KfK 4157
EUR 10533 EN
Dezember 1989

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EVALUATION OF IDA-80 DATA BY THE DOD METHOD

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ISSN 0303-4003

Abstract

The measurement data of 28 interlaboratory analyses performed under the IDA-80 programme are evaluated by the DoD method with respect to the RSDs of the interlaboratory spreads and the within-laboratory uncertainty components. The resulting estimates are compared to those obtained by variance analysis after application of outlier criteria in the official IDA-80 evaluation. Deviations found in case of the within-laboratory uncertainty components ('run' component of the IDA-80 evaluation) are discussed.

Auswertung von IDA-80 Daten mit der DoD-Methode

Die relative Standardabweichung der Interlaborstreuung sowie der Wiederholbarkeit der Messungen innerhalb der Labors wurde für 28 Interlaboranalysen des IDA-80 Programms nach dem DoD-Verfahren bestimmt. Die dabei gewonnenen Schätzwerte werden mit denen verglichen, die bei der offiziellen IDA-80 Auswertung nach der Anwendung von Ausreisserkriterien mittels Varianzanalyse erhalten wurden. Bei der Unsicherheitskomponente 'Wiederholbarkeit der Messungen innerhalb der Labors' ('run'-Komponente der IDA-80 Auswertung) auftretende Abweichungen werden diskutiert.

Table of Contents

1. Introduction

In the evaluation of analytical interlaboratory experiments handling of outliers is a particular problem: On the one hand, outliers have to be eliminated so that sufficiently homogeneous data material is obtained to which the variance analysis or other conventional statistical methods can be reasonably applied and, on the other hand, it is unsatisfactory to suppress analytical measurement values for merely statistical reasons. Besides, the selection of the outlier criterion from the many methods described in the literature as well as the arbitrary definition of the threshold for data elimination introduce a substantial amount of uncertainty into the statistical estimation of expectations.

When the standard deviation of a group of data is estimated, this difficulty can be avoided by application of the DoD[1)] method of evaluation which had been developed at KfK and which does not require homogenized sets of data. With this method the absolute values of all differences, which can be established between the results of repetitive measurements, are used as basic elements in statistical evaluation. From the cumulative frequency distribution of these differences an estimate can be made of the standard deviation of the underlying repetitive measurements. Unlike in the conventional computing method, the amount of this estimate is influenced above all by the number and hardly by the quality of the outliers produced. Where this number is less than about 20% of the measured values obtained, the estimate is almost not influenced at all /1,2/.

As also in the evaluation of the IDA-80 Measurement Evaluation Programme /3/ [2)] according to the conventional methods handling of outliers had played a substantial role, it was deemed interesting to compare the estimated standard deviations with the values obtained by application of the DoD method without exclusion of outliers.

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1) DoD means 'Distribution of Differences'.

2) This analytical measurement programme relates to the mass spectrometric isotope dilution analysis of uranium and plutonium in input solutions of a reprocessing plant for spent nuclear fuels.

The better the agreement is, the more validate the results of both methods each other: If the results obtained with the DoD method are considered as the 'correct' values, good agreement shows that in the conventional evaluation the outlier criteria have been reasonably applied; if the values furnished by the conventional method are deemed to be the correct ones, good agreement evidences the efficiency of the DoD method because, without elimination of outliers, it produces the same or similar results.

2. Data Material of IDA-80

The data material obtained in the IDA-80 Measurement Evaluation Programme are concentration values for uranium and plutonium determined in samples of different solutions as well as isotopic compositions determined for these elements.

Each assay was made by a group of p = 24 to 30[3)] laboratories i, each of them performing three repetitive measurements producing the results y_{i1} to y_{i3} and the 'laboratory mean'

$$\bar{y}_i = \frac{1}{3} \sum_{v=1}^{3} y_{iv} \qquad \text{(eq. 1)}$$

The mean of all laboratory means (i. e. the mean of all measurements carried out by the participating laboratories) is designated 'grand mean'

$$\bar{\bar{y}} = \frac{1}{p} \sum_{i=1}^{p} \bar{y}_i \qquad \text{(eq. 2)}$$

Scattering of the laboratory means around the grand mean is termed 'interlaboratory spread'

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3) Except two ^{238}Pu assays for which the measurements of only 9 laboratories could be used for this study.

$$s_R = \sqrt{\frac{\sum_{i=1}^{p} (\bar{y}_i - \bar{\bar{y}})^2}{p-1}} \qquad \text{(eq. 3)}$$

It is made up of two components: the 'within-laboratory' uncertainty component s_w,[4] which is the average value of the repeatability of the measurements within the individual laboratories[5], and the 'between-laboratory' uncertainty component s_b describing the component of the interlaboratory spread, which results from the systematic deviations between the laboratories. Since there are $n = 3$ repetitive measurements per laboratory, the relationship between these variables in the programme is [6].

$$s_R = \sqrt{s_b^2 + \frac{s_w^2}{3}} \qquad \text{(eq. 4)}$$

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4) This uncertainty component is called 'run' component in /3/.

5) The repeatability of the measurements of laboratory i is given by

$$s_w(i) = \sqrt{\frac{\sum_{v=1}^{n} (y_{iv} - \bar{y}_i)^2}{n-1}} \qquad \text{with } n = 3.$$

6) In the ISO 5725 document of the International Standard Organization /4/, S_b^2 and S_w^2 are called 'between-laboratory' and 'repeatability' variance, respectively, $(S_b^2 + S_w^2)$ is called 'reproducibility variance' and would correspond to the square of the 'interlaboratory spread' s_R if no repetitive measurements were made in the laboratories. In practical cases, the square of the 'interlaboratory spread' is, in general, a rather good approximation to the 'reproducibility' variance.

In the Appendix, the basic IDA-80 data material is compiled together with the results of conventional evaluation as well as DoD evaluation. In total, 12 elemental assays and 16 isotope determinations were suitable for this study. For each assay the data are split into two sections:

Section A gives a graphical survey of the results obtained by the participating laboratories. The laboratory means y_i are ordered by increasing values, the associated dashes indicate their relative standard deviations which in this case equal the repeatability $s_w(i)$ of the laboratory divided by the square root of three. The ordinate represents the relative deviation of the results from the certified value whose uncertainty range is indicated, too.

Extreme values occurring outside the graphs are mentioned below.

In order to estimate by variance analysis the interlaboratory spread s_R and the average within-laboratory uncertainty component s_w, the data groups had to be homogenized by excluding extreme values in the statistical meaning. For this purpose, the laboratory means were first verified by application of the Bartsch criterion /5/ which (for the size of data populations available) excludes a laboratory mean value $\bar{y}_i$ if $|\bar{y}_i - \bar{\bar{y}}| > 4s_R$ where $\bar{\bar{y}}$ is the grand mean and s_R the interlaboratory spread of the data group excluding the suspicious value $\bar{y}_i$.

