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COMMISSION OF THE EUROPEAN COMMUNITIES

**RAPID DETERMINATION
OF RADIONUCLIDES IN MILK**
Results of an intercomparison organized jointly
by the I.A.E.A. and C.E.C.
in 1972

by

**O. SUSCHNY, J. HEINONEN and D. MERTEN (I.A.E.A.)
J. SMEETS, R. AMAVIS and A. BONINI (C.E.C.)**

1973



Report prepared by
Division of Research and Laboratories
of the International Atomic Energy Agency, Wien
and
Health Protection Directorate
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ABSTRACT

The problems posed by the rapid assessment of radioactive contamination of milk are very important in view of public health protection, particularly in the case of uncontrolled discharges of radioactive substances.

For this reason the I.A.E.A. and the C.E.C. have prepared and implemented jointly an intercomparison programme to cover this field.

The following radionuclides have been analysed for two levels of contamination: Strontium 89 - Strontium 90 - Iodine 131 Caesium 137 - Barium 140.

The results obtained by the 34 participating laboratories have shown that it is possible to provide the responsible authorities with sufficiently accurate information to permit them to make decisions on measures for protection against ionizing radiation.

KEYWORDS

MILK
IAEA
SAFETY
CONTAMINATION
EUROPEAN COMMUNITIES
RADIATION PROTECTION
STRONTIUM 89
STRONTIUM 90
IODINE 131
CESIUM 137
BARIUM 140
INSPECTION
REVIEWS

P R E F A C E

The safety record of nuclear industry is satisfactory and the probability of unplanned releases of radionuclides in significant amounts is extremely small. Nevertheless, it is the duty of the national and international authorities responsible for public safety in this field to cater for all possibilities including that of serious releases.

The intercomparison reported in this document was organized by the I.A.E.A. and the C.E.C. to check if the participating laboratories, which are responsible for the analysis of radionuclides in their countries, would be able in an emergency situation to provide the competent authorities with the necessary analytical information with adequate rapidity and reliability.

Through the excellent cooperation between the two organizations 34 laboratories participated in the programme, and the laboratories had the opportunity to discuss and assess the results; this will no doubt lead to further improvements in the techniques.

It can be said that the laboratories have shown, on the whole, that they will be able to provide the required data in cases of emergency.

Dr. P. RECHT Director
Health Protection Directorate
C.E.C.

Prof. V. FERRONSKY
Director, Division of Research
and Laboratories I.A.E.A.

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I INTRODUCTION

In spite of the very low probability of emergencies occurring which would necessitate rapid availability of results concerning the extent of radioactive contamination, both the C.E.C. and I.A.E.A. have felt for sometime that it would be worthwhile to check on the rapidity and accuracy with which the laboratories concerned could provide such data.

On 28 and 29 October 1969 the Commission of the European Communities held a meeting of experts from its Member States to study the establishment of a comparison programme of the rapid measurement of radioactive contamination of milk (see Annex III).

A representative of the I.A.E.A., invited to this meeting, drew attention to the existence of a relevant programme prepared by his organization. The collaboration between the two organizations, resulting in an intercomparison, organized in January and February 1972, was based on this programme.

At a further meeting organized by the Health Protection Directorate of the C.E.C. (General Directorate V) which took place on 3 and 4 July 1972, the delegates of the laboratories of the Member States of the European Community together with a representative from the I.A.E.A. drew up a list of data obtained, and compared their results and the analytical methods adopted for measuring the radioactive pollution of milk (see Annex III).

The current document sets out the results of this first joint programme and gives a critical analysis of it.

II AIM OF THE PROGRAMME

The purpose of this project was to enable laboratories in Member States of one or both of the organizations to check the speed and accuracy of their analytical work. In addition, the intercomparison was considered to be useful also to those administrative departments of national or international scope in whose responsibilities lies the protection of the public from undue exposure to radioactive contamination in the case of a nuclear incident. The results of the intercomparison would show to them what reliability they could attach to reported results of contamination measurement which, in any real case, would form their basis for administrative action.

Milk was chosen because it is an important vehicle for radioactive contamination when an accident occurs.

The nuclides selected for use in the exercise were those normally analysed for in milk when contamination with radioactive products (including fresh fission products) is suspected, viz. ^{89}Sr , ^{90}Sr , ^{131}I , ^{137}Cs , and ^{140}Ba . For the choice of radionuclide concentrations we considered, on the one hand, the values of DWL and of ERL proposed by Bryant*, and, on the other hand, the existing rules for the transport of radioactive materials. The activity of the two samples in nCi/litre, obtained at source, was as follows:

	Sample low level nCi/l	Sample medium level nCi/l
^{89}Sr	1	20
^{90}Sr	1	1
^{131}I	10	100
^{137}Cs	10	100
^{140}Ba	2	20

These are rough values.

* "Health Physics" official journal of the Health Physics Society, Volume 17 number 1, July 1969, pp. 51 to 57.

Altogether, 34 laboratories took part in the exercise, two of these submitting two different sets of results each, obtained by different analysts, making a total of 36 sets of results.

18 laboratories submitted their results through C.E.C., the rest reported directly to the I.A.E.A. A form had been drafted for this purpose. (See Annex I). The list of laboratories and the person responsible (usually either the head of the laboratory or the responsible analyst) is given in Annex II.

III. PREPARATION OF SAMPLES

For technical reasons (difficulty of transportation and preservation of spiked milk, and also considering costs), the spike solutions were provided in aqueous form in ampoules, and laboratories were asked to prepare their spiked milk by pouring the contents of these ampoules into fresh milk. Two levels of activity were provided, one to give 2-10nCi of gamma emitters per litre of milk and one to give ten times as much, with ^{90}Sr equal to 1 nCi/l in each solution. Standard solutions of the gamma emitters and of ^{90}Sr were provided at the same time to allow laboratories to calibrate their counting equipment and so to eliminate differences due to calibration.

A time schedule was provided which required preliminary calibration, followed by four hours of analysis and measurement; after this time preliminary results were to be transmitted by cable, telex or telephone. More accurate final results were to be sent off later.

One difficulty experienced in the preparation of the exercise was the reluctance of isotope suppliers to supply ^{140}Ba and ^{89}Sr for calibration at the same time. None of the big suppliers would oblige and when finally a small company agreed to supply the two isotopes separated from a fission product solution, the ^{89}Sr solution on delivery was found to be quite empty.

Much later, when laboratories had already been informed that they would receive none of this nuclide, the latter was discovered to be present in great abundance as a contaminant in the ^{140}Ba solution and, therefore, also in both spikes. This caused some difficulty to analysts who had been told not to expect ^{89}Sr and, probably, led to a somewhat larger error than expected as well as to some delay in the determination of both strontium isotopes.

IV PRESENTATION OF RESULTS

TABLES I - XII show the results provided by the individual laboratories for the different radionuclides at "low" and "medium" spike level (1).

TABLES I - VI give the results for the following radionuclides: ^{131}I , ^{137}Cs , ^{140}Ba .

Some laboratories analysed ^{89}Sr and ^{90}Sr separately, see tables VII - X. Others determined the sum of the two; their results are shown in separate tables XI and XII.

The accuracy quoted in columns 3 and 6 of tables I to XII for the preliminary and the final results, respectively, is that claimed by the laboratories themselves who were asked also to state the confidence level of their estimated accuracy.

The last two columns in each table give information on the time taken for the analysis. Most laboratories succeeded in measuring the gamma activities in much less than the four hours allowed for the total analysis of all nuclides; a few also finished the determination of ^{89}Sr in this time.

TABLES XIII and XIV summarize the results for low and medium spiked solutions and all the radionuclides analysed.

(1) Names of laboratories are replaced in these tables by a numerical code which does not correspond to the sequence of these laboratories in the Annex.

They show the range of results obtained, the (generally small) number of results excluded, the range of those results which were used in the calculation of the mean and the deviation of this mean from the calibration value.

For more clarity results are shown also in graphical form: Fig's 1 - 8 show the frequency distribution of results for the gamma emitters and for ^{90}Sr . The number of results obtained for ^{89}Sr was considered too small to warrant a separate figure.

Fig. XV, "Administrative Data", shows for each laboratory of the Member States of the European Community the time lapse between receiving the samples, sending the preliminary results and sending the definitive results. This figure shows the length of time needed by each laboratory to obtain results. Where there is a considerable time lapse, it is due to problems within an institute (administrative and organizational problems).

V INTERPRETATION OF RESULTS

The mean value shown by the dotted line in figures 1 - 8 was calculated from the results obtained after screening of extreme values according to their statistical probability. The method used for this purpose was that of Graf and Henning (1952) as reported by Doerffel (1962) which considers permissible scattering limits as a function of the experimental standard deviation s , the number of observations N and the required probability P . A value x_{N+1} may be regarded as outside permissible limits and discarded if it differs from the mean value \bar{x} of all accepted results by more than a multiple of s defined by the statistics $g(P,N)$:

$$x_{N+1} \geq \bar{x} \pm g(P,N) \cdot s$$

The factor $g(P,N)$ for a probability of 95% (the value used in our test) and a number of 20 - 30 results is about 3.8 which means that in most cases only values falling outside the range

$$x \pm 3.8 s$$

were excluded from the evaluation. In some cases in which the number of results available was smaller, rather larger deviations had to be tolerated.

Fig's 9 - 14 are based on still another approach used to screen results: these figures are "control charts" in which results are classified according to whether they fall within the "warning limits",

$$\bar{x} \pm 2 s$$

outside of these, but still within "control limits"

$$\bar{x} \pm 3 s$$

or even outside control limits.

When examining the accuracy figures given by the laboratories and reported in columns 3 and 6 of Tables I to XII, it turned out, however, that different laboratories used different methods in making these estimates, some only providing their statistical counting error so that the figures in these columns cannot really be compared with each other. They are left in this document merely for comparison with the actual, experimentally determined deviations from the calibration values which are given in columns 4 and 7. There is little apparent correlation between these two sets of columns. In the case of ^{89}Sr and of $^{89}\text{Sr} + ^{90}\text{Sr}$ for which no calibration value was available, these columns are used to show the deviation of the individual values from the experimentally determined mean value. With regard to the information provided in Tables I to XII relative to the time taken for analysis, it must again be considered with some caution since here also not all laboratories used the same criteria, some only counting actual working time, others including time for the establishment of the required partial equilibria of daughters, some timing individual radionuclide determinations, others measuring the total time required for the separation and counting of all estimated radionuclides. It can only be said that the number of laboratories

to finish the measurement in the allotted time would most probably have been much higher, had the possible presence of ^{89}Sr been indicated in the information given to them. Many laboratories, however, were not in a position to estimate ^{90}Sr in the presence of both ^{89}Sr and ^{140}La (daughter of ^{140}Ba) in the short time allowed.

Perhaps the most important information given in tables XIII and XIV is the standard deviation for each nuclide, given in nCi/l and also in %. This standard deviation is shown to change very little from preliminary to final results. The difference between the observed mean and the calibration value which is shown in the next line is small and generally within the expected scattering limits. All this proves that the use of more time-consuming methods in place of the rapid ones adds very little precision to the analysis and that the use of the rapid methods in emergency situations does not lead to undue error. There is also little difference between standard deviations obtained on the intermediate level as compared to the low-level solution but it should be remembered that the "low-level" solution used in our experiment still contained enough radioactivity to permit measurements to be carried out without much influence by reagent contamination or radiation background fluctuations.

All values within warning limits (see tables XV and XVI) are considered completely acceptable, those between warning and control limits are considered as still tolerable but probably indicative of some analytical shortcomings which should be put right soon, finally those outside the control limits are considered as unacceptable. Laboratories producing unacceptable values should immediately check and, if necessary, improve their techniques. Until such improvement is documented (or the reason for an individual unacceptable value explained) results from the laboratory concerned may have to be regarded with caution, particularly if administrative decisions are to be based upon them.

The position of values in the control charts is shown in Table XV. It can be seen from this table as well as from the figures that the number of results falling outside the control limits is rather small, which indicates that most of the laboratories which took part in this intercomparison were performing well in the analysis of gamma emitters. Also, the overall analytical situation seems to be well in hand, at least for cesium-137 and iodine-131 which give standard deviations of 6 - 8%. The situation is less favourable in the case of ^{140}Ba where standard deviations of 13 - 18% were found.

Results obtained on the two strontium isotopes are more difficult to evaluate. A rather arbitrary classification upon which Table XVI is based, distinguishes between results which fall within 30% of the calibration value and those which fall outside these limits. In the consideration of the figures in this table we must bear in mind that no warning was given to laboratories to expect ^{89}Sr in their samples and no standard was provided for this nuclide. The comparatively large margin of error carried by the analytical results may at least partially be explained by the difficulties caused by these facts, which also caused delays and increased errors in the preliminary determination of ^{90}Sr . However, as is shown by the final results for ^{90}Sr which were obtained by most laboratories after receiving information on the presence of ^{89}Sr , and which still carry a standard deviation of between 20 and 26%, there are other factors inherent in the analysis for the strontium isotopes which lead to a larger scatter of results.

