

Intercomparison of ^{123}I solution sources in UK Hospitals, 1996

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ABSTRACT

During recent years, concerns have been raised within the nuclear medicine field about the accuracy of calibrations for ^{123}I using radionuclide calibrators. Significant variations in response between different containers have been observed due to the low energy of the associated photon emissions.

To investigate the level of measurement performance for this particular radionuclide, an intercomparison exercise was conducted 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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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⁾.

During recent years, concerns have been raised within the nuclear medicine field about the accuracy of calibrations for ^{123}I using radionuclide calibrators. Anecdotal evidence has suggested that significant variations in response between different containers have been observed due to the low energy of the associated photon emissions. The photon emissions from ^{123}I are shown in Table 1 and it will be seen that about 50% of these are in the region of 27-31 keV. It is clear that small variations in wall thickness either of the sample container or of the calibrator could produce potentially large variations in response. Indeed, some centres have attempted to minimise these effects by deliberately attenuating the low energy emissions using copper inserts, a proposal first made in 1984⁽²⁾.

To investigate the level of measurement performance for this particular radionuclide, an intercomparison exercise was conducted between the National Physical Laboratory, Amersham International plc 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 18 participants is given in Appendix 1

3 INTERCOMPARISON SAMPLES

A stock solution of ^{123}I 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. Three aliquots from the same stock solution were accurately diluted and despatched to NPL for activity determinations.

At midday on the date of receipt of the samples, the activity concentration in each vial was approximately 9.5 MBq/g. The samples comprised ^{123}I as an aqueous solution of NaI with a chemistry of 0.1 mg g⁻¹ I, 0.2 mg g⁻¹ Na₂S₂O₃ and 1 mg g⁻¹ formaldehyde.

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 ^{123}I 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, the results of an international comparison exercise⁽³⁾ conducted in 1983 may be used. In that exercise, a stock solution of ^{123}I was assayed by NPL, the Laboratoire de Metrologie Rayonnements Ionisants (the French equivalent of NPL) and the Bureau Centrale de Mesures Nucleaires (the European Joint Research Centre in Belgium). The results from all three laboratories agreed to better than 0.5%.

The solutions were also examined by gamma spectrometry. This identified the presence, at the reference time, of ^{121}Te at an activity level of about 0.03% of the ^{123}I activity level. The effect of the contaminant was taken into account when determining the ^{123}I activity concentrations.

The standard uncertainty on the NPL measurements of activity were $\pm 0.85\%$ at the 68% confidence level.

As an additional contribution to the core of knowledge about the problems surrounding the assay of ^{123}I in radionuclide calibrators, a stock solution of ^{123}I 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 277. For the 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.

Details of the containers, their nominal volumes and wall thicknesses are given in Table 2. 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

All 223 reported results were decayed to the same reference time of 12.00 GMT on 18 September 1996 using a half-life of 13.2 hours⁽⁴⁾. Some of the participants reported results already decayed to the above reference time.

For each sample, the activity content was determined from the activity concentration measurements made by NPL together with the Amersham-declared dilution factors and masses dispensed to each vial. The reported results were then compared to these NPL calculations.

None of the participants reported any evidence of contaminants and the effect of the contaminant on the participants results was disregarded. The response factors for ¹²¹Te for typical ionization chambers are generally about three times greater than those for ¹²³I. Given that most measurements were made within two days of the reference time (which would produce a maximum potential error of the order of 1%) and that the vast majority were made within 24 hours, it was felt that the contaminant effect was not significant compared with the other factors affecting the results.

The results have been tabulated as ratios of reported activity to the NPL-determined value and are presented in Table 3. Summarised breakdowns by container and chamber type are given in Table 4. 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 8. An asterisk(*) in the dial setting column indicates the participant applied a self-determined correction factor.

The reported uncertainties are presented in Table 5.

8 DISCUSSION

The principal objective of the intercomparison was to investigate the accuracy of measurements of ¹²³I using typical radionuclide calibrators and containers. Concerns had also been expressed about potential linearity (with activity) problems with a particular model of calibrator. Although some participants made measurements over several half-life periods, no evidence emerged to support this concern.

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 ^{123}I is 15%.

It will be seen from the results in Figure 1, that none of the containers provides a correct assay using the recommended Calibration Setting Number. For the syringes, correction factors of between 20% to 60% are required compared with the suggested value of 15%.

8.2 P6 VIAL DATA

The overall data, Figure 2, shows that the results are on average about 10% lower than the true value.

Interestingly, the "dial" results appear to be a few percent more accurate than the "preset" results. In many calibrator systems, the overall gain of the system can be adjusted using a check source: this would generally ensure that settings which are manually inserted (dial settings) are automatically compensated for any electronic drift. The preset options usually have an additional and individual adjustment facility which needs to be checked and may, or may not if factory sealed, be adjustable. It is not unexpected therefore that quality control procedures might not provide as much guarantee of accuracy for preset options as they should for dial settings.

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

8.2.1 CAPINTEC Systems

Capintec chambers provide results (see Figure 3) which are, on average, 10% lower than the true value. In addition, the spread of results is of the order of 40%.

In the light of the statements in the User Manual and the experimental evidence presented here, the general underestimation of activity is understandable but it is not clear that users generally are aware of the problems arising from the fact that the Calibration Setting Number is for a container which nobody uses in practice for routine assays.

More worrying is the very large spread of results. There is no obvious reason for this but a possible cause could be variations in wall thickness of the internal well between individual calibrators. However, without a detailed knowledge of the production tolerance on the wall thickness, it is not possible to pinpoint this as the cause. This spread also makes it impossible to provide a standard correction factor to the published Calibration Setting Number. The only resolution is for each user to conduct a recalibration exercise for each of their chambers.

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 for 27 keV emissions is less than 6%. Each production chamber must pass a stringent test programme at NPL and, from these measurements, it has been seen that ISOCAL IV chambers are invariably within $\pm 3\%$ of the published response factor at 27 keV. This is reflected in the results, in Figure 4, which show that all the reported values were within the $\pm 3\%$ range.

SIEL Systems

The SIEL systems (see Figure 5) show a spread of about 30% with half of the results lying within $\pm 5\%$ of the true value. The spread well may be attributable to the same cause suggested for the Capintec systems although there is no concrete evidence to support this view.

ISOCAL II systems

This uses an unsealed ionization chamber and hence is subject to pressure and temperature variations. In the previous exercise on ^{67}Ga , these chambers were seen to be giving activity estimates which were about 10% low. In this exercise, the opposite seems to be occurring, see Figure 6, with overestimates of the order of 10%, again with a spread of about 30%. This chamber is no longer available commercially and there is no evidence available from the original manufacturers on the quality of the calibration process but the evidence from this and the previous intercomparison seem to suggest that users would be well advised to check the accuracy of the calibrations for all the radionuclides they assay.

Other systems

The other systems used, with the exception of a couple of extreme outlier results as shown in Figure 7, seem to perform reasonably well.

8.3 SYRINGE DATA

It is clear that, because of the low energy emissions from ^{123}I , the responses from calibrators will be significantly greater for sources in plastic containers than for those constructed from glass. Figure 1 illustrates this point to great effect.