Then, the measurement values of those laboratories were eliminated which proved to be extremely unfavorable in terms of repeatability $s_w(i)$. For this purpose, the Dixon criterion /6/ with the probability of error $\alpha \leq 1\%$ was applied to the repeatability of all laboratories. In case the measured values from one or several laboratories had to be eliminated, the remaining laboratory means were verified once more applying the Bartsch criterion.

The laboratories excluded by the two criteria and the values estimated for s_R and s_w before and after their rejection are given at the end of Section A. For more details on this subject, one should refer to /7/.

In Section B of the data compilations given in the Appendix, the two DoD curves are shown from which the DoD estimates for the interlaboratory spread s_R and the within-laboratory uncertainty component s_w are obtained without any exclusion of outliers. These curves represent the cumulative frequency distribution of all absolute values of the differences (relative to the certified value) calculated between the laboratory mean values $\bar{y}_i$ and between the

measurement values y_{iv} (pooled over all laboratories), respectively. The estimates for the interlaboratory spread and the within-laboratory uncertainty component are given by the abscissa value corresponding to the 52%-ordinate intercept [7].

3. Results of Evaluation and Discussion

In Tables I and II the estimates for the interlaboratory spread and the average values of the within-laboratory uncertainty component obtained by the DoD method (columns 4) have been compared with the results obtained in the IDA-80 evaluation after the rejection of 10.3% of measurement data as outliers (columns 6).[8] In addition, those estimates have been entered in the tables which result from the conventional calculation with no outlier criteria applied (columns 5).
The following observations can be made:

a) The conventional estimates without outlier criteria applied are higher in all cases than the DoD values - in many cases higher by several hundred percent (see columns 9 in Tabs. I and II). This confirms the expectation that the values estimated according to the DoD method are little influenced by (individual) extreme values.

b) For the interlaboratory spread (Tab. I), the deviations of the DoD estimates from the conventional results excluding outliers are as frequently positive as they are negative (see column 10).
The DoD values occur in 24 out of 28 cases (86%) within the 99%-confidence interval of the estimates determined in the IDA-80 evaluation (see column 11) [9].

For those cases where this does not apply more detailed studies have revealed that this is very probably attributable to the exclusion of the outliers: If the DoD value occurs below the confidence interval, the last extreme value considered narrowly missed the condition for exclusion, or vice versa.

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7) In prior publications often the 48%-intercept was used because of different data presentation.

8) The values were taken from the data compilation of the Appendix.

9) If no outlier criteria had been applied in the IDA-80 evaluation, the DoD values would occur within the 99%-confidence intervals in only 5 out of the 28 cases (18%).

TAB.I: ESTIMATES OF RELATIVE STANDARD DEVIATIONS OF THE INTERLABORATORY SPREAD;
DoD METHOD IN COMPARISON WITH VARIANCE ANALYSIS (DIXON WITH ALPHA LESS THAN OR EQUAL TO 1%)

1	2	3	4	5	6	7	8	9	10	11	12
			ESTIMATE OF RSD OF INTERLABORATORY SPREAD								
TYPE OF DETERMINATION	PART OF IDA-80 PROGRAM	NUMBER OF LABS	DoD METHOD sR1 (%)	VAR. ANALYSIS OF ALL DATA sR2 (%)	VAR. ANALYSIS[1] WITHOUT OUTLIERS sR3 (%)	NUMBER[2] OF LABS EXCLUDED	99%-CONFIDENCE LIMITS OF sR3 (%)	DEVIATION OF sR2 FROM sR1 (%)	DEVIATION OF sR3 FROM sR1 (%)	sR1 WITHIN CONFIDENCE LIMITS OF sR3?	REF. ON PAGE
CONCENTRATION:											
U-ELEMENT	1.11	30	0.59	1.72	0.72	2 + 0	0.53; 1.09	+ 192	+ 22	YES	18
U-ELEMENT	1.12	27	0.78	2.70	1.03	2 + 0	0.75; 1.60	+ 246	+ 32	YES	20
U-ELEMENT	1.2	30	0.73	3.01	0.53	3 + 2	0.38; 0.83	+ 312	- 27	YES	22
U-ELEMENT	2.1	28	0.82	2.64	0.48	3 + 3	0.34; 0.78	+ 222	- 41	NO	24
U-ELEMENT	2.2	28	0.47	0.82	0.34	2 + 2	0.25; 0.53	+ 74	- 28	YES	26
U-ELEMENT	2.3	27	0.58	0.93	0.40	2 + 2	0.29; 0.64	+ 60	- 31	YES	28
Pu-ELEMENT	1.11	28	0.97	1.90	0.82	2 + 0	0.60; 1.26	+ 96	- 15	YES	30
Pu-ELEMENT	1.12	26	1.95	3.04	2.56	0 + 2	1.85; 4.03	+ 56	+ 31	YES	32
Pu-ELEMENT	1.2	29	0.65	3.77	0.35	3 + 3	0.25; 0.56	+ 480	- 46	NO	34
Pu-ELEMENT	2.1	26	1.34	3.20	1.25	2 + 1	0.90; 1.99	+ 139	- 7	YES	36
Pu-ELEMENT	2.2	27	0.43	0.66	0.35	2 + 1	0.25; 0.55	+ 53	- 19	YES	38
Pu-ELEMENT	2.3	26	0.49	0.52	0.50	0 + 3	0.36; 0.80	+ 6	+ 2	YES	40
ISOTOPE ABUNDANCE:											
U-234 ASSAY	1.11	27	4.60	6.36	4.01	1 + 0	2.93; 6.16	+ 38	- 13	YES	42
U-234 ASSAY	2.1	25	5.62	9.70	6.08	1 + 0	4.39; 9.56	+ 73	+ 8	YES	44
U-235 ASSAY	1.11	30	0.59	1.53	0.33	5 + 1	0.24; 0.52	+ 159	- 44	NO	46
U-235 ASSAY	2.1	28	0.72	2.98	0.51	3 + 3	0.36; 0.82	+ 314	- 29	YES	48
U-236 ASSAY	1.11	30	1.63	5.52	2.26	1 + 2	1.66; 3.44	+ 239	+ 39	NO	50
U-236 ASSAY	2.1	25	8.96	14.2	7.42	1 + 1	5.32;11.8	+ 58	- 17	YES	52
Pu-238 ASSAY	1.11	26	5.22	13.7	7.01	1 + 1	5.06;11.0	+ 162	+ 34	YES	54
Pu-238 ASSAY	2.1	24	5.29	16.2	6.21	2 + 2	4.36;10.3	+ 206	+ 17	YES	58
Pu-239 ASSAY	1.11	29	0.11	0.16	0.13	1 + 2	0.095;0.20	+ 45	+ 18	YES	62
Pu-239 ASSAY	2.1	27	0.079	0.093	0.093	0 + 0	0.068;0.14	+ 18	+ 18	YES	64
Pu-240 ASSAY	1.11	29	0.15	0.32	0.14	1 + 1	0.10; 0.21	+ 113	- 7	YES	66
Pu-240 ASSAY	2.1	27	0.11	0.14	0.14	0 + 0	0.10; 0.21	+ 27	+ 27	YES	68
Pu-241 ASSAY	1.11	29	0.46	0.54	0.56	0 + 4	0.41; 0.87	+ 17	+ 22	YES	70
Pu-241 ASSAY	2.1	27	0.57	0.62	0.62	0 + 0	0.45; 0.94	+ 9	+ 9	YES	72
Pu-242 ASSAY	1.11	29	1.07	1.48	1.17	1 + 0	0.86; 1.77	+ 38	+ 9	YES	74
Pu-242 ASSAY	2.1	27	1.61	3.18	1.26	2 + 0	0.91; 1.96	+ 98	- 22	YES	76
TOTAL:		771				43 + 36 = 79 (10.3%)		28+; 0-	14+; 14-	24 4	