In contrast to the three gamma emitters which were analysed by direct gamma spectrometry by most laboratories, or after chemical procedures involving a minimum of manipulation, the pure beta emitters ^{89}Sr and ^{90}Sr had to be isolated for measurement, distinguished from each other by radiation absorption, a method in which small errors in counting or in calibration may lead to large errors in ^{90}Sr values if that nuclide

is present in small quantities compared to ^{89}Sr ; or by separation and measurement of ^{90}Y , complicated by the presence of the barium-daughter ^{140}La . The final beta measurement is also more influenced by absorption, self-absorption, and backscatter than the more reproducible gamma measurement.

All these factors would be expected to lead to larger scatter of results for the strontium isotopes than those obtained with the other nuclides. The actual figures obtained nevertheless seem rather high.

VI CONCLUSIONS

As a whole the intercomparison of rapid radionuclide determinations in milk organized by the I.A.E.A. and C.E.C. in 1972 has shown that in the case of a possible emergency situation the laboratories are able to provide the responsible authorities with rapid and reliable results when the gamma emitters ^{131}I and ^{137}Cs are to be determined. Somewhat larger scatter must be expected in the analysis of ^{140}Ba .

The pure beta emitter ^{90}Sr when present together with relatively large excess of ^{89}Sr may be difficult to determine separately and either a relatively large error, depending upon the $^{89}\text{Sr}/^{90}\text{Sr}$ ratio (when the two nuclides are determined in the same precipitate and distinguished only by use of their different maximum beta energies) or a considerable delay in the analysis, when this is carried out, after separation of strontium from barium and lanthanum, by partial equilibration of ^{90}Sr with its daughter ^{90}Y and measurement of the latter, may have to be tolerated.

LITERATURE

1. GRAF, U. and HENNING, H.J., Mitteilungsbl. mathem. Stat. 4, 1 (1952)
2. DOERFFEL, K., "Beurteilung von Analyseverfahren und -ergebnissen", Springer Berlin, Göttingen, Heidelberg, 1962.
(also in: Z.anal.Chemie 185, 1-98 (1962))

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TABLE I

RESULTS OF ¹³¹I-ANALYSES BY DIFFERENT INSTITUTES ON SPIKE
SOLUTION A, LOW LEVEL
CALIBRATION VALUE 10,14 nCi/l

Lab. No.	P- results nCi/l	(x) accuracy + - %	deviation from the calib. value d %	F- results nCi/l	(x) accuracy + - %	deviation from the calib. value d %	method used		total time used for analysis h	
							P	F	P	F
1	8.80	5	-13.2	9.40	5	- 7.3	2	2	4a	19.0a
2				9.50	5	- 6.3		1		7.5a
3				10.00	20	- 1.4		1		8.0a
4	9.42	5	- 7.1	9.42	5	- 7.1	2	2	2.8	2.8
5	9.50	5	- 6.3	9.60	5	- 5.3	3	3	4.0	
6				10.60	3	+ 4.5		3		1.4a
7	10.30	5	+ 1.6				1		2.5	
8				12.60	5	+24.2		1		1.2
9				8.20	10	-19.1		2		0.6a
10				8.70	10	-14.2		2		0.6a
11	9.90	10	- 2.4				1		0.6	
12	11.20	7	+10.5	11.19	5	+10.4	2	2	0.2	1.3
13				10.50	5	+ 3.5		3		10.7
14	9.70	10	- 4.3	9.70	10	- 4.3	1	2	1.2	1.2
15	8.67	20	-14.5	8.65	20	-14.7	2	2	1.0a	2.5a
16	10.40	20	+ 2.5				1		0.9	
17	10.4	2	+ 2.5	10.3	2	+ 1.6	1	2	1.3a	1.3a
18	9.80	2	- 3.4	10.10	1	- 0.4	2	2	0.6	2.1
19	9.75	1	- 3.8	9.75	1	- 3.8	1	1	1.0a	1.0a
20	9.80	2	- 3.8	9.80	2	- 3.4	4	4	0.8	0.8
21	10.00	20	- 1.4				4		1.0	
22	9.19	5	- 9.4	9.50	4	- 6.3	1	1	0.5a	1.6a
23	10	12	- 1.4	10.00	6	- 1.4	2	2	1.8a	3.5a
24	10.49	15	+ 3.4	10.40	15	+ 2.5	4	4	1.0	120.0a
25	10.60	10	+ 4.5	10.60	10	+ 4.5	1	1	2.5	2.5
26	8.60	15	-15.2	9.00	10	-11.2	3	3	3.6a	14.5a
27	10.96	10	+ 8.1	10.80	10	+ 6.5	3	3	2.0	2.0
28	10.38	1	+ 2.4	10.38	1	+ 2.4	1	1	1.3	1.3
29	10.69		+ 5.4	10.69		+ 5.4	4	4	1.0	1.0
30	10.27	9	+ 1.3	10.27	9	+ 1.3	3	3	2.1a	2.1a
31	10.30	10	+ 1.6	10.30	10	+ 1.6	2	2	1.5	1.5
32	10.80	3	+ 6.5	10.80	3	+ 6.5	2	2	1.5	1.5
33	9.70	4	- 4.3	9.70	4	- 4.3	1	1	14.6a	14.6a
34	10.00	15	- 1.4				1		3.5a	
35				9.19	10	- 9.4		3		9.0a
36										

P = preliminary; F = final; (x) estimated overall accuracy given by the laboratory
a = total time used for analyses of three to five nuclides

- 1 = γ -spectrometry without chemical separation
- 2 = " " " " " " " " with NaI-crystal
- 3 = " " " " " " " " with Ge(Li)-crystal
- 4 = " " " " " " " " after chemical separation

TABLE II RESULTS OF ¹³¹I ANALYSES BY DIFFERENT INSTITUTES ON SPIKE SOLUTION B, MEDIUM LEVEL, CALIBRATION VALUE 108,9 nCi ¹³¹I/l

Lab. No.	P- results nCi/l	x) accu- racy + - %	deviation from the calib. value d %	F- results nCi/l	x) accu- racy + - %	deviation from the calib. value d %	method used		total time used for analysis	
							P	F	h	
									P	F
1	89.6	5	-17.7	100.2	5	- 8.0	2	2	4.0 a	19.0a
2				95.2	1	-12.6		1		5
3				110.0	20	+ 1.0		1		9.9a
4	96.4	5	-11.5	96.3	5	-11.5	2	2	2.7	2.7
5	103.0	5	- 5.4	103.0	5	- 5.4	3	3	1.3	
6				111.0	3	+ 1.9		3		0.2a
7	110.9	5	+ 1.8				1		1.7	
8				112.0	4	+ 2.8		1		1.2
9				88.5	9	-18.7		2		0.6a
10				89.0	9	-18.2		2		0.6a
11	104.0	6	- 4.5				1		0.6	
12	118.0	6	+ 8.4	118.8	5	+ 9.1	2	2	0.1	0.8
13				99.8	5	- 8.4		3		2.7
14	110.0	10	+ 1.0	110.0	10	+ 1.0	1	2	1.2	1.2
15	93.7	20	-13.9	108.6	20	- 0.3	2	3	0.8a	1.5a
16	98.8	5	- 9.2				1		0.9	
17	107.7	0.5	- 1.1	108.8	0.5	- 0.1	1	2	1.3a	1.3a
18	106.0	1	- 2.7	106.0	1	- 2.6	2	2	0.6	0.9
19	104.4	1	- 4.1	104.4	1	- 4.1	1	1	0.5a	0.5a
20	107.8	2	- 1.0	107.8	2	- 1.0	4	4	0.7	0.7
21	116.2	20	+ 6.6				4			0.8
22	101.6	3.5	- 6.7	101.1	1	- 7.2	1	1	0.2a	5.0a
23	110.0	8	+ 1.0	110.0	6	+ 1.0	2	2	1.8a	3.5a
24	113.1	15	+ 3.8	113.0	15	+ 3.8	4	4	1.0	48.0a
25	112.0	10	+ 2.8	112.0	10	+ 2.8	1	1	2.5	2.5
26	98.0	10	-10.0	99.0	10	- 9.1	3	3	2.3a	3.9a
27	105.9	10	- 2.8	107.3	10	- 1.4	3	3	2.0	2.0
28	107.4	1	- 1.4	107.4	1	- 1.4	1	1	0.9	0.9
29	114.7		+ 5.3	114.7		+ 5.3	4	4	0.8	0.8
30	111.0	4	+ 1.9	111.0	4	+ 1.9	3	3	1.1a	1.1a
31	110.3	10	+ 1.3	110.3	10	+ 1.3	2	2	1.5	1.5
32	106.0	2	- 2.7	106.0	2	- 2.7	2	2	1.2	1.2
33	95.8	4	-12.0	95.8	4	-12.0	1	1	2.9a	2.9a
34	112.0	10	+ 2.8				1		3.5a	
35				98.1	10	- 9.8		3		9.0a
36										

P = preliminary; F = final; x) estimated overall accuracy given by the laboratory; a = total time used for analyses of three to five nuclides simultaneously;

- 1 = γ -spectrometry without chemical separation
- 2 = " " " " with NaI crystal
- 3 = " " " " with GeLi crystal
- 4 = " " " " after chemical separation

TABLE III RESULTS OF ¹³⁷Cs-ANALYSES BY DIFFERENT INSTITUTES ON SPIKE SOLUTION A, LOW LEVEL CALIBRATION VALUE 9,11 nCi/l

Lab. No.	P- results nCi/l	x) accu- racy ± %	deviation from the calib. value d %	F- results nCi/l	x) accu- racy ± %	deviation from the calib. value d %	method used		total time used for analysis h	
							P	F	P	F
1	8.90	5	- 2.3	9.10	5	- 0.1	2	2	4a	19.0a
2				9.40	5	+ 3.2		1		7.5a
3				8.50	20	- 6.7		1		8.0a
4	8.83	5	- 3.1	8.84	5	- 3.0	2	2	2.8	2.8
5	8.00	5	-12.2	8.20	5	-10.0	3	3	4.0	
6				9.10	5	- 0.1		3		1.4a
7	9.18	5	+ 0.8				1		2.5	
8				8.00	5	-12.2		1		1.2
9				8.90	10	- 2.3		2		0.6a
10				8.80	10	- 3.4		2		0.6a
11	9.10	10	- 0.1				1		0.6	
12	10.30	8	+ 2.1	10.12	6	+12.0	2	2	0.2	1.3
13				9.42	5	+ 3.4		3		10.7
14	10.00	10	+10.0	10.00	10	+10.0	1	2	1.2	1.2
15	8.96	20	- 1.6	8.89	20	- 2.4	2	2	1.0a	2.5a
16	8.90	6	- 2.3				1		0.9	
17	9.6	2	+ 5.4	9.40	2	+ 3.2	1	2	1.3a	1.3a
18	10.10	2	+11.0	9.80	1	+ 7.6	2	2	0.6	2.1
19	8.99	1	- 1.3	8.99	1	- 1.3	1	1	1.0a	1.0a
20	9.64	3	+ 5.8	9.64	3	+ 5.8	4	4	1.0	1.0
21	9.55	20	+ 4.8				4		0.8	
22	9.13	6	+ 0.2	9.09	4	- 0.2	1	1	0.5a	1.6a
23	8.4	12	- 7.8	8.50	6	- 6.7	2	2	1.8a	3.5a
24	8.32	15	- 8.7	11.30	15	+24.2	4	4	1.5	120.0a
25	9.80	10	+ 7.6	9.80	10	+ 7.6	1	1	2.5	2.5
26	8.20	15	-10.0	9.00	10	- 1.2	3	3	3.6a	14.5a
27	10.43	10	+14.5	10.30	10	+13.0	3	3	2.0	2.0
28	9.51	1	+ 4.4	9.51	1	+ 4.4	1	1	1.3	1.3
29	9.78		+ 7,4	9.78		+ 7.4	4	4	1.3	1.3
30	9.13	4	+ 0.2	9.13	4	+ 0.2	3	3	2.1a	2.1a
31	9.10	10	- 0.1	9.10	10	- 0.1	2	2	1.5	1.5
32	10.20	6	+12.0	10.20	6	+12.0	2	2	1.5	1.5
33	9.20	3	+ 1.0	9.20	3	+ 1.0	1	1	14.6a	14.6a
34	10.00	15	+10.0				1		3.5a	
35				8.38	10	- 8.0		3		9.0a
36	4.57*	5	-49.8	4.57*	5	-49.8	1	1	1.5	1.5

x) estimated overall accuracy given by the laboratory; P = preliminary; F = final; a = total time used for analyses of three to five nuclides simultaneously

1 = γ-spectrometry without chemical separation

2 = " " " " " with NaI-crystal

3 = " " " " " with Ge(Li)-crystal

4 = " " " after chemical separation

* = result not used in calculation of mean

TABLE IV RESULTS OF ¹³⁷Cs-ANALYSES BY DIFFERENT INSTITUTES ON SPIKE SOLUTION B, MEDIUM LEVEL CALIBRATION VALUE 98,0 nCi/l

