods
Centre for Ionising Radiation and Acoustics
National Physical Laboratory
Teddington
Middlesex TW11 0LW

Tel No. 0181-943-6425
Fax No. 0181-943-6161
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