[1] FIGURES CORRESPOND TO THE OFFICIAL IDA-80 EVALUATION.

[2] THE NUMBER OF EXCLUDED LABORATORIES IS SPLIT WITH RESPECT TO THE REASON FOR REJECTION:
FIGURES REFER TO LABORATORIES EXCLUDED FOR EXTREME MEAN VALUES (BARTSCH CRITERION) AND
FOR EXCEPTIONALLY HIGH REPEATABILITY VALUES (DIXON CRITERION).

TAB.II: ESTIMATES OF RELATIVE STANDARD DEVIATIONS OF THE WITHIN-LABORATORY UNCERTAINTY COMPONENT (REPEATABILITY); DoD METHOD IN COMPARISON WITH VARIANCE ANALYSIS (DIXON WITH ALPHA LESS THAN OR EQUAL TO 1%)

1	2	3	4	5	6	7	8	9	10	11	12
			ESTIMATE OF RSD OF REPEATABILITY								
TYPE OF DETERMINATION	PART OF IDA-80 PROGRAM	NUMBER OF LABS	DoD METHOD sw1 (%)	VAR. ANALYSIS OF ALL DATA sw2 (%)	VAR. ANALYSIS[1] WITHOUT OUTLIERS sw3 (%)	NUMBER[2] OF LABS EXCLUDED	99%-CONFIDENCE LIMITS OF sw3 (%)	DEVIATION OF sw2 FROM sw1 (%)	DEVIATION OF sw3 FROM sw1 (%)	sw1 WITHIN CONFIDENCE LIMITS OF sw3?	REF. ON PAGE
CONCENTRATION:											
U-ELEMENT	1.11	30	0.20	0.77	0.37	2 + 0	0.30; 0.49	+ 285	+ 85	NO	18
U-ELEMENT	1.12	27	0.24	2.17	0.43	2 + 0	0.34; 0.57	+ 804	+ 79	NO	20
U-ELEMENT	1.2	30	0.15	0.64	0.18	3 + 2	0.14; 0.24	+ 327	+ 20	YES	22
U-ELEMENT	2.1	28	0.17	3.52	0.26	3 + 3	0.20; 0.35	+1971	+ 53	NO	24
U-ELEMENT	2.2	28	0.12	0.41	0.18	2 + 2	0.14; 0.24	+ 242	+ 50	NO	26
U-ELEMENT	2.3	27	0.23	0.71	0.37	2 + 2	0.29; 0.50	+ 209	+ 61	NO	28
Pu-ELEMENT	1.11	28	0.15	0.37	0.38	2 + 0	0.30; 0.50	+ 147	+ 153	NO	30
Pu-ELEMENT	1.12	26	0.24	1.05	0.50	0 + 2	0.40; 0.67	+ 338	+ 108	NO	32
Pu-ELEMENT	1.2	29	0.22	1.09	0.31	3 + 3	0.24; 0.42	+ 395	+ 41	NO	34
Pu-ELEMENT	2.1	26	0.20	3.44	0.28	2 + 1	0.22; 0.38	+1620	+ 40	NO	36
Pu-ELEMENT	2.2	27	0.15	1.00	0.36	2 + 1	0.28; 0.48	+ 567	+ 140	NO	38
Pu-ELEMENT	2.3	26	0.20	0.75	0.27	0 + 3	0.21; 0.37	+ 275	+ 35	NO	40
ISOTOPE ABUNDANCE:											
U-234 ASSAY	1.11	27	2.30	10.0	4.77	1 + 0	3.80; 6.32	+ 335	+ 107	NO	42
U-234 ASSAY	2.1	25	2.25	5.39	4.33	1 + 0	3.42; 5.81	+ 140	+ 92	NO	44
U-235 ASSAY	1.11	30	0.21	0.52	0.27	5 + 1	0.21; 0.36	+ 148	+ 29	YES	46
U-235 ASSAY	2.1	28	0.19	0.88	0.16	3 + 3	0.13; 0.22	+ 363	- 16	YES	48
U-236 ASSAY	1.11	30	0.45	1.71	0.47	1 + 2	0.38; 0.62	+ 280	+ 4	YES	50
U-236 ASSAY	2.1	25	4.48	6.61	4.67	1 + 1	3.67; 6.31	+ 48	+ 4	YES	52
Pu-238 ASSAY	1.11	9	1.59	3.75	1.50	1 + 0	1.02; 2.65	+ 136	- 6	YES	56
Pu-238 ASSAY	2.1	9	1.56	6.35	1.21	1 + 1	0.81; 2.24	+ 307	- 22	YES	60
Pu-239 ASSAY	1.11	29	0.032	0.12	0.035	1 + 2	0.028;0.046	+ 275	+ 9	YES	62
Pu-239 ASSAY	2.1	27	0.024	0.045	0.045	0 + 0	0.036;0.059	+ 88	+ 88	NO	64
Pu-240 ASSAY	1.11	29	0.068	0.25	0.097	1 + 1	0.078;0.13	+ 268	+ 43	NO	66
Pu-240 ASSAY	2.1	27	0.060	0.15	0.15	0 + 0	0.12; 0.20	+ 150	+ 150	NO	68
Pu-241 ASSAY	1.11	29	0.21	0.59	0.18	0 + 4	0.14; 0.24	+ 181	- 14	YES	70
Pu-241 ASSAY	2.1	27	0.23	0.40	0.40	0 + 0	0.32; 0.53	+ 74	+ 74	NO	72
Pu-242 ASSAY	1.11	29	0.36	1.75	0.95	1 + 0	0.76; 1.25	+ 386	+ 164	NO	74
Pu-242 ASSAY	2.1	27	0.32	0.86	0.79	2 + 0	0.63; 1.05	+ 169	+ 147	NO	76
TOTAL:		739				42 + 34 = 76 (10.3%)		28+; 0-	24+; 4-	9 19	

[1] FIGURES CORRESPOND TO THE OFFICIAL IDA-80 EVALUATION.