Lab. No.	P- results nCi/l	x) accu- racy ± %	deviation from the calib. value d %	F- results nCi/l	x) accu- racy ± %	deviation from the calib. value d %	method used		total time used for analysis h	
							P	F	P	F
1	93.5	5	- 4.6	99.5	5	- 1.5	2	2	4.0a	19.0a
2				97.2	1	- 0.8		1		7.5a
3				100.0	20	+ 2.0		1		9.9a
4	90.5	5	- 7.6	90.4	5	- 7.7	2	2	2.8	2.8
5	94.0	5	- 4.1	90.0	5	- 8.2	3	3	1.3	
6				98.0	5	0.0		3		0.2a
7	98.4	5	+ 0.4				1		1.7	
8				92.0	4	- 6.1		1		1.2
9				91.5	10	- 6.6		2		0.6a
10				91.0	10	- 7.1		2		0.6a
11	96.0	6	- 2.0				1		0.6	
12	108.0	8	+10.2	107.9	6	+10.1	2	2	0.1	0.8
13				85.6	5	-12.6		3		2.7
14	111.0	10	+13.3	111.0	10	+13.3	1	2	1.2	1.2
15	96.5	20	- 1.5	109.2	20	+11.4	2	3	0.8a	1.5a
16	94.7	3	- 4.0				1		0.9	
17	97.0	0.5	- 1.0	97.8	0.5	- 0.2	1	2	1.3a	1.3a
18	102.9	0.6	+ 5.0	103.5	0.5	+ 5.6	2	2	0.6	0.9
19	92.3	0.7	- 5.8	92.3	0.7	- 5.8	1	1	0.5a	0.5a
20	104.5	3	+ 3.6	104.5	3	+ 3.6	4	4	1.0	1.0
21	103.0	20	+ 5.1				4		0.8	
22	95.5	4	- 2.5	88.2	0.8	-10.0	1	1	0.2a	5.0a
23	91	8	- 7.1	95.0	6	- 3.1	2	2	1.8a	3.5a
24	91.8	15	- 6.3	91.8	15	- 6.3	4	4	1.5	48.0a
25	98.9	10	+ 0.9	98.9	10	+ 0.9	1	1	2.5	2.5
26	92.0	10	- 6.1	94.0	10	- 4.1	3	3	2.3a	3.9a
27	97.1	10	- 0.9	96.9	10	- 1.1	3	3	2.0	2.0
28	101.2	1	+ 3.3	101.2	1	+ 3.3	1	1	0.9	0.9
29	106.0		+ 8.2	106.0		+ 8.2	4	4	1.1	1.1
30	98.3	2	+ 0.3	98.3	2	+ 0.3	3	3	1.1a	1.1a
31	96.9	10	- 1.1	96.9	10	- 1.1	2	2	1.5	1.5
32	114.0	3	+16.3	114.0	3	+16.3	2	2	1.2	1.2
33	91.6	3	- 6.5	91.6	3	- 6.5	1	1	2.9a	2.9a
34	100.0	10	+ 2.0				1		3.5a	
35				90.5	10	- 7.7		3		9.0a
36	49.6*	5	-49.4	49.6*	5	-49.4	1	1	1.5	1.5

P = preliminary; F = final; x) estimated overall accuracy given by the laboratory; a = total time used for analyses of three to five nuclides simultaneously

1 = γ -spectrometry without chemical separation

2 = " " " " " " with NaI crystal

3 = " " " " " " with Ge(Li) crystal

4 = " " " " after chemical separation

* = result not used in calculation of mean

TABLE V RESULTS OF ¹⁴⁰Ba-ANALYSES BY DIFFERENT INSTITUTES ON SPIKE SOLUTION A, LOW LEVEL CALIBRATION VALUE 1,98 nCi/l

Lab. No.	P- results nCi/l	x) accuracy		deviation from the calibration value		F- results nCi/l	x) accuracy		deviation from the calibration value		method used		total time used for analysis	
		+	%	d	%		+	%	d	%	P	F	h	
													P	F
1						2.80	10	+41.5				2		19.0a
2						1.80	10	- 9.1				1		7.5a
3						2.00	20	+ 1.0				1		8.0a
4	1.93	5		- 2.5		1.92	5	- 3.0			2	2	2.8	2.8
5	2.20	10		+11.1		2.20	8	+11.1			3	3	4.0	
6						2.10	10	+ 6.0				3		1.4a
7	1.98	5		0.0							1		2.5	
8						1.60	7	-19.2				1		0.7
9						1.80	10	- 9.1				2		0.6a
10						1.90	10	- 4.0				2		0.6a
11	2.00	7		+ 1.0							1		0.6	
12	2.00	17		+ 1.0		2.11	10	+ 6.6			2	2	0.2	1.3
13						2.78	5	+40.5				3		10.7
14	2.70	15		+36.4		2.70	15	+36.4			1	2	1.2	1.2
15	1.26	25		-36.4		1.66	20	-16.2			2	2	1.0	2.5
16	2.10	35		+ 6.0							1		0.9	
17	1.3	2		-34.4		1.5	2	-24.2			1	2	1.3a	1.3a
17a						1.9		- 4.0				5		
18	1.90	10		- 4.0		1.89	3	- 4.5			2	2	0.6	2.1
19	2.01	4		+ 1.5		2.01	4	+ 1.5			1	1	1.0a	1.0a
20	2.38	4		+10.1		2.38	8	+10.1			4	4	2.4	2.4
21														
22	1.66	20		-16.2		1.56	20	-21.2			1	1	0.5a	1.6a
23	1.9	20		- 4.0		2.00	10	+ 1.0			2	2	1.8a	3.5a
24	1.69	15		-14.6		2.06	15	+ 4.0			4	4	3.0	120.0a
25	2.10	10		+ 6.0		2.10	10	+ 6.0			1	1	2.5	2.5
26	3.50*			+76.7		2.70	25	+36.4			3	3	3.6a	14.5a
26a	2.90			+46.5		2.28		-35.3						
27	1.90	25		- 4.0		2.10	25	+ 6.0			3	3	2.0	2.0
28	2.20	1		+11.1		2.20	1	+11.1			1	1	1.3	1.3
29	1.53			-22.8		1.53		-22.8			5	5	1.7	1.7
30	1.84	10		- 7.0		1.84	10	- 7.0			3	3	2.1a	2.1a
31	2.10	10		+ 6.0		2.10	10	+ 6.0			2	2	1.5	1.5
32	2.02	13		+ 2.0		2.00	13	+ 1.0			2	2	1.5	1.5
33	1.73	18		-12.6		1.73	18	-12.6			1	1	14.6a	14.6a
34	1.70	25		-14.1							1		3.5a	
35						1.76	10	-11.1				3		9.0a
36	6.32*	5		+219.0		5.26*	5	+165.0			4	4	11.0	11.0

P = preliminary; F = final; x) estimated overall accuracy given by the laboratory; a = total time used for analyses of three to five nuclides simultaneously

- 1 = γ -spectrometry without chemical separation
- 2 = " " " " " " with NaI-crystal
- 3 = " " " " " " with Ge(Li)-crystal
- 4 = " " " " after chemical separation
- 5 = β -counting " " " "
- * = result not used in calculation of mean

TABLE VI RESULTS OF ¹⁴⁰Ba-ANALYSES BY DIFFERENT INSTITUTES ON SPIKE SOLUTION B, MEDIUM LEVEL CALIBRATION VALUE 21,8 nCi/l

Lab. No.	P- results nCi/l	x) accuracy + - %	deviation from the cali-bration value d %	F- results nCi/l	x) accuracy + - %	deviation from the cali-bration value d %	method used		total time used for analysis h	
							P	F	P	F
1	15.7	5	-28.0	21.1	10	- 3.2	2	2	4a	19.0a
2				21.7	5	- 0.5		1		7.5a
3				20.0	20	- 8.3		1		8.0a
4	23.2	5	+ 6.4	22.4	5	+ 2.7	2	2	2.8	2.8
5	22.0	10	+ 0.9	21.0	8	- 3.7	3	3	1.3	
6				24.0	13	+10.2		3		0.2a
7	21.7	5	- 0.5				1		1.7	
8				15.3	5	-29.8		1		0.7
9				19.7	10	- 9.5		2		0.6a
10				19.0	10	-12.8		2		0.6a
11	20.0	4	- 8.3				1		0.6	
12	24.0	8	+10.1	23.6	6	+ 8.3	2	2	0.1	0.8
13				23.1	5	+ 5.9		3		2.7
14	27.0	10	+23.8	27.0	10	+23.8	1	2	1.2	1.2
15	17.9	25	-17.9	17.0	25	-22.0	2	3	0.8a	1.5
16	18.2	10	-16.5				1		0.9	
17	20.6	0.5	- 5.5	19.5	0.5	-10.5	1	2	1.3a	1.3a
17a				21.1		- 3.2		5		
18	19.5	2	-10.6	19.4	2	-11.0	2	2	0.6	0.9
19	21.0	2	- 3.7	21.0	2	- 3.7	1	1	0.5a	0.5a
20	22.7	3	+ 4.1	22.7	8	+ 4.1	4	4	2.4	2.4
21	19.8	14	- 9.2				4		0.7	
22	19.2	10	-11.9	19.0	2	-12.9	1	1	0.2a	5.0a
23	20	12	- 8.3	21.0	7	- 3.7	2	2	1.8a	3.5a
24	12.8	15	-41.3	22.5	15	+ 3.2	4	4	3.0a	48.0a
25	21.7	10	- 0.5	21.7	10	- 0.5	1	1	2.5	2.5
26	29.0	25	+33.1	26.0	20	+19.3	3	3	2.3a	3.9a
26a	25.9		+18.8	22.9		+ 5.0				
27	22.1	17	+ 1.4	22.5	17	+ 3.2	3	3	2.0	2.0
28	21.0	1	- 3.7	21.0	1	- 3.7	1	1	0.9	0.9
29	14.8		-32.2	14.8		-32.2	5	5	1.7	1.7
30	20.4	12	- 6.4	20.4	12	- 6.4	3	3	1.1a	1.1a
31	22.9	10	+ 5.0	22.9	10	+ 5.0	2	2	1.5	1.5
32	20.5	6	- 5.7	20.5	6	- 5.7	2	2	1.2	1.2
33	17.9	19	-17.9	17.9	19	-17.9	1	1	2.9a	2.9a
34	22.0	10	+ 0.9				1		3.5a	
35				19.5*	10	-10.6		3		9.0a
36	35.5*	5		30.3*	5	+39.0	4	4	11.0	11.0

P = preliminary; F = final; x) estimated overall accuracy given by the laboratory; a = total time used for analyses of three to five nuclides simultaneously

- 1 = γ-spectrometry without chemical separation
- 2 = " " " " " " " " with NaI-crystal
- 3 = " " " " " " " " with Ge(Li)-crystal
- 4 = " " " " " " " " after chemical separation
- 5 = β-counting after chemical separation
- * = result not used in the calculation of mean

TABLE VII RESULTS OF ⁹⁰Sr-ANALYSES BY DIFFERENT INSTITUTES ON SPIKE SOLUTION A, LOW LEVEL-CALIBRATION VALUE 1,11 nCi/1

Lab. No.	P- results nCi/1	x) accu- racy + - %	deviation from the calib. value d%	F- results nCi/1	x) accu- racy + - %	deviation from the calib. value d%	method used		total time used for analysis h	
							P	F	P	F
1										
2				1.05	8	- 5.4		2		7.5a
3				1.00	100	-10.0		2		8.0
4				0.26	5	-76.5		4, 3.6		3.6b
5	0.18*	5	-83.7	1.02	5	- 8.1	1.5	1.6	4.3	
6				1.00	50	-10.0		3		9.1
7	1.04	30	- 6.3	1.04	20	- 6.3	3.6	3.6	3.0	4.4
8				1.80	20	+62.1		2		3.2
9										
10										
11										
12										
13										
14				1.08	10	- 2.7		2.6		
15										
16										
17	1.14	2.5	+2.7	1.10	2.5	- 0.9	1.6	1.6	9.3b	9.3c
18				1.00	33	-10.0		1		6.1
19				1.61	17	+45.0		1.6		2.8a
20				1.10	15	- 0.9		1.6		
21	1.05	14	-5.4							
22										
23				1.10	25	-0.9		4.5		4.8a
24	0.08*		-91.5	0.07*	15	-92.0	1.6	1.6	5.5	120.0
25	0.99	91	-10.8	1.19	10	+ 7.2	1.6	1.6	9.6	12.5
26	1.10		- 0.9				1		3.7	
27	1.12		+ 0.9	1.14	3.9	+ 2.7	1	1	7.3a	8.5
28										
29										
30	0.99		-10.8	0.99		-10.8	2, 2.6	2, 2.6	3.4	3.4
31				1.00	20	-10.0		2.6		
32	1.30	11	+17.1	1.30	11	+17.1	2	2	11.8	11.8
33	0.92	4	-17.1	0.92	4	-17.1	3.6	3.6	5.9	5.9
34	2.00*	25	+80.2				1		7.0	
35				1.06	10	-4.5		2, 2.6		
36	0.89	5	-19.8	0.89	5	-19.8	4.6	4.6	12.5	12.5