In Figure 8, the syringe results have been displayed pictorially. A 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 those who recalibrated have achieved a significantly better performance. The "recalibrated" results centre about the "1.0" value whilst the unadjusted results centre about 30% high. However, it is interesting to note that both sets of syringe results have spreads of the order of 35%. This is similar to the spreads observed with P6 vials measured in some of the calibrators. This begs the same question as raised before about variations in calibrator wall thicknesses.

An additional point to consider is that most, if not all, of these recalibrations will probably have been made using solutions which were characterised in-house. The P6 vial data shows that many of those in-house assays may have been in error themselves and these errors would obviously propagate into the syringe factors. It would be interesting to see, if the results of this intercomparison were fed back into the original recalibration calculations, whether those syringe results would have a smaller spread centred about the "1.0" value.

8.3.1 CAPINTEC systems

It is clear that the syringe correction factor recommended in the User Manual should not be used if accurate results are required: it should only be regarded, as the Manual states, as a guide. The experimental data illustrates the fact that a single correction factor is not suitable and that factors should be derived for each syringe type.

ISOCAL IV systems

Syringe calibration factors have not been established for these systems precisely because of the large variation in syringe types. The User Manual recommends the user should determine their own factors and provides advice on how to do this.

Other systems

The authors have no knowledge of manufacturers guidance for these systems.

8.4 COPPER INSERTS

As mentioned previously, some centres have attempted to minimise the effects of the low energy emissions. This has been achieved by manufacturing a copper insert which is placed between the source and the ionization chamber. The low energy emissions are significantly attenuated compared with the higher energy emissions and consequently any variations in the low energy response contribute little to the overall response. The users have then carried out a recalibration exercise and determined new calibration factors for their chambers. Two centres which had done this reported results. One centre just reported results with the copper insert and produced a ratio value of 1.010 for the P6 vial. The other centre presented results for both the copper insert and also without the insert and using the manufacturers recommended calibration factor. Interestingly, the non-insert value for the P6 vial was 0.968 whilst, with the insert, the value was 1.122!

8.5 USER-GENERATED CALIBRATION FACTORS

As evidenced by the "copper insert" comments above, some centres have had cause to suspect the accuracy of some of the manufacturers recommended calibration factors. They have either sought radical approaches, as above, or recalibrated using either standards or the values provided by the suppliers of their ^{123}I . It is well known, however, that suppliers will often provide stocks which are at or very close to the maximum of their tolerance levels: for example, a nominal "100 MBq" from one supplier will generally be more likely to be 110 MBq. On the other hand, occasionally supplies have been seen to be at the bottom end of the tolerance level. It will be seen therefore that recalibrating using suppliers' nominal values is not to be recommended.

8.6 UNCERTAINTIES

The response to the request for estimates of uncertainty produced more contributions than the previous exercise but the same comments apply as before: the methods of estimation and combination of individual contributions shows no consistency. Certainly the reported uncertainties are too small to account for the spread of results. Basically more attention needs to be given to this aspect of measurement and it would perhaps be appropriate for NPL to provide some advice.

8.7 COMPARISON WITH PREVIOUS EXERCISES

Since 1980, five radionuclides have been intercompared prior to this exercise, namely, $^{57}\text{Co}^{(6)}$, $^{125}\text{I}^{(6)}$, $^{99\text{m}}\text{Tc}^{(7)}$, $^{131}\text{I}^{(7)}$ and $^{67}\text{Ga}^{(8)}$. The last intercomparison, with ^{67}Ga , 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 $\pm 5\%$ and

$\pm 10\%$ of the NPL value. That position, as shown in Table 6, has been reversed quite dramatically with ^{123}I .

It must be recognised, however, that there are particular problems associated with the assay of this radionuclide. It would be unreasonable, therefore, to assume that the results of this intercomparison are a reflection of the measurement performance to be expected with other radionuclides.

9 CONCLUSIONS

The exercise has clearly been beneficial in justifying the concerns about the accuracy of calibrations for ^{123}I . The authors propose the following conclusions.

- (a) The spreads of results for both P6 vials and syringes are unacceptably large.

These spreads may be due to the production tolerances on the wall thicknesses of particular calibrators.

- (c) Some recommended calibration factors are not applicable to P6 vials and recalibrations are required.

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 of ISOCAL II systems should consider the advisability of checking the accuracy and traceability of all their calibration factors.
- (f) Users should ensure that their quality assurance procedures check the accuracy of their preset options on a regular basis.
- (g) For syringes, recommended 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.
- (h) The reporting and understanding of uncertainties is poor. The user community should consider the significance of this and NPL should consider providing relevant advice.
- (i) Another intercomparison of ^{123}I should be conducted in the near future, after users have had time to digest the results of this exercise and perform suitable recalibrations.

10 ACKNOWLEDGEMENTS

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Table 1.

Photon Emissions from ¹²³I

Photon Energy (keV)	Emission Proability (%)
27.2	24.7
27.4	45.9
30.9	13.2
31.7	2.7
158.97	83.3
440.02	0.4
528.96	1.4

Table 2.

Details 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	1	1.27
Plastic syringe (A)	5	1.30
Plastic syringe (B)	5	1.25
Plastic syringe	10	1.50

Table 3. 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	279	38.45	38.48	38.09	1.009	1.010
2a	CAPINTEC	CRC-15R	220		37.51	38.10		0.985
2b		"	277		31.49	38.10		0.827
2c		syringe	420		8.21	9.93		0.827
2d		syringe	277		11.57	9.93		1.165
2e		residue	220		27.75	28.17		0.985
2f		residue	277		23.27	28.17		0.826
3a	CAPINTEC	CRC-15R	277		37.1	38.33		0.968
3b		"	Cu46		43.0	38.33		1.122
3c		syringe 2ml	Cu46		10.1	9.11		1.109
3d		residue 3ml	Cu46		32.5	29.22		1.113
3e		syringe 5ml	Cu46		27.4	24.39		1.123
3f		residue 0.5ml	Cu46		5.1	4.83		1.056
4	SIEL	BIC	278		42.90	38.57		1.112
5a	VINTEN	ISOCAL III	1506	39.32	39.27	38.56	1.020	1.018
5b		"	*	41.52	41.47	38.56	1.077	1.075
5c		syringe 5ml		20.996		19.03	1.103	
6a	CAPINTEC	CRC-15R	277	33.02	33.05	38.81	0.851	0.852
6b		syringe 2ml	277	6.63	6.64	5.58	1.188	1.190
6c		residue	277		28.27	33.23		0.851
7a	CAPINTEC	ARC-10BC	255		35.88	38.05		0.943
7b		"	277		33.58	38.05		0.883
8a	VINTEN	ISOCAL II	1430		58.97	39.3		1.501
8b		"	2281		36.78	39.3		0.936
9a	CAPINTEC	ARC-120	277	30.09	36.28	39.48	0.762	0.919
9b		"	277	29.95	36.10	39.48	0.759	0.914
9c		"	277	30.39	36.47	39.48	0.770	0.924
9d		"	277	30.37	36.47	39.48	0.770	0.924
9e		"	277	30.51	36.80	39.48	0.773	0.932
9f		"	277	30.62	36.99	39.48	0.776	0.937
10	SIEL	BIC-1	253	39.14	39.24	38.09	1.028	1.030
11a	SIEL	BIC-3P		33.44		37.97	0.881	
11b		"		33.65		37.97	0.886	
11c		"		33.78		37.97	0.890	
11d		"		33.43		37.97	0.880	
11e		"		33.35		37.97	0.878	
11f		syringe 5ml	5000	49.92	34.45	37.13	1.344	0.928
11g		residue		0.74		0.84	0.881	