[2] THE NUMBER OF EXCLUDED LABORATORIES IS SPLIT WITH RESPECT TO THE REASON FOR REJECTION: FIGURES REFER TO LABORATORIES EXCLUDED FOR EXTREME MEAN VALUES (BARTSCH CRITERION) AND FOR EXCEPTIONALLY HIGH REPEATABILITY VALUES (DIXON CRITERION).

These observations indicate a satisfactory agreement of the estimates of the interlaboratory spread obtained by the DoD method with those of the IDA-80 evaluation. Since the IDA-80 estimates scatter around the DoD values and do not exhibit any bias, application of the Bartsch-outlier criterion to the laboratory mean values in the IDA-80 evaluation was obviously meaningful.

c) For the within-laboratory uncertainty component (Tab. II), the IDA-80 estimate exceeds the DoD estimate in 24 out of the 28 cases (see column 10), and the DoD estimate falls in only 32% of the cases (9 out of 28) in the 99%-confidence interval of the IDA-80 value (see column 11). This agreement is poor. It may indicate that in evaluating IDA-80, the Dixon criterion was not used strong enough taking a risk of only $\alpha \leq 1\%$ that a value is excluded which really belongs to the group.

In order to verify that assumption, the IDA-80 evaluation procedure was repeated allowing $\alpha \leq 10\%$ probability of error in application of the Dixon criterion. The results are given in Table III:

The rate of outliers according to the Dixon criterion changed from 34 to 50 out of 739 measurement values (see column 7) and the percentage of DoD estimates within the 99%-confidence limits of the IDA-80 values increased from 9 to 15 out of 28 (or from 32% to 54%; see column 11). This is a clear improvement as far as the agreement of the results of both evaluation methods is concerned. However, the IDA-80 estimates are still positively biased in relation to the DoD results (see column 10).

To elucidate this effect, the IDA-80 estimate gained by variance analysis was replaced by the arithmetic mean value of the repeatabilities calculated for the individual laboratories

$$\overline{s_w} = \frac{1}{p} \sum_{i=1}^{p} s_w(i) \qquad \text{(eq. 5)}$$

Prior to this calculation, the Dixon criterion was applied with $\alpha \leq 1\%$ as well as $\alpha \leq 10\%$. The results are shown in Tabs. IV and V:
Now in 18 or even 21 out of the 28 cases (i.e. in 64% and 75%, respectively), the DoD estimates are within the 99%-confidence limits of the conventionally derived values (see columns 11). Furthermore, in case the Dixon criterion was

TAB.III: ESTIMATES OF RELATIVE STANDARD DEVIATIONS OF THE WITHIN-LABORATORY UNCERTAINTY COMPONENT (REPEATABILITY); DoD METHOD IN COMPARISON WITH VARIANCE ANALYSIS (DIXON WITH ALPHA LESS THAN OR EQUAL TO 10%)

1	2	3	4	5	6	7	8	9	10	11	12
			ESTIMATE OF RSD OF REPEATABILITY								
TYPE OF DETERMINATION	PART OF IDA-80 PROGRAM	NUMBER OF LABS	DoD METHOD sw1 (%)	VAR. ANALYSIS OF ALL DATA sw2 (%)	VAR. ANALYSIS[1] WITHOUT OUTLIERS sw3 (%)	NUMBER[2] OF LABS EXCLUDED	99%-CONFIDENCE LIMITS OF sw3 (%)	DEVIATION OF sw2 FROM sw1 (%)	DEVIATION OF sw3 FROM sw1 (%)	sw1 WITHIN CONFIDENCE LIMITS OF sw3?	REF. ON PAGE
CONCENTRATION:											
U-ELEMENT	1.11	30	0.20	0.77	0.24	2 + 2	0.19; 0.32	+ 285	+ 20	YES	18
U-ELEMENT	1.12	27	0.24	2.17	0.27	2 + 3	0.21; 0.37	+ 804	+ 13	YES	20
U-ELEMENT	1.2	30	0.15	0.64	0.18	3 + 2	0.14; 0.24	+ 327	+ 20	YES	22
U-ELEMENT	2.1	28	0.17	3.52	0.26	3 + 3	0.20; 0.35	+1971	+ 53	NO	24
U-ELEMENT	2.2	28	0.12	0.41	0.15	2 + 3	0.12; 0.20	+ 242	+ 25	YES	26
U-ELEMENT	2.3	27	0.23	0.71	0.37	2 + 2	0.29; 0.50	+ 209	+ 61	NO	28
Pu-ELEMENT	1.11	28	0.15	0.37	0.38	2 + 0	0.30; 0.50	+ 147	+ 153	NO	30
Pu-ELEMENT	1.12	26	0.24	1.05	0.50	0 + 2	0.40; 0.67	+ 338	+ 108	NO	32
Pu-ELEMENT	1.2	29	0.22	1.09	0.31	3 + 3	0.24; 0.42	+ 395	+ 41	NO	34
Pu-ELEMENT	2.1	26	0.20	3.44	0.25	2 + 2	0.20; 0.34	+1620	+ 25	YES	36
Pu-ELEMENT	2.2	27	0.15	1.00	0.17	2 + 4	0.13; 0.23	+ 567	+ 13	YES	38
Pu-ELEMENT	2.3	26	0.20	0.75	0.27	0 + 3	0.21; 0.37	+ 275	+ 35	NO	40
ISOTOPE ABUNDANCE:											
U-234 ASSAY	1.11	27	2.30	10.0	4.77	1 + 0	3.80; 6.32	+ 335	+ 107	NO	42
U-234 ASSAY	2.1	25	2.25	5.39	4.33	1 + 0	3.42; 5.81	+ 140	+ 92	NO	44
U-235 ASSAY	1.11	30	0.21	0.52	0.27	5 + 1	0.21; 0.36	+ 148	+ 29	YES	46
U-235 ASSAY	2.1	28	0.19	0.88	0.16	3 + 3	0.13; 0.22	+ 363	- 16	YES	48
U-236 ASSAY	1.11	30	0.45	1.71	0.47	1 + 2	0.38; 0.62	+ 280	+ 4	YES	50
U-236 ASSAY	2.1	25	4.48	6.61	4.67	1 + 1	3.67; 6.31	+ 48	+ 4	YES	52
Pu-238 ASSAY	1.11	9	1.59	3.75	1.50	1 + 0	1.02; 2.65	+ 136	- 6	YES	56
Pu-238 ASSAY	2.1	9	1.56	6.35	1.21	1 + 1	0.81; 2.24	+ 307	- 22	YES	60
Pu-239 ASSAY	1.11	29	0.032	0.12	0.031	1 + 3	0.025;0.041	+ 275	- 3	YES	62
Pu-239 ASSAY	2.1	27	0.024	0.045	0.045	0 + 0	0.036;0.059	+ 88	+ 88	NO	64
Pu-240 ASSAY	1.11	29	0.068	0.25	0.087	1 + 2	0.069;0.12	+ 268	+ 28	NO	66
Pu-240 ASSAY	2.1	27	0.060	0.15	0.074	0 + 3	0.058;0.099	+ 150	+ 23	YES	68
Pu-241 ASSAY	1.11	29	0.21	0.59	0.18	0 + 4	0.14; 0.24	+ 181	- 14	YES	70
Pu-241 ASSAY	2.1	27	0.23	0.40	0.40	0 + 0	0.32; 0.53	+ 74	+ 74	NO	72
Pu-242 ASSAY	1.11	29	0.36	1.75	0.95	1 + 0	0.76; 1.25	+ 386	+ 164	NO	74
Pu-242 ASSAY	2.1	27	0.32	0.86	0.68	2 + 1	0.54; 0.91	+ 169	+ 113	NO	76
TOTAL:		739				42 + 50 = 92 (12.4%)		28+; 0-	23+; 5-	15 13	