P = preliminary; F = final; x) estimated overall accuracy given by the laboratory

a = total time used for analyses of ⁸⁹Sr and ⁹⁰Sr simultaneously

b = not including 14 days' waiting time for the growing in of ⁹⁰Y

c = - " - one night's - " -

1 = β-counting after chemical separation

2 = - " - - " - " by precipitation

3 = - " - - " - " by solvent extraction

4 = - " - - " - " by ion exchange

5 = - " - through selective absorption

6 = - " - of ⁹⁰Y after separation

* = result not used in calculation of mean

TABLE VIII RESULTS OF ⁹⁰Sr-ANALYSES BY DIFFERENT INSTITUTES ON SPIKE SOLUTION B, MEDIUM LEVEL- CALIBRATION VALUE 1,63 nCi/l

Lab. No.	P- results nCi/l	x) accu- racy + - %	deviation from the calib. value d %	F- results nCi/l	x) accu- racy + - %	deviation from the calib. value d %	method used		total time used for analysis h	
							P	F	P	F
1										
2				0.99	8	-39.4		2		7.5a
3										
4				1.69	5	+ 3.7		1.2.6		3.6b
5	1.20	5	-26.4	1.34	5	-17.8	1.5	1.6	3.6	
6				2.00	100	+16.6		3		9.1
7	1.50	30	- 8.0	1.35	20	-17.2	3.6	3.6		4.4
8				2.20	30	+35.0		2		3.7
9										
10										
11										
12										
13										
14				1.50	10	- 8.0		2.6		
15										
16										
17	2.22	2	+36.3	1.88	2	+15.2	1.6	1.6	9.3b	9.3c
18				2.00	50	+22.7		1		6.1
19				2.14	13	+31.3		1.6		2.8a
20				1.23	18	-24.6		1.6		2.9
21										
22										
23				2.30	30	+41.1		4.5		4.2a
24	0.96		-41.1	0.96	15	-41.1	1.6	1.6	5.5	18.0
25	2.50		+53.4	1.44	10	-11.7	1.6	1.6	9.6	14.3
26	6.00*		+268.0				1		3.7	
27	0.94		-43.0	2.08	4.8	+27.6	1	1	7.3a	8.5a
28										
29										
30	1.46		-10.4	1.46		-10.4	3.2.6	3.2.6	3.4	3.4
31										
32	1.70	11	+ 4.3	1.70	11	+ 4.3	2	2	11.8	11.8
33	2.40	4	+47.4	1.10	10	-32.6	3.6	3.6	5.9	5.9
34										
35				1.59	10	-2.4		3.2.6		
36	2.84	5	+74.4	3.14*	5	+92.2	4.6	4.6	12.5	12.5

P = preliminary; F = final; x) estimated overall accuracy given by the laboratory
a = total time used for analysis of ⁸⁹Sr and ⁹⁰Sr simultaneously
b = not including 14 days' waiting time for the growing in of ⁹⁰Y
c = - " - one night's - " - - " -
1 = β-counting after chemical separation
2 = - " - - " - by precipitation
3 = - " - - " - by solvent extraction
4 = - " - - " - by ion exchange
5 = - " - through selective absorption
6 = - " - of ⁹⁰Y after separation
* = result not used in calculation of mean

TABLE IX RESULTS OF ⁸⁹Sr-ANALYSES BY DIFFERENT INSTITUTES ON SPIKE SOLUTION A, LOW LEVEL - MEAN VALUE 2.70 nCi/l for P-results and 3.15 nCi/l for F-results

Lab. No.	P- results nCi/l	x) accu- racy + - %	deviation from the mean value d %	F- results nCi/l	x) accu- racy + - %	deviation from the mean value d %	method used		total time used for analysis		
							P	F	P	h	F
1											
2				2.90	8	- 7.9		2			7.5a
3											
4											
5	2.90	10	- 7.4	2.60		-17.5	1.5	1.6	4.3		
6											
7				3.20		+ 1.6					
8											
9											
10											
11											
12											
13											
14				2.60	10	-17.5		2.6			
15											
16											
17				3.05		- 3.2					
18				3.00	10	- 4.8		1			6.1
19				6.60*	3	+109.5		1.6			2.8a
20											
21	1.3	14	-51.8								
22											
23				2.90	25	- 7.9		4.5			4.9a
24											
25	3.28	6	+21.5	3.28	6	+ 4.1	1.6	1.6	9.6		18.0
26	2.40		-11.2				1		3.7		
27	3.64		+34.8	3.90	1.1	+23.8	1	1	7.3a		8.5a
28											
29											
30											
31				3.40	15	+ 7.9		2.6			
32											
33											
34											
35											
36											
37				3.79	20	+20.3		2			15

P = preliminary; F = final; x) estimated overall accuracy given by the laboratory
a = total time used for analysis of ⁸⁹Sr and ⁹⁰Sr simultaneously

- 1 = β -counting after chemical separation
- 2 = " " " " " by precipitation
- 4 = " " " " " by ion exchange
- 5 = " " through selective absorption
- 6 = " " after separation of ⁹⁰Y
- * = result not used in calculation of mean

TABLE X RESULTS OF ⁸⁹Sr-ANALYSES BY DIFFERENT INSTITUTES ON SPIKE SOLUTION B, MEDIUM LEVEL
 MEAN VALUE 33,4 nCi/l for P-results and 35,0 nCi/l for F-results

Lab. No.	P- results nCi/l	x) accu- racy + - %	deviation from the mean value d%	F- results nCi/l	x) accu- racy + - %	deviation from the mean value d%	method used		total time used for analysis h	
							P	F	P	F
1										
2				29.0	8	-17.1		2		7.5a
3										
4										
5	32.0	10	- 4.2	29.0	5	-17.1	1.5	1.6	3.6	
6										
7				34.4		- 1.7				
8										
9										
10										
11										
12										
13										
14				24.0	10	-31.4		2.6		
15										
16										
17				33.7		- 3.7				
18				30.0	3	-14.3		1		6.1
19				58.0	1	+68.5		1.6		2.8a
20										
21										
22										
23				33.0	20	- 5.7		4.5		4.2a
24										
25	32.0	3.3	- 4.2	32.0	3.3	- 8.6	1.6	1.6	9.6	18.0
26	30.0		-10.4				1		3.7	
27	39.4		+18.0	40.4	0.3	+15.4	1	1	7.3a	8.5a
28										
29										
30										
31										
32										
33										
34										
35										
36										
37				41.8	20	+19.4		2		15

P = preliminary; F = final; x) estimated overall accuracy given by the laboratory
 a = total time used for analyses of ⁸⁹Sr and ⁹⁰Sr simultaneously

- 1 = B-counting after chemical separation
- 2 = " " " " " " " " by precipitation
- 4 = " " " " " " " " by ion exchange
- 5 = " " " " " " " " through selective absorption
- 6 = " " " " " " " " after separation of ⁹⁰Y

TABLE XII RESULTS OF ⁸⁹⁺⁹⁰Sr-ANALYSES BY DIFFERENT INSTITUTES ON SPIKE SOLUTION B, MEDIUM LEVEL
 MEAN VALUE 51,5 nCi/l for P-results and 48,2 nCi/l for F-results

Lab. No.	P-results nCi/l	x) accu- racy + - %	deviation from the mean value d %	F- results nCi/l	x) accu- racy + - %	deviation from the mean value d %	method used		total time used for analysis h	
							P	F	P	F
1				45.6	20	- 5.4		1		33.0
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16	38.0		-26.2				2		5.8	
17										
18	55.8	10	+ 8.3				1		4.8	
19	87.0	1	+69.0				1		2.8	
20	80.4	6	+56.1				1		2.9	
21										
22	27.5	20	-46.6	30.4	15	-37.0	1	1	5.4	5.4
23	44	20	-14.5				4		3.9	
24										
25										
26										
27										
28	43.8	1	-15.0	43.8	1	-9.1	1	1	24.4	24.4
29	44.1		-14.4	44.1		-8.5	1	1	1.9	1.9
30										
31	77.3	10	+50.1	77.3	10	+60.5	2	2	3.0	3.0
32										
33										
34	17.0	25	-67.0				1		7.0	
35										
36										

P = preliminary; F = final; x) estimated overall accuracy given by the laboratory
 1 = β -counting after chemical separation
 2 = " " " " " " " " by precipitation
 4 = " " " " " " " " by ion exchange

TABLE XIII AVERAGE VALUES AND RANGES OF THE RESULTS OBTAINED ON SPIKE SOLUTION A; LOW LEVEL

	¹³¹ I		¹³⁷ Cs		¹⁴⁰ Ba		⁹⁰ Sr		⁸⁹ Sr		⁸⁹⁺⁹⁰ Sr	
	P	F	P	F	P	F	P	F	P	F	P	F
calibrat. value nCi/l (x)	10,14 + - 3%		9,11 + - 3%		1,98 + - 3%		1,11 + - 3%					
number of reported results	27	30	28	31	27	33	13	22	5	12	9	4
number of values considered	27	30	27	30	25	32	10	20	5	11	9	4
number of values excluded	-	-	1	1	2	1	3	2	-	1	-	-
max. value nCi/l	11.20	12.60	10.43	11.30	6.32	5.26	2.00	1.80	3.64	6.60	9.26	7.40
min. value nCi/l	8.60	8.20	4.57	4.57	1.26	1.50	0.08	0.07	1.30	2.60	3.09	3.62
total range nCi/l	2.60	4.40	5.86	6.73	5.06	3.76	1.92	1.73	2.34	4.00	6.17	3.78
range considered nCi/l	2.60	4.40	2.43	3.30	1.64	1.30	0.41	0.91	2.34	1.30	6.17	3.78
mean of cons.val. nCi/l	9.99	9.99	9.30	9.28	1.96	2.03	1.05	1.12	2.70	3.15	6.37	5.31
\pm nCi/l	0.67	0.86	0.65	0.70	0.37	0.35	0.12	0.22	0.91	0.42	2.08	1.56
S												
% + -	6.7	8.6	7.0	7.5	18.7	17.1	11.3	19.8	33.6	13.5	32.7	29.4
d									no calibration value available			
nCi/l	-0.15	-0.15	+0.19	+0.17	-0.02	+0.05	-0.06	+0.01				
%	-1.5	-1.5	+2.1	+1.9	-1.0	+2.5	-5.4	+0.9				

P = preliminary; F = final;

S = estimated standard deviation;

d = difference between the observed mean and calibration value;

(x) The overall uncertainty of the calibration values ($\pm 3\%$) is the sum of the statistical and the estimated systematical errors

TABLE XIV

AVERAGE VALUES AND RANGES OF THE RESULTS OBTAINED ON SPIKE SOLUTION B; MEDIUM LEVEL

	¹³¹ I		¹³⁷ Cs		¹⁴⁰ Ba		⁹⁰ Sr		⁸⁹ Sr		⁸⁹⁺⁹⁰ Sr	
	P	F	P	F	P	F	P	F	P	F	P	F
calibrat. value nCi/l (x)	108.9 ± 3%		98.0 ± 3%		21.8 ± 3%		1.63 ± 3%					
number of reported results	27	30	28	31	29	33	11	20	4	11	10	5
number of values consider.	27	30	27	30	28	32	10	19	4	11	10	5
number of values excluded	-	-	1	1	1	1	1	1	-	-	-	-
max. value nCi/l	118.0	118.8	114.0	114.0	35.5	30.3	6.00	3.14	39.4	58.0	87.0	77.3
min. value nCi/l	89.6	88.5	49.6	49.6	12.8	14.8	0.94	0.96	30.0	24.0	17.0	30.4
total range nCi/l	28.4	30.3	64.4	64.4	22.7	15.5	5.06	2.18	9.4	34.0	70.0	46.9
range considered nCi/l	28.4	30.3	23.0	28.4	16.2	12.2	1.90	1.34	9.4	34.0	70.0	46.9
mean of cons. value nCi/l	106.2	105.2	98.4	97.5	20.8	20.9	1.77	1.63	33.4	35.0	51.5	48.2
S $\frac{nCi/l}{\pm}$	7.0	7.4	6.2	7.2	3.4	2.6	0.68	0.42	4.1	9.2	23.3	17.3
$\frac{\%}{\pm}$	6.6	7.1	6.3	7.4	16.2	12.5	38.1	25.6	12.4	26.1	45.3	36.0
d $\frac{nCi/l}{\pm}$	-2.7	-3.7	+0.4	-0.5	-1.0	-0.9	+0.14	0.00	no calibration value available			
$\frac{\%}{\pm}$	-2.5	-3.4	+0.4	-0.5	-4.6	-4.1	+8.6	0.0				

P = preliminary; F = final;
 S = estimated standard deviation;
 d = difference between the observed mean and calibration value
 (x) The overall uncertainty of the calibration values ($\pm 3\%$) is the sum of the statistical and the estimated systematic errors