Code	Calibrator Manufacturer	Model	Dial Setting	Reported activity (MBq)		NPL activity (MBq)	Reported values	
				Preset	Dial		Preset/NPL	Dial/NPL
12	CAPINTEC	CRC-15R	277	33.84	33.84	38.14	0.887	0.887
13	PTW	CURIEMENTOR	352	38.40	38.44	38.57	0.996	0.997
14	VINTEN	ISOCAL II	1238		43.36	38.33		1.131
15a	CAPINTEC	ARC-120	277	35.95	35.97	39.46	0.911	0.912
15b		syringe 2ml		13.15		9.77	1.346	
15c		syringe 5ml		25.25		19.36	1.304	
15d		residue		9.28		10.33	0.898	
16	CAPINTEC	CRC-15R	239		40.02	38.57		1.038
17	VINTEN	ISOCAL II	506	38.05	38.05	38.10	0.999	0.999
18	CAPINTEC	CRC-10BC	270	33.80	33.82	37.97	0.890	0.891
19	CAPINTEC	CRC-15R	277	35.64	35.67	39.48	0.903	0.903
20a	CAPINTEC	CRC-15R	277	35.24	35.18	39.67	0.888	0.887
20b		syringe 3ml	277	26.92	26.78	20.35	1.323	1.316
20c		residue	277	17.58	17.58	19.32	0.910	0.910
21	VINTEN	ISOCAL II	1300		42.96	39.3		1.093
22a	CAPINTEC	CRC-15R	277	33.9	33.04	38.81	0.853	0.851
22b		syringe 2ml	277	6.74	6.73	5.58	1.208	1.206
22c		residue	277		28.23	33.23		0.850
23	SIEL	BIC-1	259	39.23	39.36	38.09	1.030	1.033
24	VINTEN	ISOCAL II	1314	41.68	41.21	39.46	1.056	1.044
25	VINTEN	ISOCAL II	1300	42.9	42.93	38.57	1.112	1.113
26	VEENSRTA	VDC-202	537	38.43	39.46	38.09	1.009	1.036
27	ATOMLAB	Atomlab 100	157	30.07	36.66	37.97	0.792	0.966
28	CAPINTEC	ARC-120	277	37.26	37.23	39.75	0.937	0.937
29a	CAPINTEC	CRC-15R	277	33.97	33.40	38.09	0.892	0.877
29b		"	4123		33.40	38.09		0.877
29c		"	240		37.82	38.09		0.993
30a	CAPINTEC	ARC-120	277	36.12	36.20	38.56	0.937	0.939
30b		"	"	40.9	41.0	38.56	1.061	1.063
30c		syringe 5ml	277	24.05	24.07	19.03	1.264	1.265
30d		syringe 2ml		13.24		10.14	1.306	
30e		"		10.68		10.14	1.053	
31	CAPINTEC	CRC-15R	277	35.62	35.65	38.57	0.924	0.924
32a	CAPINTEC	CRC-15R	277	36.74	36.72	39.48	0.931	0.930
32b		"	277	36.76	36.79	39.48	0.931	0.932
32c		"	277	36.88	36.88	39.48	0.934	0.934
32d		"	277	37.02	36.58	39.48	0.938	0.927
32e		"	277	37.12	37.26	39.48	0.940	0.944

Code	Calibrator Manufacturer	Model	Dial Setting	Reported activity (MBq)		NPL activity (MBq)	Reported values	
				Preset	Dial		Preset/NPL	Dial/NPL
32f		"	277	37.10	37.14	39.48	0.940	0.941
33	PITMAN	270	10367		38.21	39.3		0.972
34a	CAPINTEC	CRC-15R	192		47.22	38.65		1.222
34b		"	277		36.02	38.65		0.932
34c		syringe 3ml	400		17.10	17.03		1.004
34d		syringe 3ml	277		23.03	17.03		1.352
34e		residue	192		26.37	21.62		1.220
35	SIEL	BIC-1	249	37.86	39.2	38.09	0.994	1.024
36a	CAPINTEC	CRC-15R	277	35.94	35.94	38.09	0.944	0.944
36b		"	4123		35.97	38.09		0.944
37	VINTEN	ISOCAL IV	0506	39.99	39.97	39.75	1.006	1.006
38a	CAPINTEC	ARC-120	277	33.53	33.84	39.48	0.849	0.857
38b		"	277	34.53	34.94	39.48	0.875	0.885
38c		"	277	34.95	35.35	39.48	0.885	0.895
38d		"	277	34.83	35.30	39.48	0.882	0.894
38e		"	277	35.69	36.16	39.48	0.904	0.916
38f		"	277	34.73	35.22	39.48	0.880	0.892
39	CAPINTEC	CRC-15R	277	33.72	33.64	38.14	0.884	0.882
40a	CAPINTEC	CRC-15R	CAL45		39.02	38.62		1.010
40b		syringe 2ml	CAL45		10.13	9.96		1.017
40c		25ml plastic bottle	CAL45		10.04	9.84		1.020
40d		10ml glass bottle	CAL45		9.00	8.85		1.017
41	SIEL	BIC-1	317	37.75	37.84	38.09	0.991	0.993
42a	CAPINTEC	CRC-15R	277	32.56	32.59	38.56	0.844	0.845
42b		"	"	41.74	41.77	38.56	1.082	1.083
42c		syringe 5ml	277	21.74	21.74	19.03	1.142	1.142
42d		syringe 2ml		11.80		10.14	1.164	
42e		"		10.67		10.14	1.052	
43	CAPINTEC	CRC-15R		36.35		39.46	0.921	
44a	CAPINTEC	ARC-120	277	35.32	35.54	38.05	0.928	0.934
44b		SORIN VIAL		37.16		37.85	0.982	
44c		residue		0.19		0.20	0.950	
45	SIEL	BIC	278		40.75	38.57		1.057
46a	CAPINTEC	CRC-15R	CU46		42.5	38.33		1.109
46b		"	277		37.2	38.33		0.971
47a	VINTEN	ISOCAL II	1300		39.64	38.11		1.040
47b		plastic bottle	1300		43.12	33.22		1.298
47c		residue	1300		4.34	4.89		0.888