[1] IN SOME CASES THE FIGURES ARE DIFFERENT TO THOSE OF THE OFFICIAL IDA-80 EVALUATION.

[2] THE NUMBER OF EXCLUDED LABORATORIES IS SPLIT WITH RESPECT TO THE REASON FOR REJECTION: FIGURES REFER TO LABORATORIES EXCLUDED FOR EXTREME MEAN VALUES (BARTSCH CRITERION) AND FOR EXCEPTIONALLY HIGH REPEATABILITY VALUES (DIXON CRITERION).

TAB.IV: ESTIMATES OF RELATIVE STANDARD DEVIATIONS OF THE WITHIN-LABORATORY UNCERTAINTY COMPONENT (REPEATABILITY); DoD METHOD IN COMPARISON WITH MEAN-VALUE DETERMINATION (DIXON WITH ALPHA LESS THAN OR EQUAL TO 1%)

1	2	3	4	5	6	7	8	9	10	11	12
			ESTIMATE OF RSD OF REPEATABILITY								
TYPE OF DETERMINATION	PART OF IDA-80 PROGRAM	NUMBER OF LABS	DoD METHOD sw1 (%)	MEAN-VALUE DETERMINATION OF ALL DATA sw2 (%)	MEAN-VALUE[1] DET. WITHOUT OUTLIERS sw3 (%)	NUMBER[2] OF LABS EXCLUDED	99%-CONFIDENCE LIMITS OF sw3 (%)	DEVIATION OF sw2 FROM sw1 (%)	DEVIATION OF sw3 FROM sw1 (%)	sw1 WITHIN CONFIDENCE LIMITS OF sw3?	REF. ON PAGE
CONCENTRATION:											
U-ELEMENT	1.11	30	0.20	0.39	0.25	2 + 0	0.20; 0.33	+ 95	+ 25	YES	18
U-ELEMENT	1.12	27	0.24	0.88	0.32	2 + 0	0.25; 0.43	+ 267	+ 33	NO	20
U-ELEMENT	1.2	30	0.15	0.31	0.14	3 + 2	0.11; 0.19	+ 107	- 7	YES	22
U-ELEMENT	2.1	28	0.17	1.19	0.18	3 + 3	0.14; 0.25	+ 600	+ 6	YES	24
U-ELEMENT	2.2	28	0.12	0.25	0.14	2 + 2	0.11; 0.19	+ 108	+ 17	YES	26
U-ELEMENT	2.3	27	0.23	0.44	0.26	2 + 2	0.20; 0.35	+ 91	+ 13	YES	28
Pu-ELEMENT	1.11	28	0.15	0.25	0.25	2 + 0	0.20; 0.33	+ 67	+ 67	NO	30
Pu-ELEMENT	1.12	26	0.24	0.58	0.37	0 + 2	0.29; 0.50	+ 142	+ 54	NO	32
Pu-ELEMENT	1.2	29	0.22	0.59	0.22	3 + 3	0.17; 0.30	+ 168	± 0	YES	34
Pu-ELEMENT	2.1	26	0.20	1.13	0.22	2 + 1	0.17; 0.30	+ 465	+ 10	YES	36
Pu-ELEMENT	2.2	27	0.15	0.43	0.22	2 + 1	0.17; 0.30	+ 187	+ 47	NO	38
Pu-ELEMENT	2.3	26	0.20	0.42	0.21	0 + 3	0.17; 0.28	+ 110	+ 5	YES	40
ISOTOPE ABUNDANCE:											
U-234 ASSAY	1.11	27	2.30	4.35	3.09	1 + 0	2.46; 4.10	+ 89	+ 34	NO	42
U-234 ASSAY	2.1	25	2.25	4.17	3.28	1 + 0	2.59; 4.40	+ 85	+ 46	NO	44
U-235 ASSAY	1.11	30	0.21	0.33	0.21	5 + 1	0.17; 0.28	+ 57	± 0	YES	46
U-235 ASSAY	2.1	28	0.19	0.41	0.14	3 + 3	0.11; 0.19	+ 116	- 26	YES	48
U-236 ASSAY	1.11	30	0.45	0.77	0.40	1 + 2	0.32; 0.53	+ 71	- 11	YES	50
U-236 ASSAY	2.1	25	4.48	4.67	3.56	1 + 1	2.80; 4.81	+ 4	- 21	YES	52
Pu-238 ASSAY	1.11	9	1.59	2.49	1.24	1 + 0	0.85; 2.19	+ 57	- 22	YES	56
Pu-238 ASSAY	2.1	9	1.56	3.48	1.03	1 + 1	0.69; 1.91	+ 123	- 34	YES	60
Pu-239 ASSAY	1.11	29	0.032	0.061	0.031	1 + 2	0.025;0.041	+ 91	- 3	YES	62
Pu-239 ASSAY	2.1	27	0.024	0.031	0.031	0 + 0	0.025;0.041	+ 29	+ 29	NO	64
Pu-240 ASSAY	1.11	29	0.068	0.13	0.074	1 + 1	0.059;0.098	+ 91	+ 9	YES	66
Pu-240 ASSAY	2.1	27	0.060	0.093	0.093	0 + 0	0.074;0.12	+ 55	+ 55	NO	68
Pu-241 ASSAY	1.11	29	0.21	0.32	0.16	0 + 4	0.13; 0.21	+ 52	- 24	YES	70
Pu-241 ASSAY	2.1	27	0.23	0.29	0.29	0 + 0	0.23; 0.38	+ 26	+ 26	YES	72
Pu-242 ASSAY	1.11	29	0.36	0.89	0.62	1 + 0	0.50; 0.81	+ 147	+ 72	NO	74
Pu-242 ASSAY	2.1	27	0.32	0.60	0.56	2 + 0	0.44; 0.75	+ 88	+ 75	NO	76
TOTAL:		739				42 + 34 = 76 (10.3%)		28+; 0-	18+; 8-	18 10	

[1] IN GENERAL THE FIGURES ARE DIFFERENT TO THOSE OF THE OFFICIAL IDA-80 EVALUATION.