TABLE XV DISTRIBUTION OF RESULTS IN CONTROL CHARTS
NUMBER OF LABORATORIES IN EACH CATEGORY

Nuclide and Activity nCi/l	Number of Results			Total number of results
	Between warning limits	Between control and warning limits	Outside of control limits	
¹³¹ I 10,14	P	25	2	27
	F	27	2	30
108,9	P	25	2	27
	F	28	2	30
¹³⁷ Cs 9,11	P	26	1	28
	F	29	-	31
98,0	P	25	2	28
	F	27	3	31
¹⁴⁰ Ba 1,98	P	21	4	27
	F	28	4	33
21,8	P	24	3	29
	F	30	2	33

TABLE XVI DISTRIBUTION OF Sr-RESULTS WITHIN THE ERROR LIMITS OF 30%

Nuclide and Activity nCi/l	Number of results between 30% limits $\bar{X} \pm 30\%$	Outside of limits	Total number of results
⁸⁹ Sr 2,7 P 3,2 F	3	2	5
	11	1	12
	4	-	4
33,4 P 35,0 F	9	2	11
⁹⁰ Sr 1,11 P F	10	3	13
	18	4	22
1,63 P F	4	7	11
	14	6	20
⁸⁹⁺⁹⁰ Sr 6,37 P 5,31 F	6	3	9
	2	2	4
51,5 P 48,2 F	5	5	10
	3	2	5

ADMINISTRATIVE DATA

— Number of days between the date when the samples to be measured were received and the date when the first results were sent off (X-----X).
- - - - - Number of days between the date when the samples to be measured were received and the date when the final results were sent off (O-----O).
(for all the radionuclides with the exception of ^{89}Sr and ^{90}Sr)