Code	Calibrator Manufacturer	Model	Dial Setting	Reported activity (MBq)		NPL activity (MBq)	Reported values	
				Preset	Dial		Preset/NPL	Dial/NPL
48	VINTEN	ISOCAL II	1238		42.53	38.33		1.110
49a	CAPINTEC	ARC-120R	277	37.35	37.49	38.81	0.962	0.966
49b		syringe 2ml	277	7.76	7.77	5.58	1.391	1.392
49c		residue	277		31.92	33.23		0.961
50	VINTEN	ISOCAL II		40.64		39.3	1.034	
51	VINTEN	ISOCAL II	1300	42.67	42.77	39.75	1.073	1.076
52	SIEL	BIC-1	317	37.17	37.2	38.09	0.976	0.977
53a	CAPINTEC	CRC-120R	277	38.46	38.39	38.81	0.991	0.898
53b		syringe 2ml	277	7.98	7.99	5.58	1.430	1.432
53c		residue	277		32.44	33.23		0.976
54a	CAPINTEC	CRC-10RB	277	35.53	35.36	38.56	0.921	0.917
54b		"	*	41.28	41.28	38.56	1.071	1.071
54c		syringe 5ml	277	25.26	25.10	19.03	1.327	1.319
54d		syringe 2ml		13.82		10.14	1.363	
54e		"		10.68		10.14	1.053	
55	VEENSRTA	VDC-202	551	38.42	38.52	38.09	1.009	1.011
56	CAPINTEC	CRC-15R	277	33.32	33.34	38.14	0.874	0.874
57	CAPINTEC	10-BC	277	35.54	35.57	39.48	0.900	0.901
58a	SIEL	BIC-1		32.87		37.97	0.866	
58b		"		32.61		37.97	0.859	
58c		"		32.38		37.97	0.853	
58d		"		32.29		37.97	0.851	
58e		"		32.16		37.97	0.847	
58f		syringe 5ml	495	48.61	32.27	37.13	1.310	0.869
58g		residue		8.61		0.84	10.25	
59	VINTEN	ISOCAL II	1238		44.16	38.33		1.152
60	VINTEN	ISOCAL IV	04466		38.38	38.09		1.008
61a	CAPINTEC	CRC-15R	210		42.15	38.10		1.106
61b		"	277		34.28	38.10		0.900
62	PTW	CURIEMENTOR		36.82		38.57	0.955	
63a	VINTEN	ISOCAL IV	1506	37.51	37.48	38.56	0.973	0.972
63b		"	*	37.74	37.71	38.56	0.979	0.978
63c		syringe 5ml		20.30		19.03	1.067	
64a	PITMAN	270	10367		62.24	39.3		1.58
64b		"	10610		37.49	39.3		0.954
65a	VINTEN	ISOCAL II	1300		37.9	38.11		0.994
65b		plastic bottle	1300		39.53	33.22		1.190
65c		residue	1300		4.04	4.89		0.826

Table 4. Results summarised by calibrator and container

		Numbers of ratio results (reported value/NPL value) in given ranges															
DATA GROUPS		0.75 to 0.80	0.80 to 0.85	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 1.35	1.35 to 1.40	1.40 to 1.58	>1.58	
		7	9	44	46	29	25	18	14	6	4	3	9	4	4	1	
ALL DATA																	

Table 5. Reported uncertainties

Participants	Type A uncertainty (random)	Type B uncertainty (non-random)	Overall uncertainty
a	0.6%	0%	0.6%
b	0.1%	not quoted	>1%
c1	0.2%	1.4%	1.4%
c2	0.2%	1.5%	1.5%
c3	0.2%	2.8%	2.8%
d1	0.15%	not quoted	not quoted
d2	0.06%	not quoted	not quoted
d3	0.1%	not quoted	not quoted
e1	0.1%	not quoted	not quoted
e2	0.02%	not quoted	not quoted
e3	0.03%	not quoted	not quoted
f	1.0%	2.0%	2.2%
g1	0.18%	5.0%	5.0%
g2	0.17%	1.12%	1.13%
g3	0.12%	4.57%	4.57%
g4	0.41%	1.29%	1.35%
h1	0.1%	0%	0.1%
h2	0.05%	0%	0.05%
i	not quoted	not quoted	15% for syringe

Letters (e.g. f) indicate individual participants.

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

Table 6. Distributions of results from past and present intercomparisons
(expressed as percentage of results within given range of NPL value)