[2] THE NUMBER OF EXCLUDED LABORATORIES IS SPLIT WITH RESPECT TO THE REASON FOR REJECTION: FIGURES REFER TO LABORATORIES EXCLUDED FOR EXTREME MEAN VALUES (BARTSCH CRITERION) AND FOR EXCEPTIONALLY HIGH REPEATABILITY VALUES (DIXON CRITERION).

TAB.V: ESTIMATES OF RELATIVE STANDARD DEVIATIONS OF THE WITHIN-LABORATORY UNCERTAINTY COMPONENT (REPEATABILITY); DoD METHOD IN COMPARISON WITH MEAN-VALUE DETERMINATION (DIXON WITH ALPHA LESS THAN OR EQUAL TO 10%)

1	2	3	4	5	6	7	8	9	10	11	12
			ESTIMATE OF RSD OF REPEATABILITY								
TYPE OF DETERMINATION	PART OF IDA-80 PROGRAM	NUMBER OF LABS	DoD METHOD sw1 (%)	MEAN-VALUE DETERMINATION OF ALL DATA sw2 (%)	MEAN-VALUE[1] DET. WITHOUT OUTLIERS sw3 (%)	NUMBER[2] OF LABS EXCLUDED	99%-CONFIDENCE LIMITS OF sw3 (%)	DEVIATION OF sw2 FROM sw1 (%)	DEVIATION OF sw3 FROM sw1 (%)	sw1 WITHIN CONFIDENCE LIMITS OF sw3?	REF. ON PAGE
CONCENTRATION:											
U-ELEMENT	1.11	30	0.20	0.39	0.19	2 + 2	0.15; 0.25	+ 95	- 5	YES	18
U-ELEMENT	1.12	27	0.24	0.88	0.23	2 + 3	0.18; 0.31	+ 267	- 4	YES	20
U-ELEMENT	1.2	30	0.15	0.31	0.14	3 + 2	0.11; 0.19	+ 107	- 7	YES	22
U-ELEMENT	2.1	28	0.17	1.19	0.18	3 + 3	0.14; 0.25	+ 600	+ 6	YES	24
U-ELEMENT	2.2	28	0.12	0.25	0.12	2 + 3	0.094;0.16	+ 108	± 0	YES	26
U-ELEMENT	2.3	27	0.23	0.44	0.26	2 + 2	0.20; 0.35	+ 91	+ 13	YES	28
Pu-ELEMENT	1.11	28	0.15	0.25	0.25	2 + 0	0.20; 0.33	+ 67	+ 67	NO	30
Pu-ELEMENT	1.12	26	0.24	0.58	0.37	0 + 2	0.29; 0.50	+ 142	+ 54	NO	32
Pu-ELEMENT	1.2	29	0.22	0.59	0.22	3 + 3	0.17; 0.30	+ 168	± 0	YES	34
Pu-ELEMENT	2.1	26	0.20	1.13	0.20	2 + 2	0.16; 0.27	+ 465	± 0	YES	36
Pu-ELEMENT	2.2	27	0.15	0.43	0.13	2 + 4	0.10; 0.18	+ 187	- 13	YES	38
Pu-ELEMENT	2.3	26	0.20	0.42	0.21	0 + 3	0.17; 0.28	+ 110	+ 5	YES	40
ISOTOPE ABUNDANCE:											
U-234 ASSAY	1.11	27	2.30	4.35	3.09	1 + 0	2.46; 4.10	+ 89	+ 34	NO	42
U-234 ASSAY	2.1	25	2.25	4.17	3.28	1 + 0	2.59; 4.40	+ 85	+ 46	NO	44
U-235 ASSAY	1.11	30	0.21	0.33	0.21	5 + 1	0.17; 0.28	+ 57	± 0	YES	46
U-235 ASSAY	2.1	28	0.19	0.41	0.14	3 + 3	0.11; 0.19	+ 116	- 26	YES	48
U-236 ASSAY	1.11	30	0.45	0.77	0.40	1 + 2	0.32; 0.53	+ 71	- 11	YES	50
U-236 ASSAY	2.1	25	4.48	4.67	3.56	1 + 1	2.80; 4.81	+ 4	- 21	YES	52
Pu-238 ASSAY	1.11	9	1.59	2.49	1.24	1 + 0	0.85; 2.19	+ 57	- 22	YES	56
Pu-238 ASSAY	2.1	9	1.56	3.48	1.03	1 + 1	0.69; 1.91	+ 123	- 34	YES	60
Pu-239 ASSAY	1.11	29	0.032	0.061	0.029	1 + 3	0.023;0.039	+ 91	- 9	YES	62
Pu-239 ASSAY	2.1	27	0.024	0.031	0.031	0 + 0	0.025;0.041	+ 29	+ 29	NO	64
Pu-240 ASSAY	1.11	29	0.068	0.13	0.068	1 + 2	0.054;0.090	+ 91	± 0	YES	66
Pu-240 ASSAY	2.1	27	0.060	0.093	0.056	0 + 3	0.044;0.075	+ 55	- 7	YES	68
Pu-241 ASSAY	1.11	29	0.21	0.32	0.16	0 + 4	0.13; 0.21	+ 52	- 24	YES	70
Pu-241 ASSAY	2.1	27	0.23	0.29	0.29	0 + 0	0.23; 0.38	+ 26	+ 26	YES	72
Pu-242 ASSAY	1.11	29	0.36	0.89	0.62	1 + 0	0.50; 0.81	+ 147	+ 72	NO	74
Pu-242 ASSAY	2.1	27	0.32	0.60	0.49	2 + 1	0.39; 0.66	+ 88	+ 53	NO	76
TOTAL:		739				42 + 50 = 92 (12.4%)		28+; 0-	11+; 12-	21 7	

[1] IN GENERAL THE FIGURES ARE DIFFERENT TO THOSE OF THE OFFICIAL IDA-80 EVALUATION; IN SOME CASES THEY ARE DIFFERENT TO THOSE GIVEN IN TAB.IV.