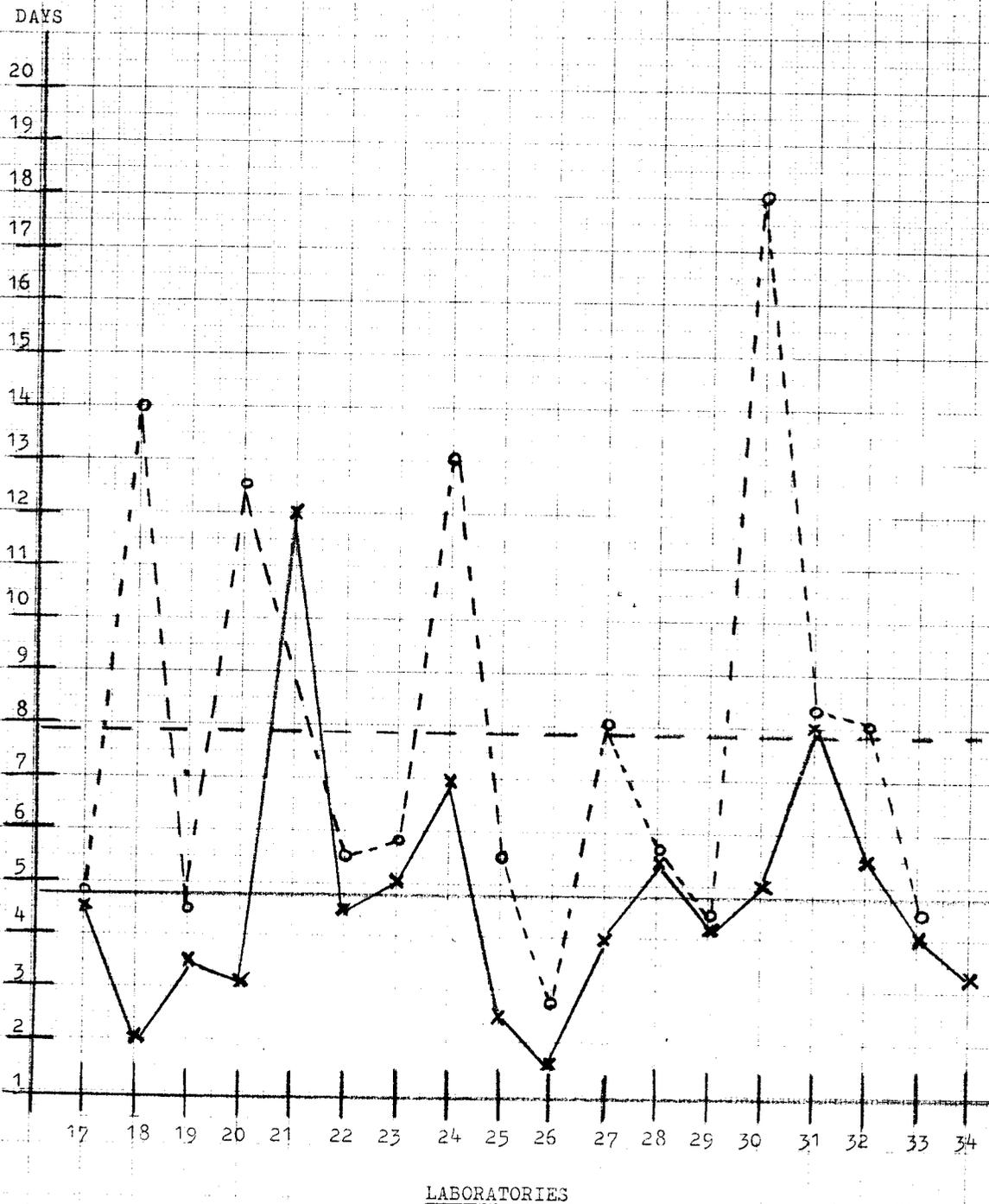


Fig. XVII

Distribution of results of ^{131}I -ANALYSES at 10.14 nCi/l

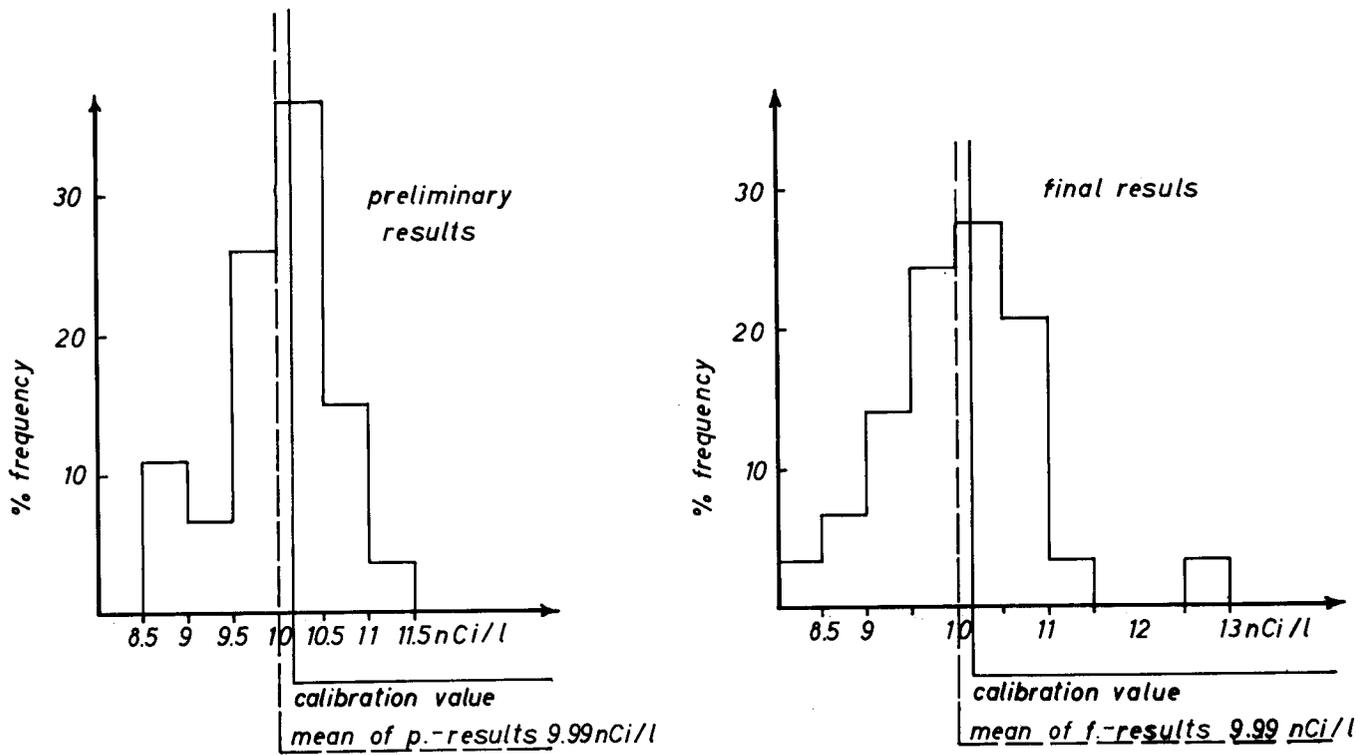


FIG. 1

Distribution of results of ^{131}I -ANALYSES at 108.9 nCi/l

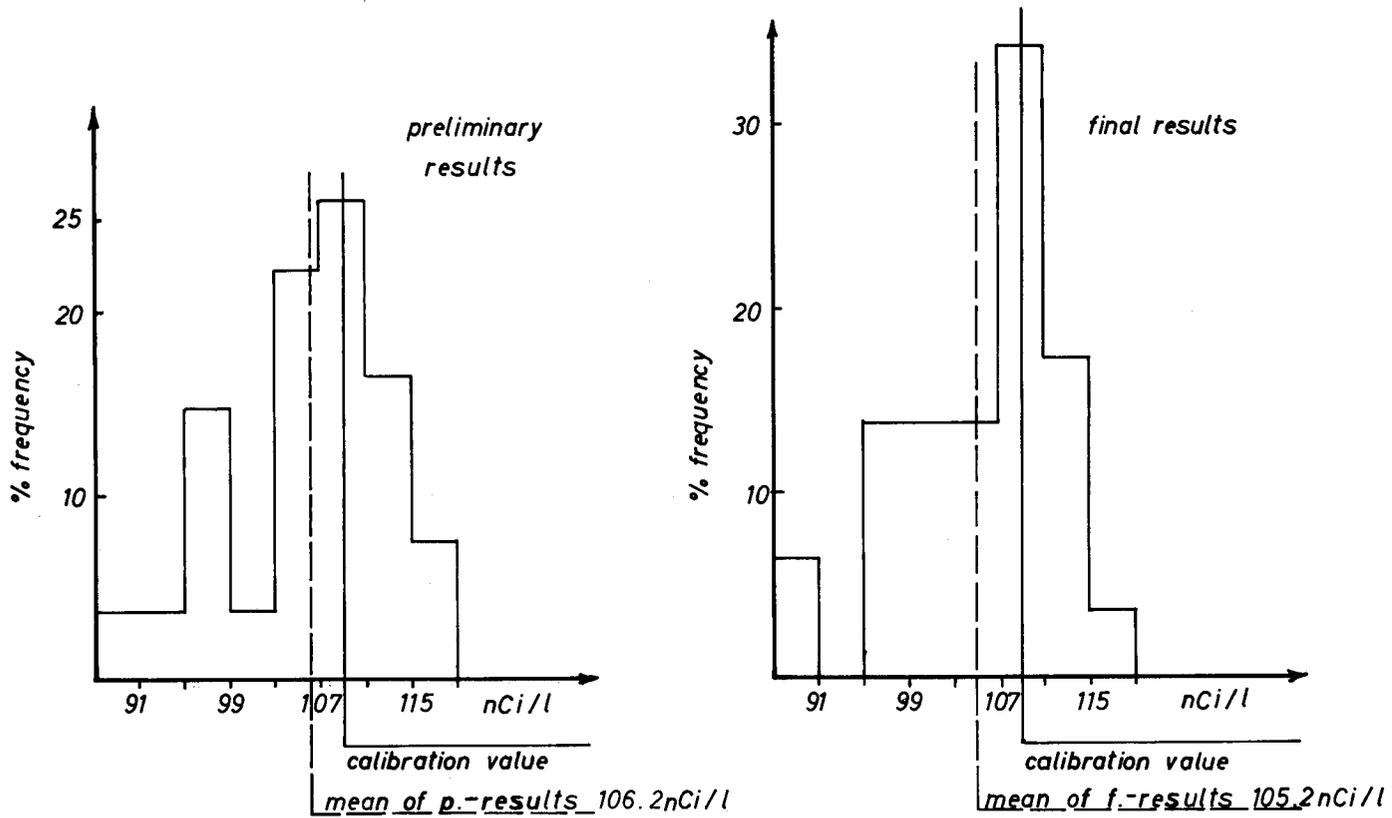


FIG. 2

Distribution of results of ^{137}Cs -ANALYSES at 9.11 nCi/l

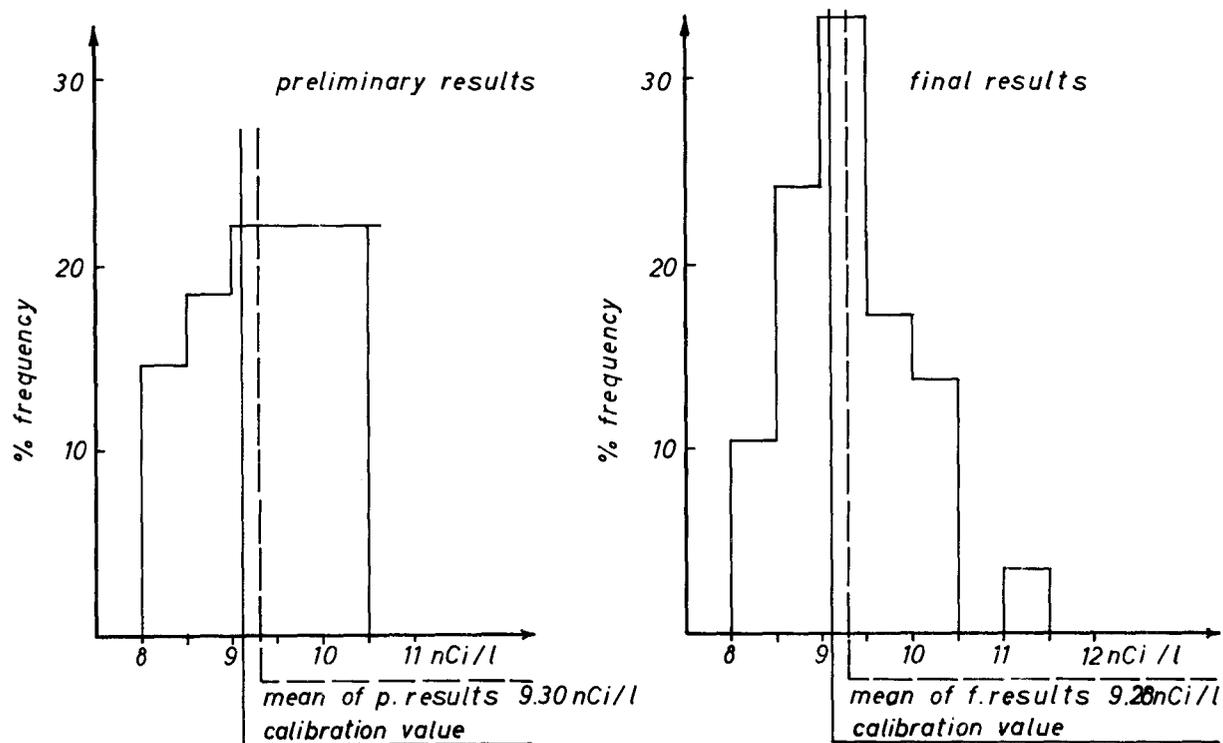


FIG. 3

Distribution of results of ^{137}Cs -ANALYSES at 98.0 nCi/l

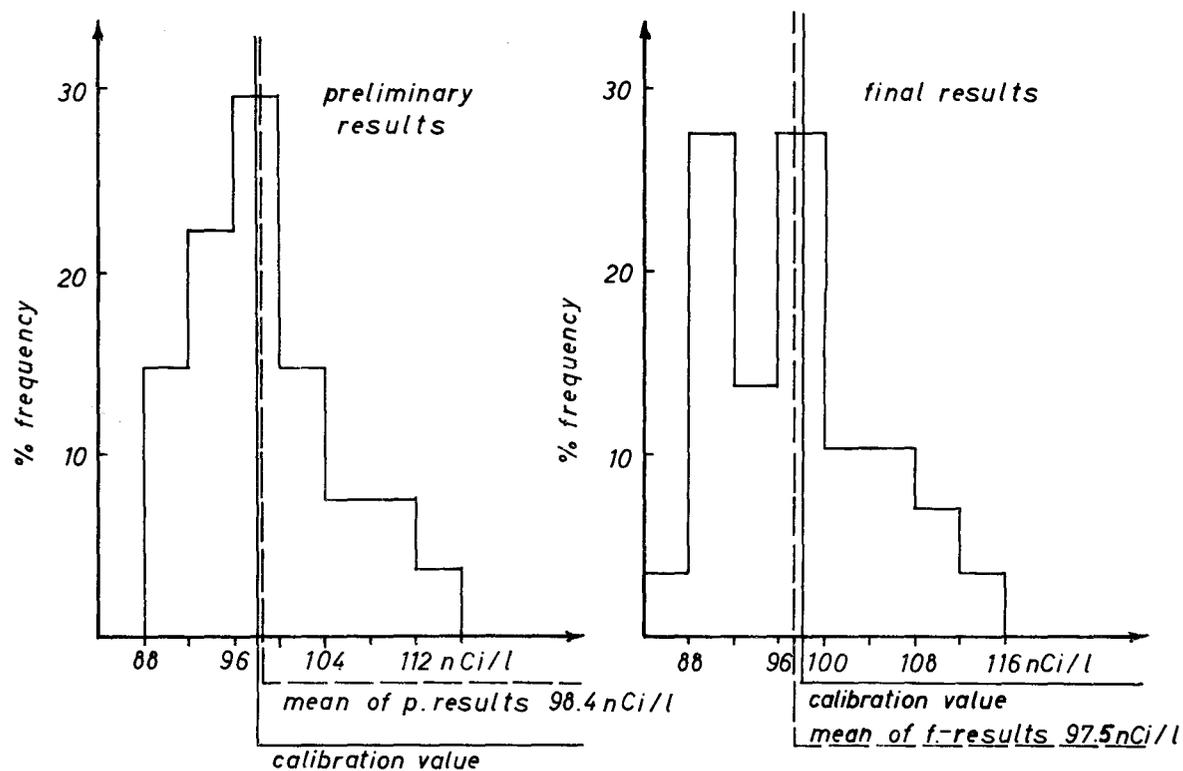


FIG. 4

Distribution of results of ^{140}Ba -ANALYSES at 1.98 nCi/l

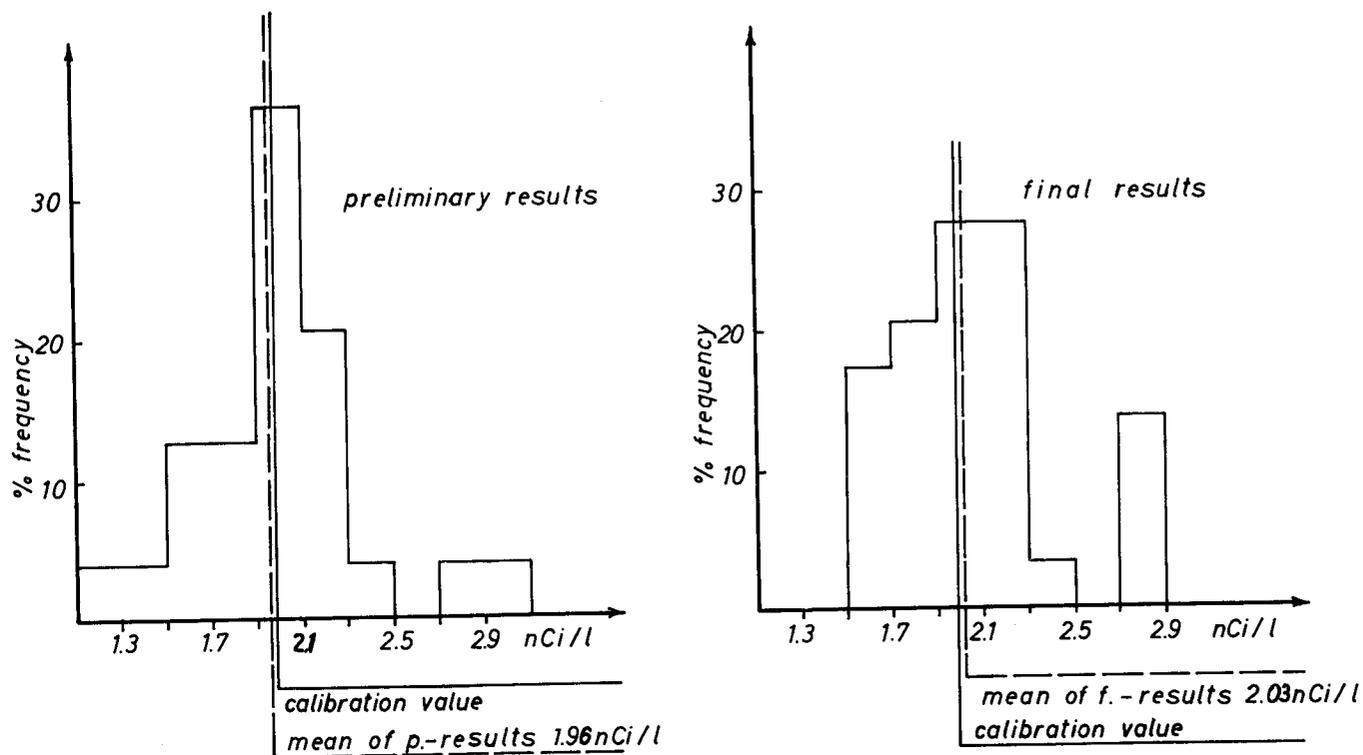
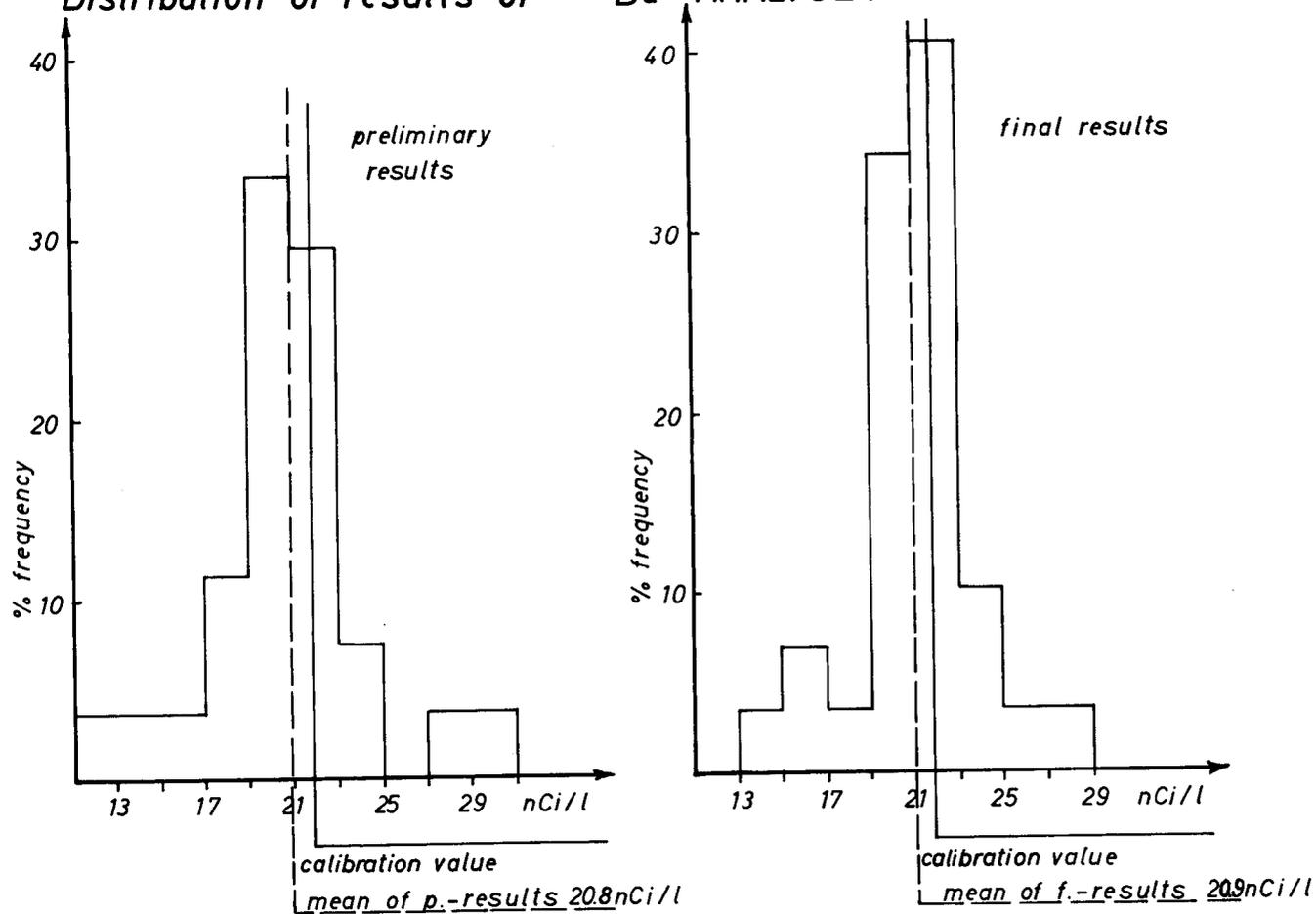