		Range	
Year	Nuclide	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%

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

Figure 1 Variation of response with container in Capintec ARC 120

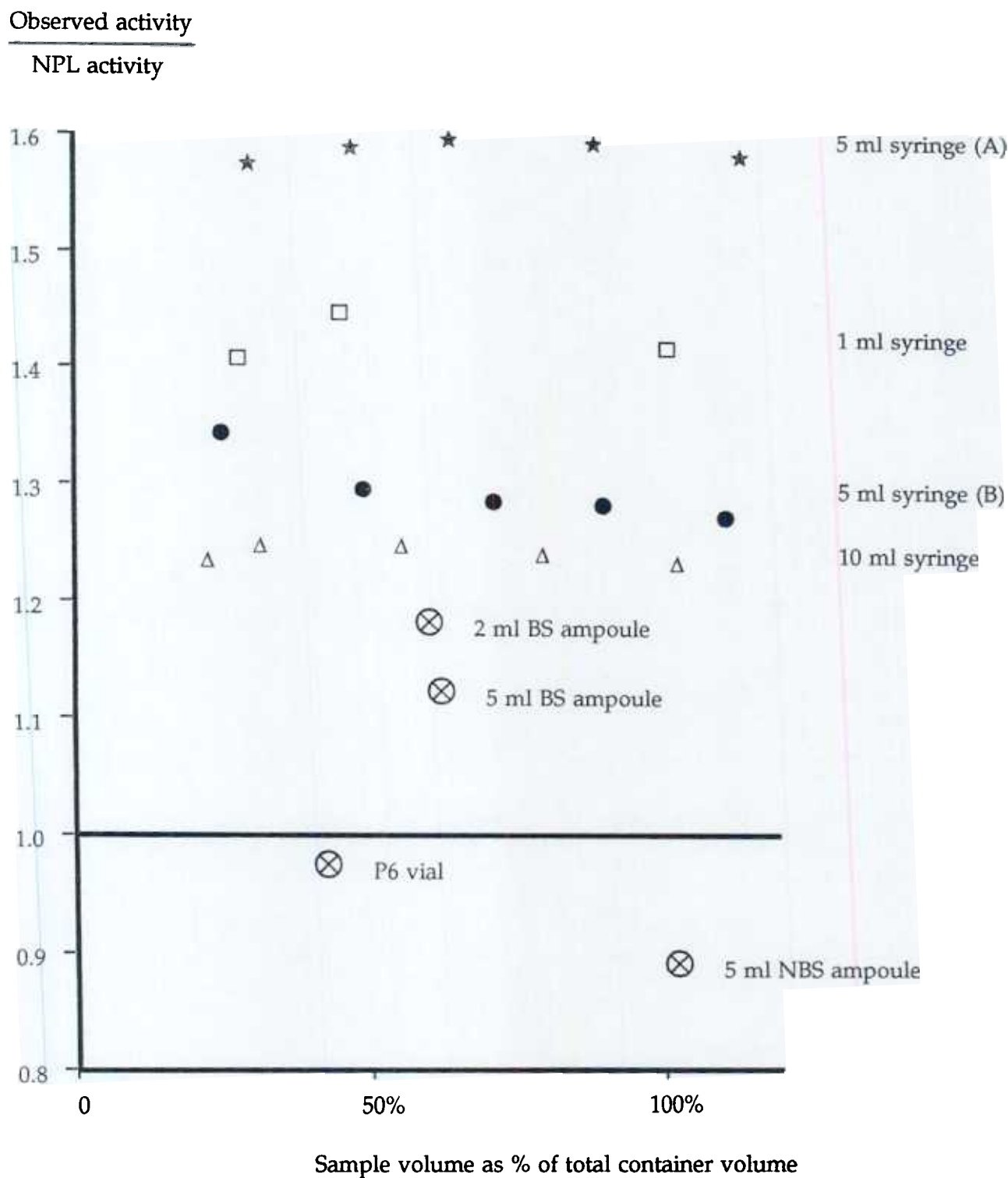


Figure Distribution of results (4 ml solution only in P6 vials

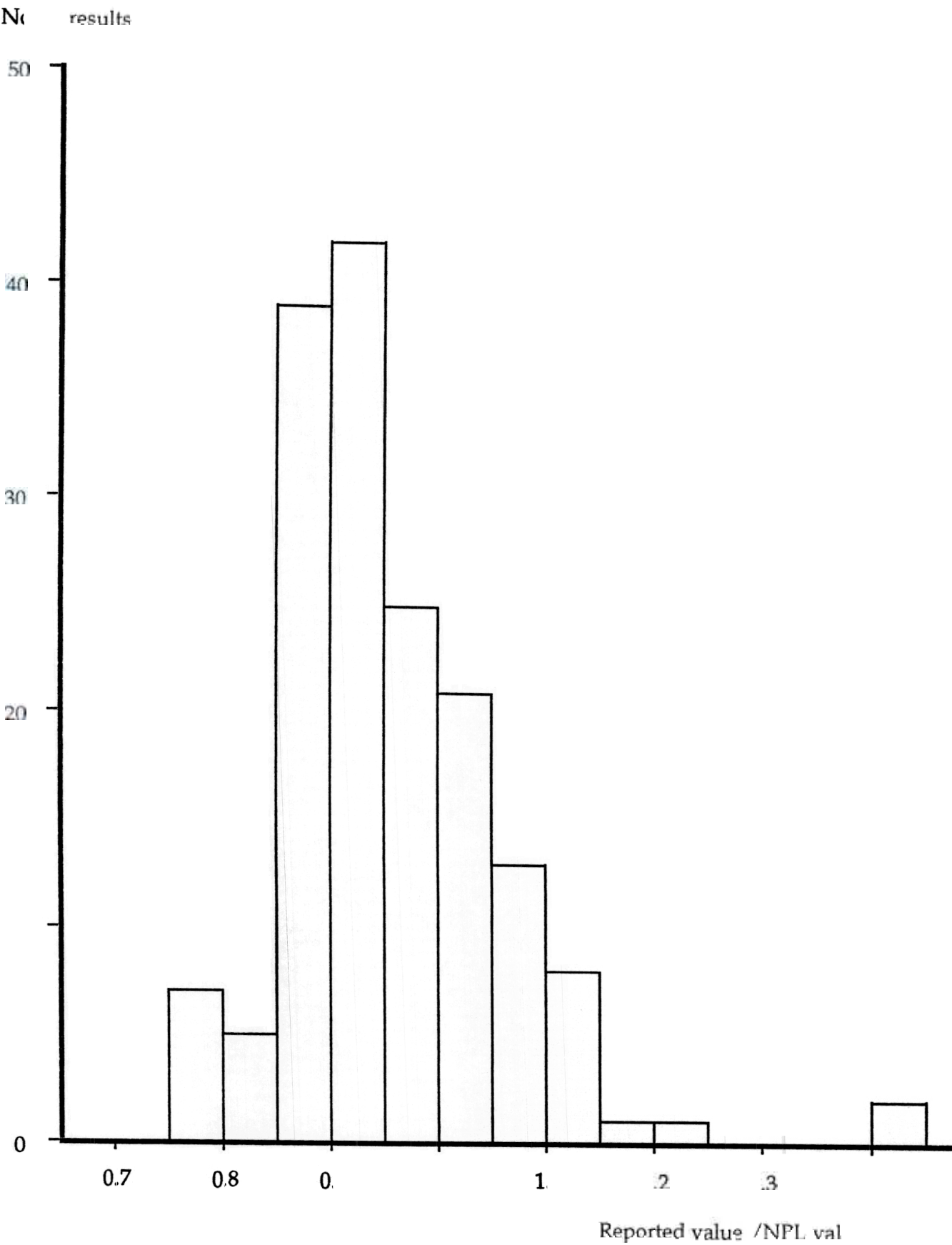


Figure 3 Distribution of results (4 ml solution only in P6 vials) - CAPINTEC SYSTEMS

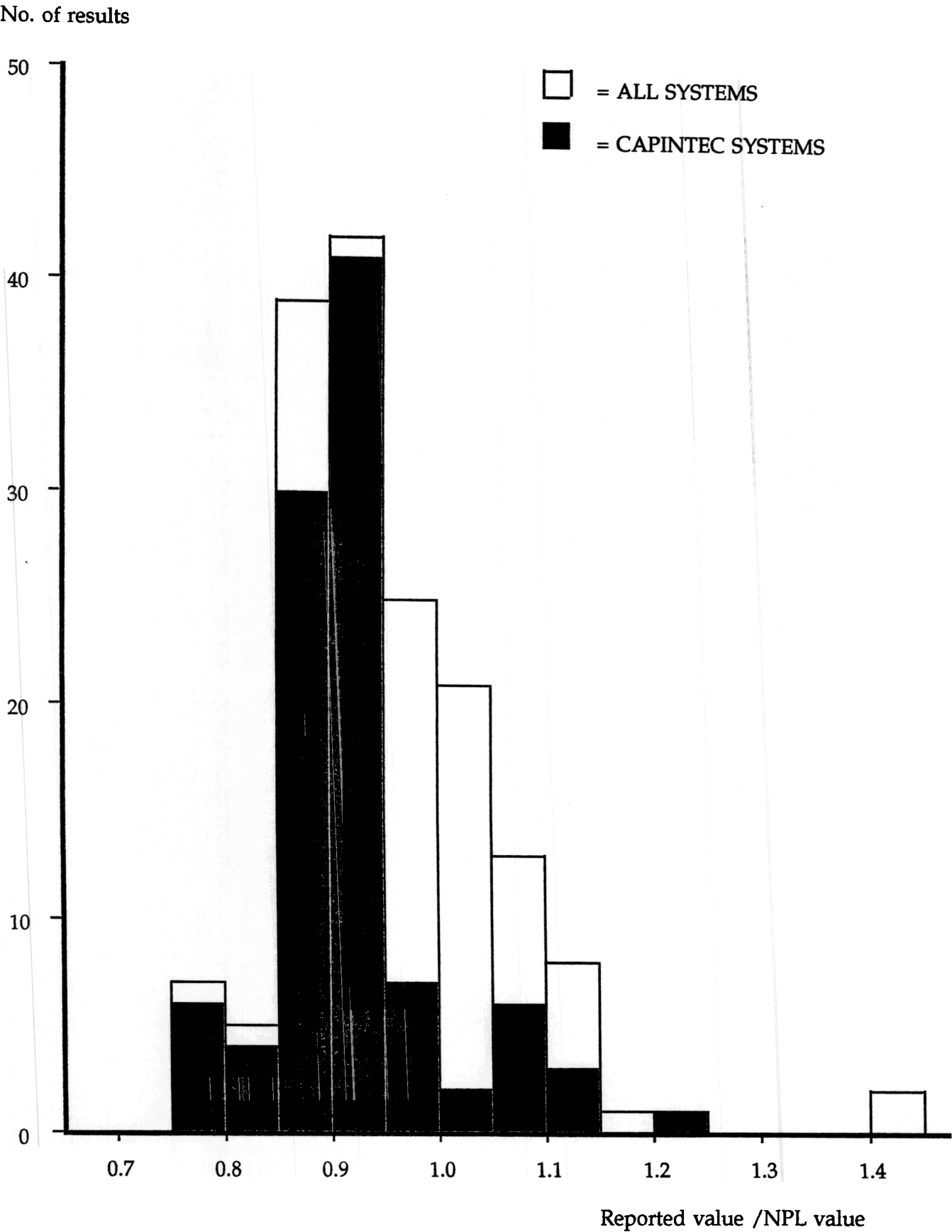


Figure 4 Distribution of results (4 ml solution only in P6 vials) ISOCAL IV SYSTEMS