[2] THE NUMBER OF EXCLUDED LABORATORIES IS SPLIT WITH RESPECT TO THE REASON FOR REJECTION: FIGURES REFER TO LABORATORIES EXCLUDED FOR EXTREME MEAN VALUES (BARTSCH CRITERION) AND FOR EXCEPTIONALLY HIGH REPEATABILITY VALUES (DIXON CRITERION).

applied with an error probability of 10% (Tab. V), the deviations of the two estimates are about as frequently positive as they are negative (see columns 10) indicating that there is no longer a significant bias between the results of both evaluation methods.

Table VI summarizes the percentages of DoD results within the 99%-confidence limits of the different conventionally gained estimates as a measure of the agreement of the results of the evaluation methods:

Table VI:

Agreement of DoD estimates for the RSD of the within-laboratory uncertainty component with the estimates obtained by different conventional methods of calculation

Calculation method	Percentage of DoD estimates within 99%-confidence interval
Variance analysis; Dixon with $\alpha \leq 1\%$ (as performed in IDA-80)	32
Variance analysis; Dixon with $\alpha \leq 10\%$	54
Arithmetic mean of laboratory repeatabilities; Dixon with $\alpha \leq 1\%$	64
Arithmetic mean of laboratory repeatabilities; Dixon with $\alpha \leq 10\%$	75

If the degree of agreement is considered as a measure of the quality of the results estimated by the different conventional methods, calculation of the arithmetic mean of the laboratory repeatabilities after outlier rejection seems to be superior to the derivation of the within-laboratory uncertainty component as average repeatability by variance analysis which may overestimate the influence of individual high repeatability values by using squared terms.

4. Conclusion

DoD estimates of the interlaboratory spread based on all available data confirm the values derived in the official IDA-80 evaluation by variance analysis after rejection of laboratory mean values by the Bartsch criterion.

As far as the within-laboratory uncertainty component [10] is concerned, the DoD results indicate that the IDA-80 estimates are in some cases too high. This seems to be caused partly by the low error probability of $\alpha \leq 1\%$ chosen in the IDA-80 evaluation for the Dixon outlier criterion applied to the repeatabilities of the laboratories, and partly by the method of variance analysis which may overestimate the influence of individual high repeatability values on the basis of squared terms.

There is evidence that estimation of both uncertainty components by the DoD method without any exclusion of extreme values gives results which are at minimum in 75% of the cases within the 99%-confidence limits of estimates calculated by conventional statistical methods after the rejection of more than 10% of the basic measurement data on the basis of outlier criteria.

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10) Called 'run' component in IDA-80

References

/1/ W. Beyrich, W. Golly, G. Spannagel;
"The DoD Method: An Empirical Approach to the Treatment of Measurement Data Comprising Extreme Values", Proc. 3rd ESARDA Symp., Karlsruhe, May 6-8, 1981, pp. 289-294.

/2/ W. Beyrich, W. Golly (EKS); R. Beedgen, G. Spannagel (IDT);
"The DoD Method of Measurement Data Evaluation," International Symposium on Nuclear Material Safeguards, IAEA, Vienna, Austria,
Nov. 10-16, 1986, Proc. 'Nuclear Safeguards Technology 1986,' Vol. II, pp. 509-522.

/3/ W. Beyrich, W. Golly, G. Spannagel (KfK), P. De Bièvre, W. Wolters (CBNM);
"The IDA-80 Measurement Evaluation Programme on Mass Spectrometric Isotope Dilution Analysis of Uranium and Plutonium, Volume I: Design and Results", KfK 3760/EUR 7990e (1984).

/4/ "Precision of Test Methods - Determination of Repeatability and Reproducibility by Interlaboratory Tests", International Standard Organization Document ISO 5725-1981 (E).

/5/ H. J. Bartsch;
"Handbook of Mathematical Formulas," Academic Press Inc., New York (1974).

/6/ W.J. Dixon, F.J. Massay;
"Introduction to Statistical Analysis", Mc Graw-Hill Inc., New York (1969).

/7/ W. Beyrich, W. Golly, G. Spannagel;
"The IDA-80 Measurement Evaluation Programme on Mass Spectrometric Isotope Dilution Analysis of Uranium and Plutonium, Volume III: Compilation of Evaluation Data", KfK 3762/EUR 7992e (1985).

Appendix:

Compilation of Data Evaluation

ASSAY: U ELEMENT CONCENTRATION (about 2.0 mg U/g sol.) / IDA-80; PART 1.11

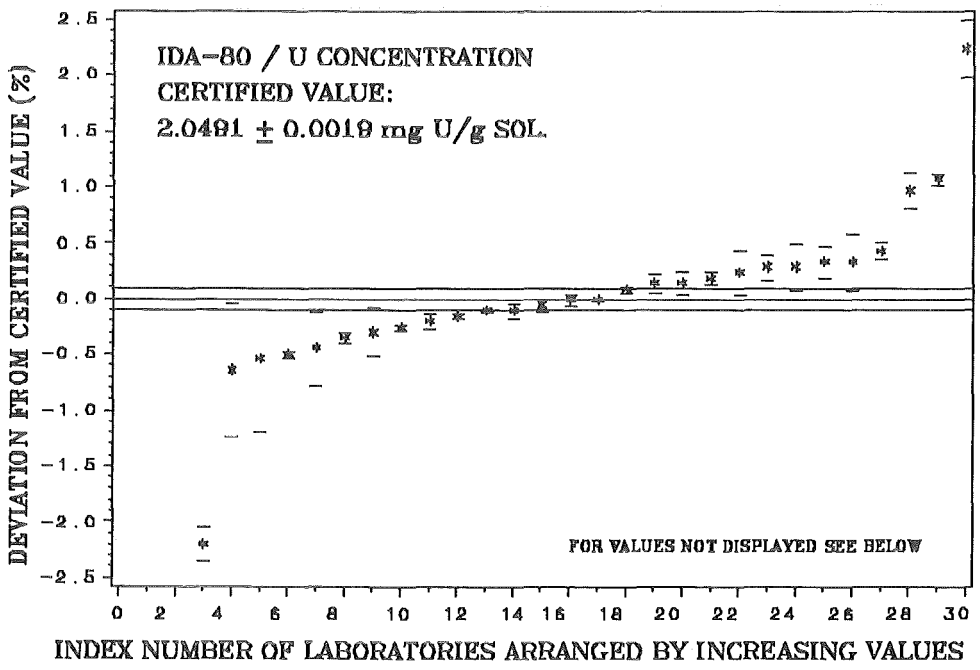
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 68