FIG. 5

Distribution of results of ^{140}Ba -ANALYSES at 21.8 nCi/l



Distribution of results of ^{90}Sr -ANALYSES at 1.11nCi/l

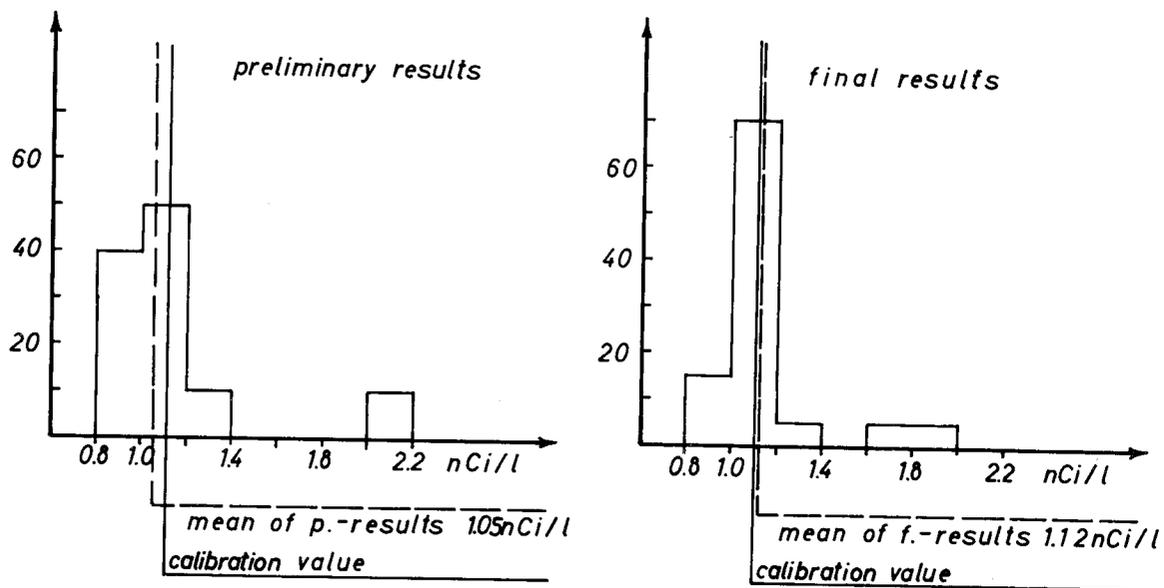


FIG. 7

Distribution of results of ^{90}Sr -ANALYSES at 1.63nCi/l

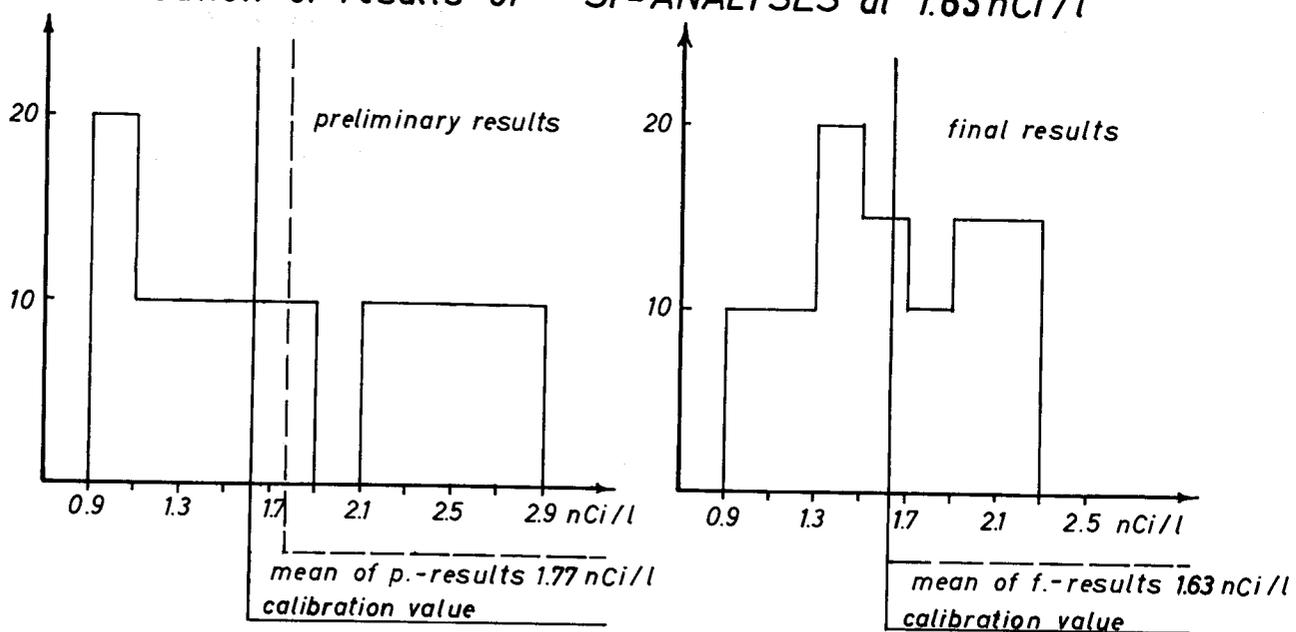
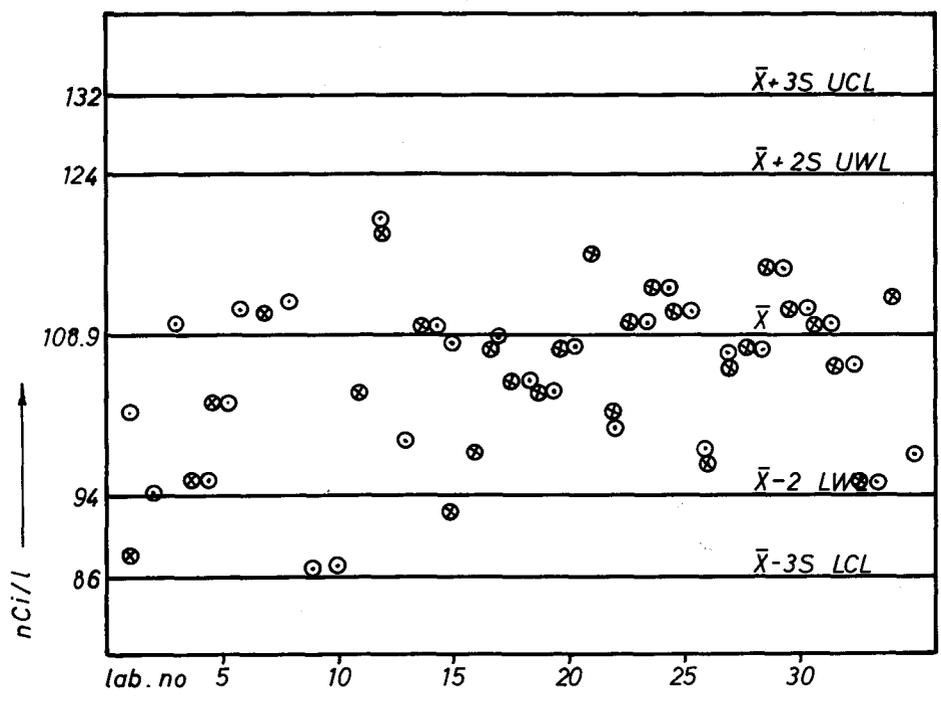