No. of results

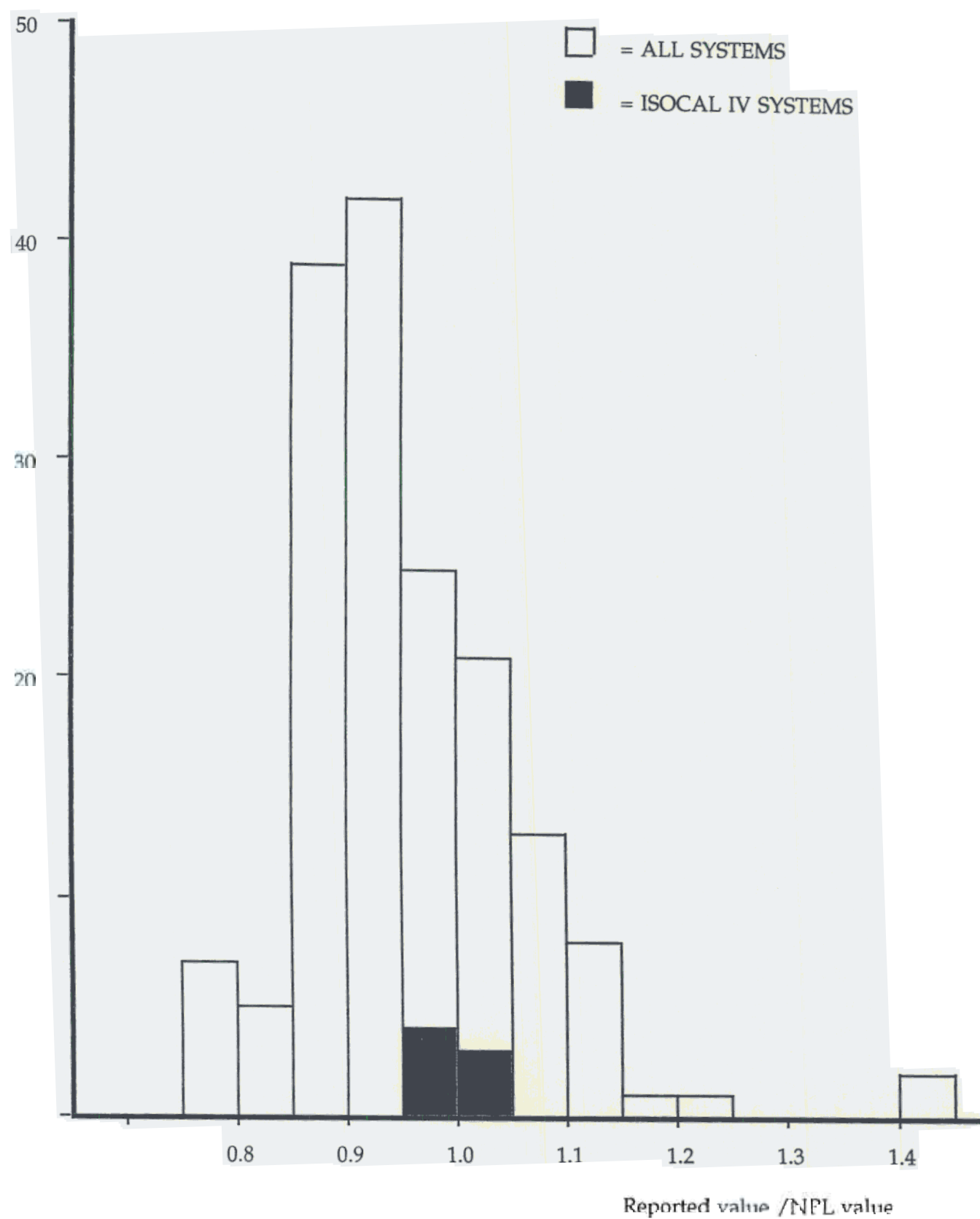


Figure Distribution of results (4 ml solution only in P6 vials) SIEL SYSTEMS

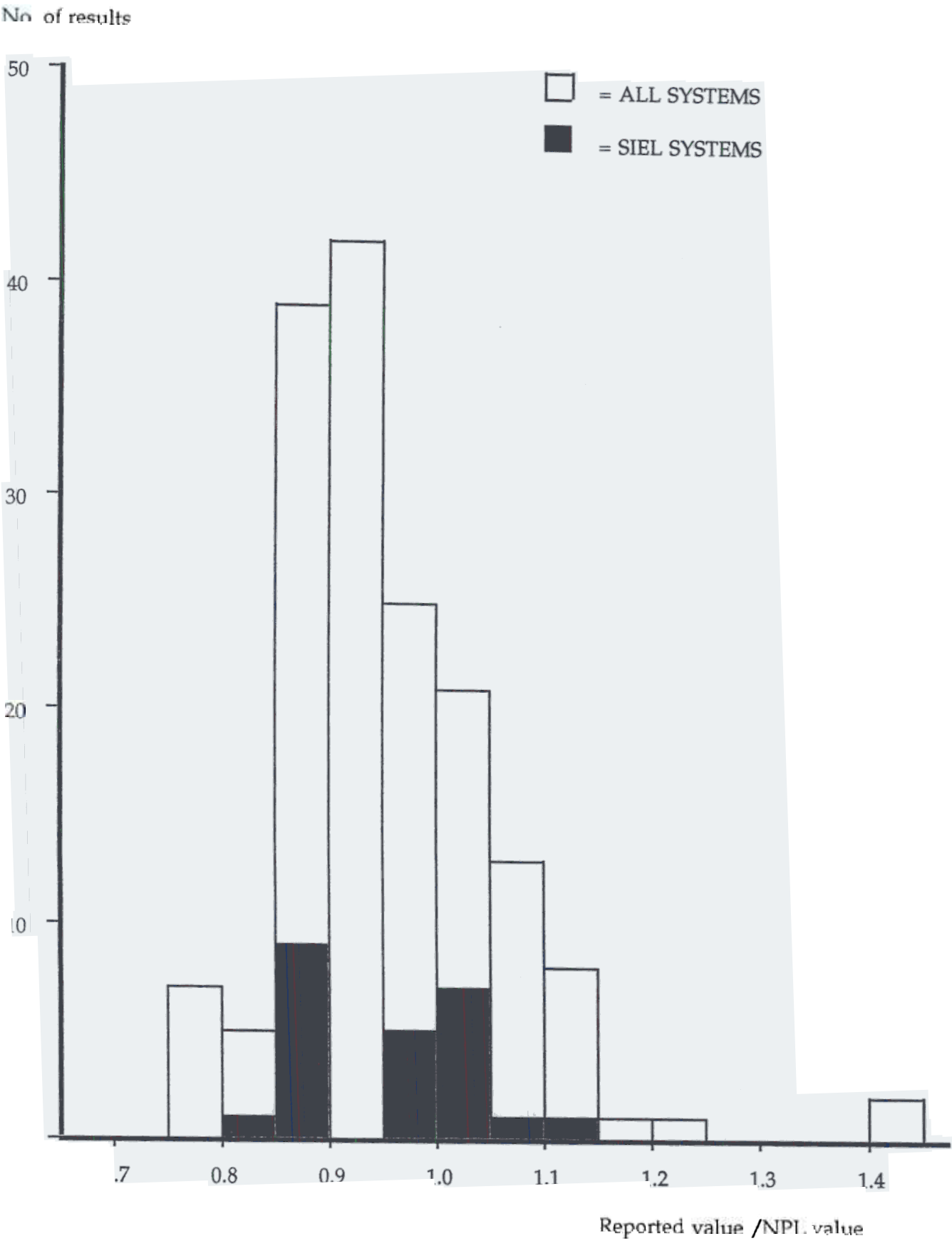


Figure 6 Distribution of results (4 ml solution only in P6 vials) ISOCAL II SYSTEMS

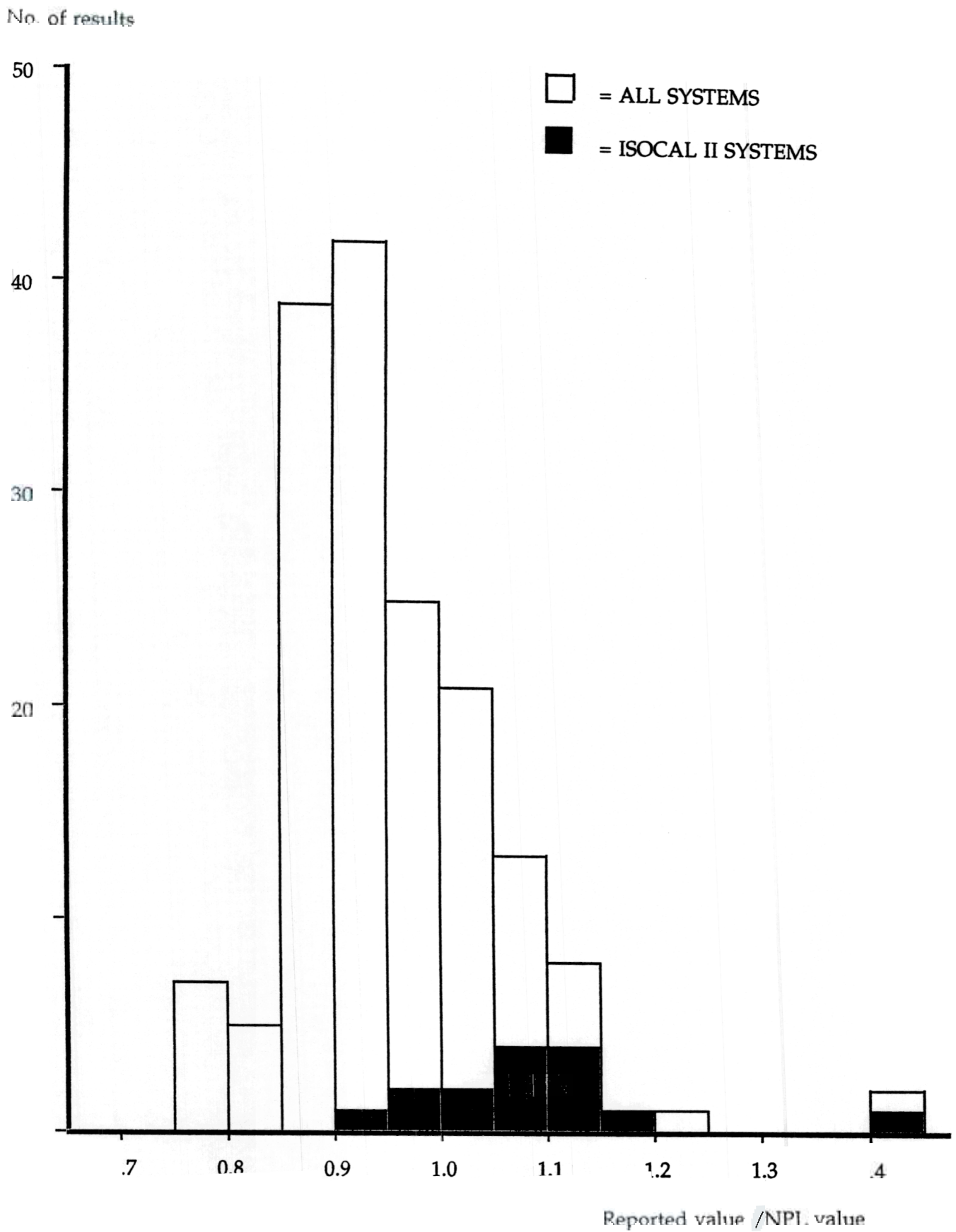


Figure 7 Distribution of results (4 ml solution only in P6 vials) OTHER SYSTEMS

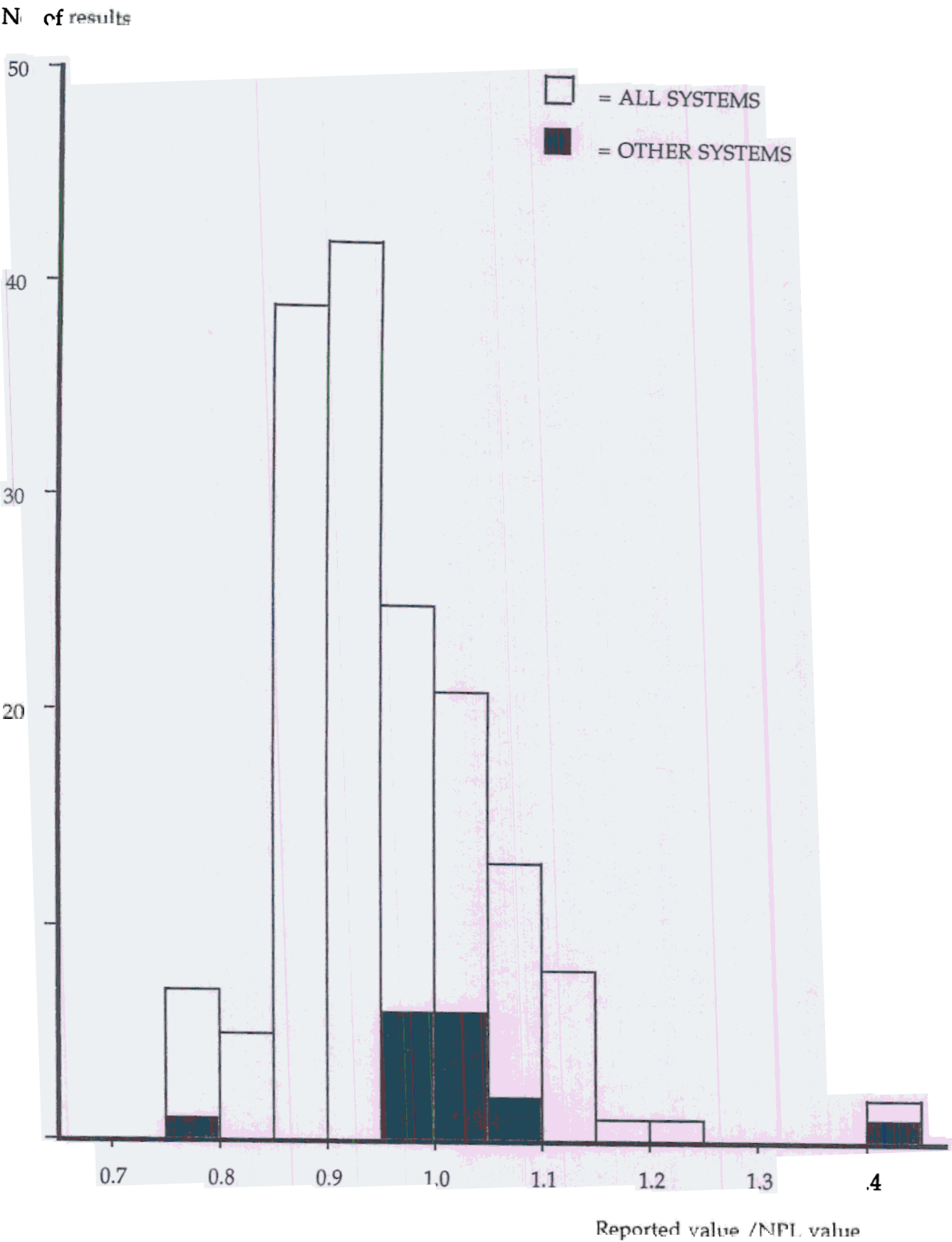
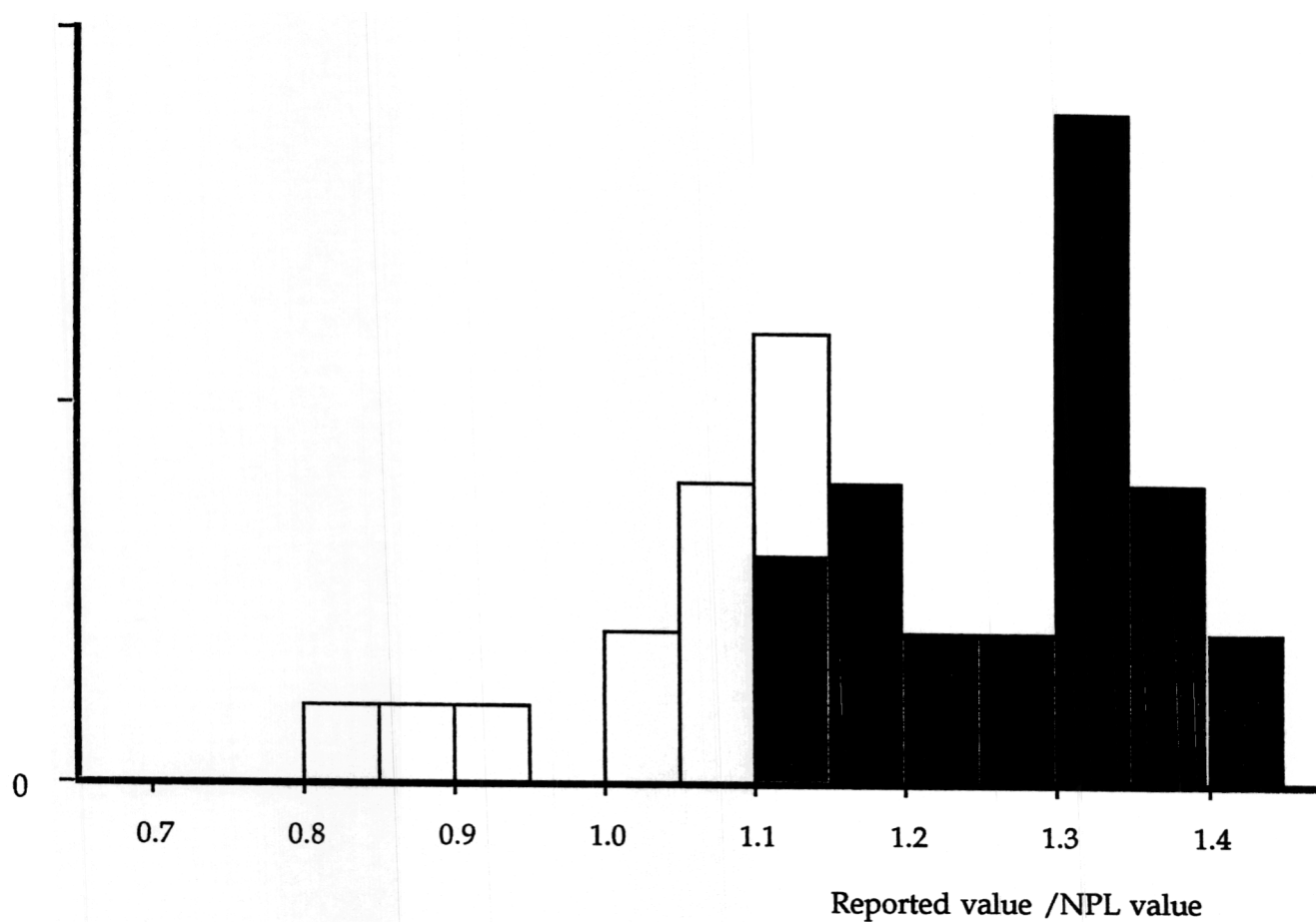


Figure Distribution of results SYRINGES

□ WITH USER-ADJUSTED FACTORS
■ WITH MANUFACTURERS ACTORS

No. of results



APPENDIX 1

PARTICIPANTS

<u>Participant</u>	<u>Hospital</u>
P Anderson	University Hospital Birmingham
R W Barber	Addenbrookes
M Clarke	Queen Elizabeth (Woolwich, London)
S Douglas	Mount Vernon
R Gadd	North Staffordshire
T E Hilditch	Western Infirmary Glasgow
S Hooper	University Hospital of Wales
J MacDonald	Glan Clwyd
C Marshall	County (Lincoln)
Munby	Royal Marsden
J Nettleton	Manchester Royal Infirmary
C Nottage	Oldchurch Broomfield Harlow
D Simpson	Kent & Canterbury
A H Smith	Leeds General Infirmary
H R Stockdale	Royal Liverpool University
W Thomson	City Hospital (Birmingham)
R Ward	Royal Devon and Exeter
F Zananiri	Bristol General Hospital

APPENDIX 2

AMERSHAM INTERNATIONAL/NATIONAL PHYSICAL LABORATORY

INTERCOMPARISON OF ^{123}I ACTIVITY - SEPTEMBER 1996

Organisation	Participant
Address	Tel No.
.....	Fax No.
.....	e-mail
.....	

Vial identifier Nominal volume: 4.0 ml

Chem. form: 0.1mg g⁻¹ I as NaI
 0.2mg g⁻¹ Na₂S₂O₃
 1mg g⁻¹ formaldehyde

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) $\pm$ %, Non-random (Type B) $\pm$ %, Overall $\pm$ %

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
e-mail mjw@newton.npl.co.uk