FIG. 8

CONTROL CHART for individual determinations

^{131}I ; 108.9 nCi/l S = 7%

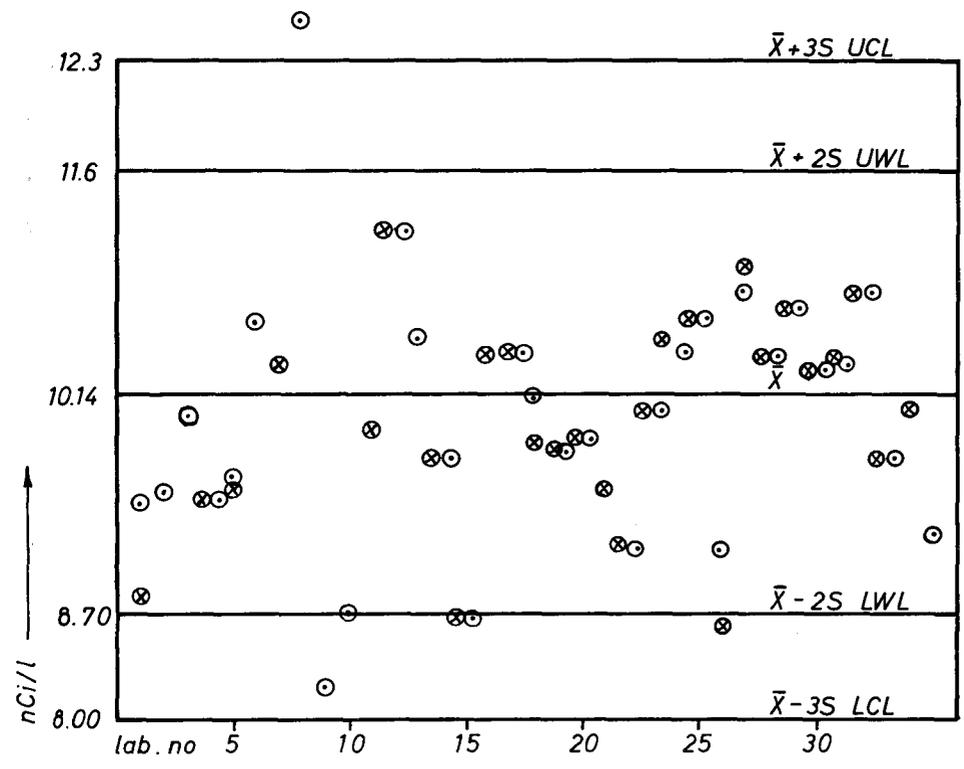


⊗ = preliminary results
 ⊙ = final results

FIG. 10

CONTROL CHART for individual determinations

^{131}I ; 10.14 nCi/l S = 7%



⊗ = preliminary results
 ⊙ = final results

FIG. 9

CONTROL CHART for individual determinations
¹³⁷Cs; 98.0nCi/l S = 6%

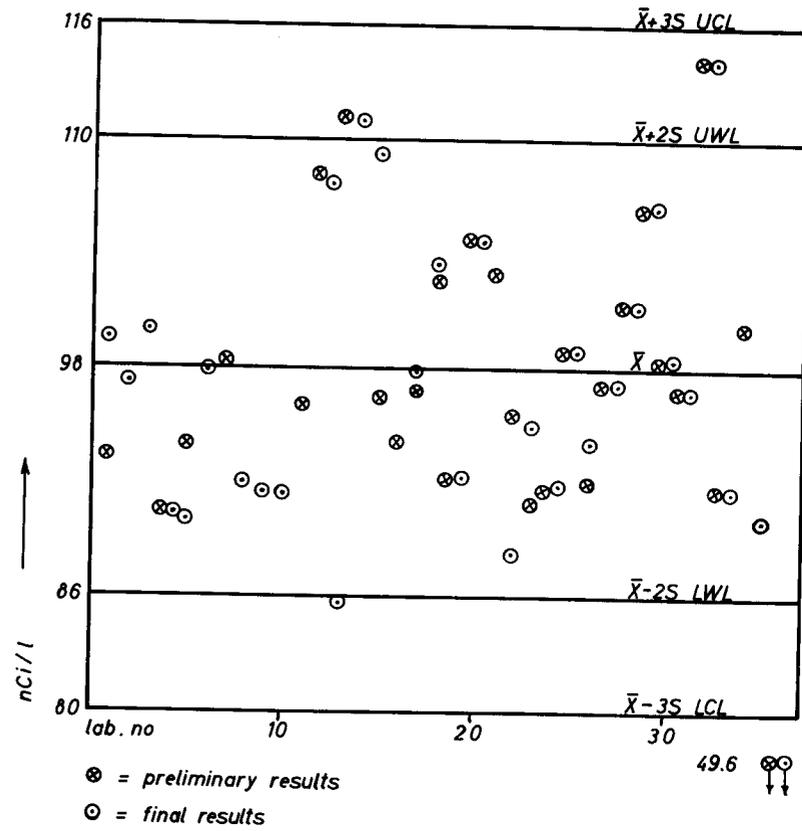


FIG. 12

CONTROL CHART for individual determinations
¹³⁷Cs; 9.11nCi/l S = 7%

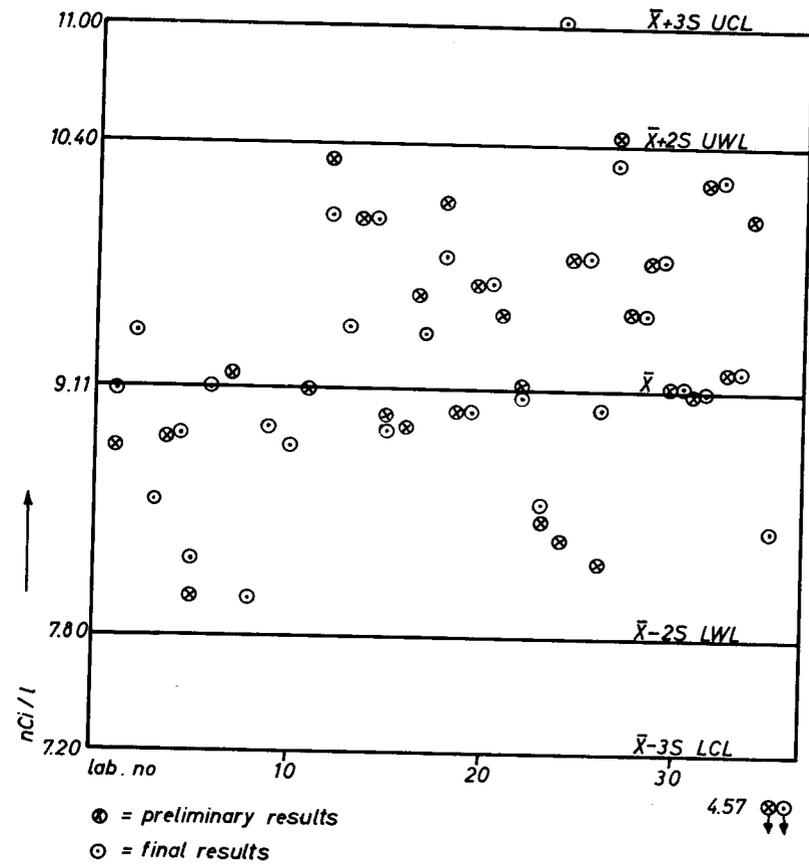


FIG. 11

CONTROL CHART for individual determinations

^{140}Ba ; 21.8 nCi/l $S = 13\%$

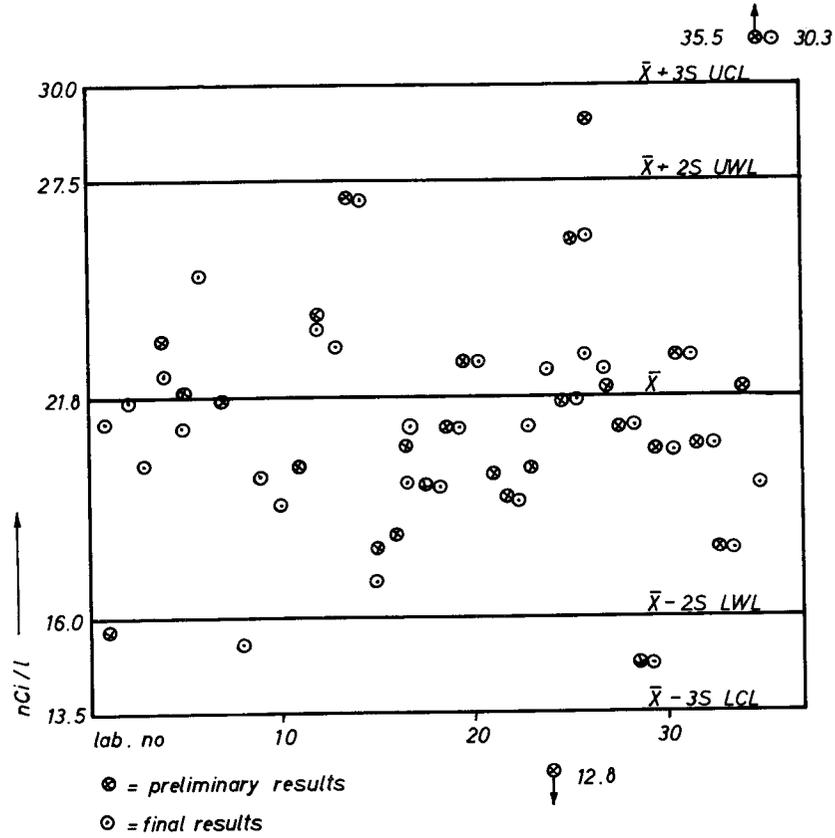


FIG. 14

CONTROL CHART for individual determinations

^{140}Ba ; 1.98 nCi/l $S = 17\%$

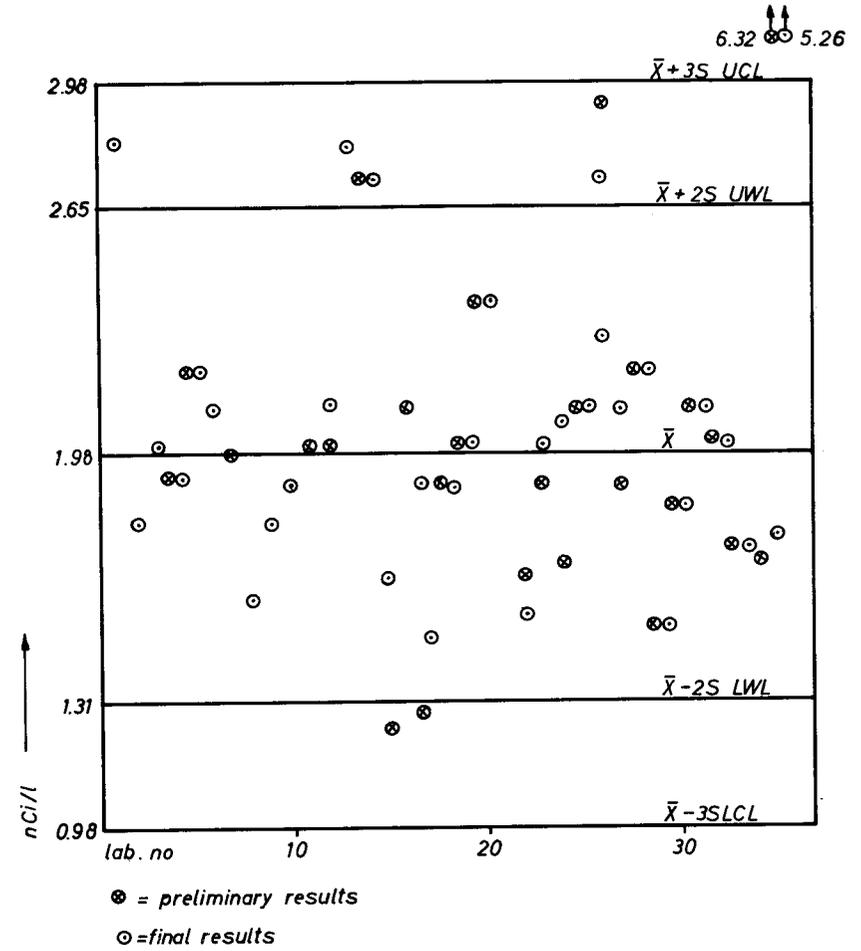


FIG. 13

ANNEX: I

Luxembourg,

EURATOM Intercomparison Programme RAPID MEASUREMENTS

Participating Institute:

Name :
Address :
Country :

Report of Results:

Time schedule (minutes)

<u>Radio-</u> <u>nuclides</u>	<u>nCi/l^x</u>	<u>Estimated</u> <u>overall</u> <u>accuracy xx)</u> <u>of results</u>	<u>Methods of</u> <u>Analysis^{xxx)}</u>
I-131
Sr-89
Sr-90
Ca-137
Ba-140

<u>Sample processing</u>		<u>Counting time</u>	<u>Data calculation</u>	<u>Total time</u>
<u>Sample preparation</u>	<u>Chemical separation</u>			
.....
.....
.....
.....
.....

Reference date :

Date and hour of sample reception (laboratory)

Date and hour of data transmission

telegr. Dr. J. SMEETS, 29 rue Aldringen, Luxembourg. Telex EUROPE LUX. 423 and 446

- x) activity at reference date and hour
xx) state confidence level
xxx) give a short description of method on separate sheet.

ANNEX II

List of Participating Institutes

BELGIUM

Centre d'Etudes de l'Energie Nucléaire, Mol
(Mrs. J. Colard and G. Koch)

Institut d'Hygiène et d'Epidémiologie,
Bruxelles (Dr. A. Lafontaine)

DENMARK

Danish Atomic Energy Commission, Health
Physics Department, Risø (Dr. A. Aarkrog)

GERMANY

Chem. Landesuntersuchungsanstalt, Stuttgart
(Dr. Stoll)

Badische Anilin-Soda-Fabrik AG, Isotopen-
laboratorium, Ludwigshafen (Rhein)
(Dr. H. Guenzler)

Materialprüfungsamt der Landesgewerbeanstalt
Bayern, Abt. Strahlenschutz, Nürnberg
(Dr. Dechert)

Institut für Biophysik der Universität des
Saarlandes, "Boris Rajewsky-Institut",
Homburg/Saar (Dr. R. Kunkel)

Chem. Landesuntersuchungsanstalt, Münster
(Dr. H. Baumann)

Chem.- und Lebensm. Unters., Messtelle für
Radioaktivität, Hamburg (Dr. K. Boek)

Bundesforschungsanstalt für Lebensmittel-
frischhaltung, Karlsruhe (Dr. R. Schelenz)

Bundesforschungsanstalt für Milchwirtschaft,
Kiel (Dr. E. Knoop)

Isotopenlaboratorium, Hamburg-Sueldorf
(Dr. W. Feldt)

Kernforschungsanlage Jülich, Jülich
(Dr. H. Jacobs)

Gesellschaft für Strahlenforschung, München
(Dr. B. Sansoni)

FRANCE S.C.P.R.I., Ministère de la Santé, Le Vésinet
(Dr. P. Pellerin)

Ministère de l'Agriculture, Laboratoire de
Radiobiologie, Paris (Dr. J. Morre)

Commissariat à l'Energie Atomique - D.P.S.,
92 Fontenay-aux-Roses (Mr. L. Jeanmaire)

ITALY Commission des Communautés Européennes
C.C.R./Euratom, Ispra (Dr. A. Malvicini)

Istituto di Igiene dell'Università di Pavia,
Pavia (Dr. E. Lanzola)

Ministero degli Interni, Centro Studi e
Esperienze, Roma (Dr. F. Mazzini)

Comitato Nazionale per l'Energia Nucleare,
Casaccia - Roma (Dr. A. Cigna)

KOREA Atomic Energy Research Institute,
Chongryangri, Seoul (Dr. Young Ku Yoon)

MEXICO Instituto de Energia Nuclear, Mexico 18, D.F.
(Mrs. R.M. de Nulman)

NETHERLANDS Rijksinstituut te Leiden, Leiden
(Dr. W.G. de Ruig)

Rijksinstituut voor de Volksgezondheid,
Bilthoven (Dr. F.C.M. Mattern)

NORWAY Institutt for Atomenergi, Kjeller
(Dr. E. Steinnes)

SOUTH AFRICA Atomic Energy Board, Isotopes and Radiation,
Pretoria (Dr. J.K. Basson)

SWITZERLAND Eidg. Kommission zur Überwachung der Radio-
aktivität, Freiburg (Dr. P. Winiger)

SWEDEN National Institute of Radiation Protection,
Special Labs. for Environmental Research,
Stockholm (Dr. Swedjemark)

UNITED KINGDOM

Reactor Physics Div., Central Electricity
Generating Board, Berkeley Nuclear Labs.,
Gloucestershire (Mr. H.M. Christie)

South of Scotland Electricity Board, Hunterston
Nuclear Power Station, Ayrshire, Scotland

U.S.A.

Dept. of Nuclear Sciences, Eberline Instrument
Corp., Santa Fe, New Mexico (Dr. E.A. Sanchez)

Radiological Sciences Lab., New York State
Dept. Health, Albany N.Y. (Dr. J.M. Matuszek)

Radiochemistry Div., U.S. Atomic Energy
Commission, Health and Safety Lab.,
New York N.Y. (Dr. G.A. Welford)

ANNEX III

List of Participants at C.E.C. Meetings

BELGIUM

Mrs. J. BARUH	Institut d'Hygiène et d'Epidémiologie 14, rue Juliette Wytsman <u>1050 Bruxelles</u>	(1-2)
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Mr. J. COLARD	Centre d'Etudes de l'Energie Nucléaire, <u>Mol</u>	(1-2)
Mrs. DE CLERCQ	Institut d'Hygiène et d'Epidémiologie 14, rue Juliette Wytsman <u>1050 Bruxelles</u>	(2)
Mr. G. KOCH	Centre d'Etudes de l'Energie Nucléaire <u>Mol</u>	(1-2)

FRANCE

Mr. L. FARGES	Commissariat à l'Energie Atomique - D.P.S. Rue de la Fédération <u>Paris 15e</u>	(1)
Mr. L. JEANMAIRE	Commissariat à l'Energie Atomique - D.P.S. B.P. n° 6 <u>92 Fontenay-aux-Roses</u>	(2)
Dr. J. MORRE	Ministère de l'Agriculture Laboratoire de Radiobiologie 39, rue de Dantzig <u>Paris 15e</u>	(1-2)

FRANCE

Mr. F. PATTI
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Dr. A. WIECHEN
Bundesforschungsanstalt für Milch-
forschung
Institut für Physik
Hermann Weigmann Strasse I/27
23 Kiel (2)

ITALY

Dr. G. BAGLIANO	Comitato Nazionale per l'Energia Nucleare C.P. 2400 <u>Casaccia - Roma</u>	(1-2)
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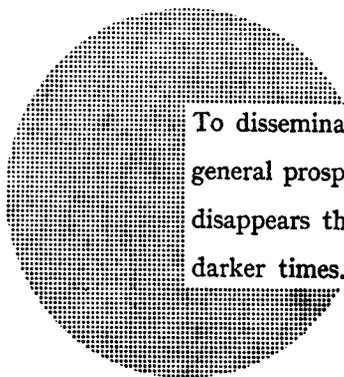




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