NUMBER OF PARTICIPATING LABORATORIES: p = 30
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: SPENT FUEL SAMPLE

MEASUREMENT DATA



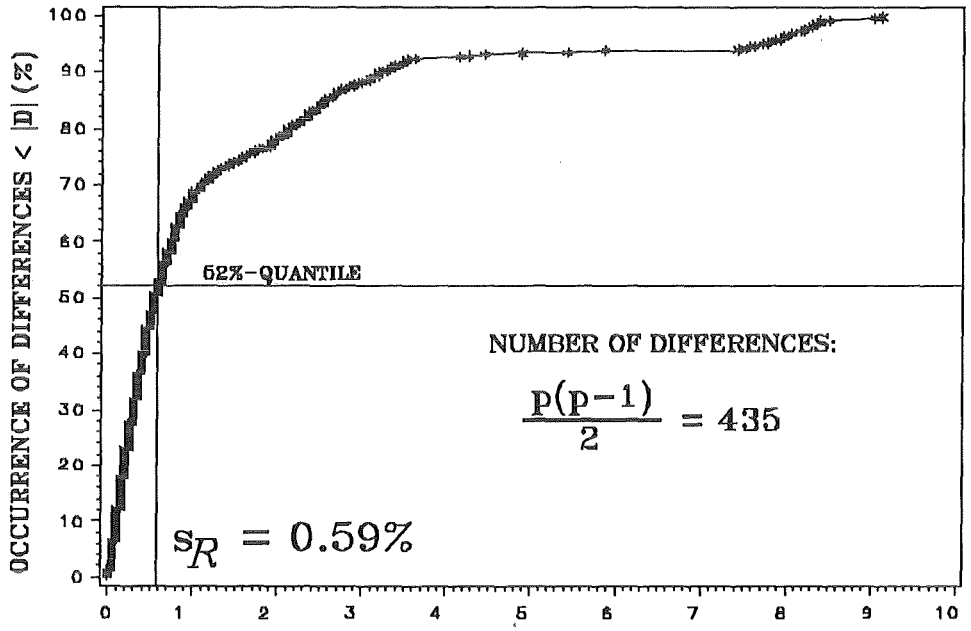
VALUES NOT DISPLAYED IN THE GRAPH: LAB 1: -8.06%; ±2.29%
LAB 2: -3.18%; ±0.40%

INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 1;2
THE DIXON CRITERION, $\alpha \leq 1\%$ (REPEATABILITY): NONE
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 1.72% / 0.72%
ESTIMATED WITHIN-LAB. COMPONENT s_W
BEFORE / AFTER EXCLUSION: 0.77% / 0.37%

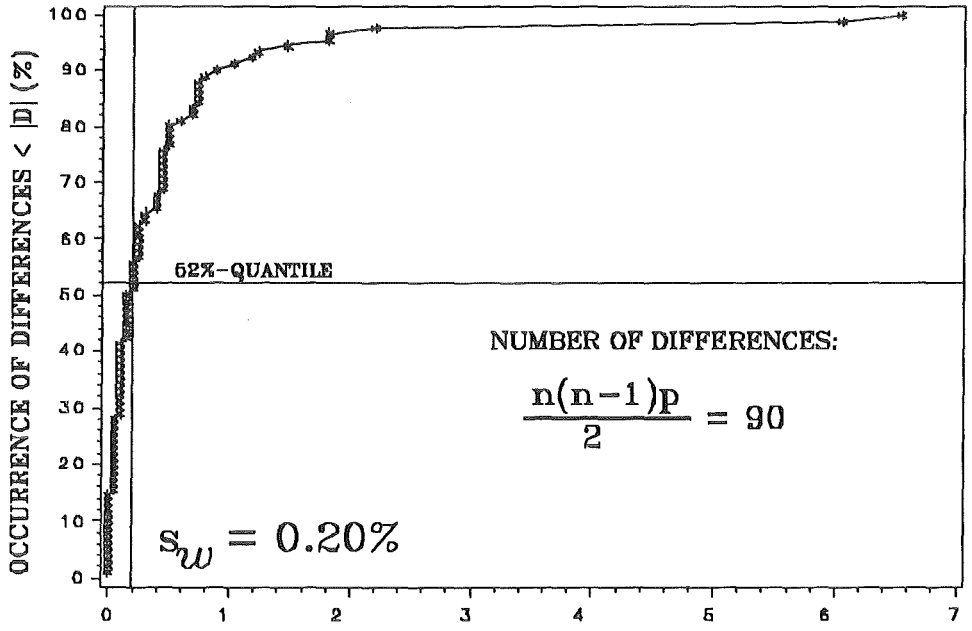
ASSAY: U ELEMENT CONCENTRATION (about 2.0 mg U/g sol.) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: U ELEMENT CONCENTRATION (about 2.0 mg U/g sol.) / IDA-80; PART 1.12

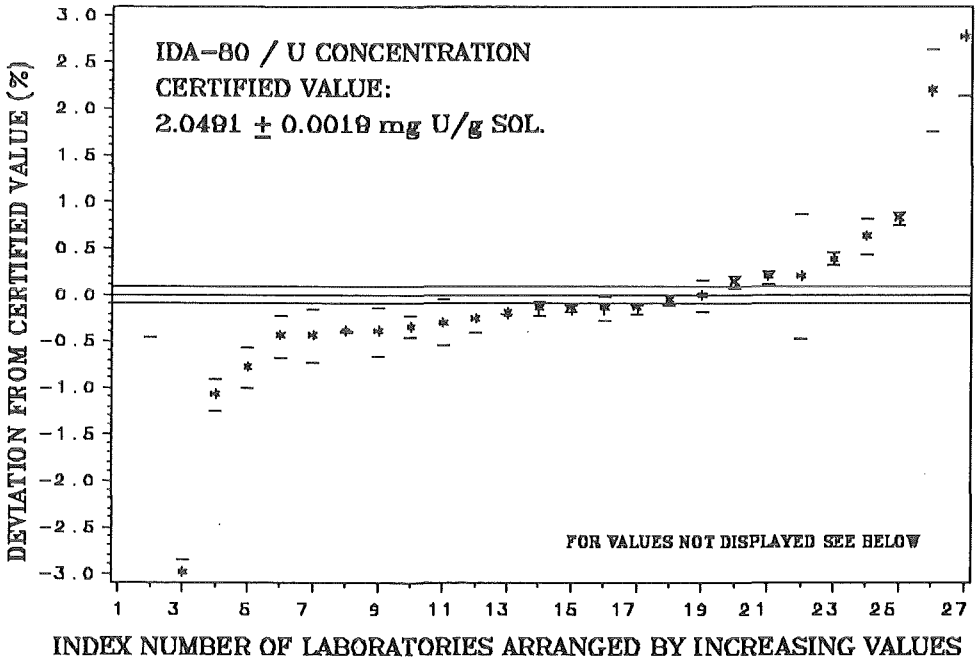
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 69

NUMBER OF PARTICIPATING LABORATORIES: p = 27
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: SPENT FUEL SAMPLE, DRIED

MEASUREMENT DATA



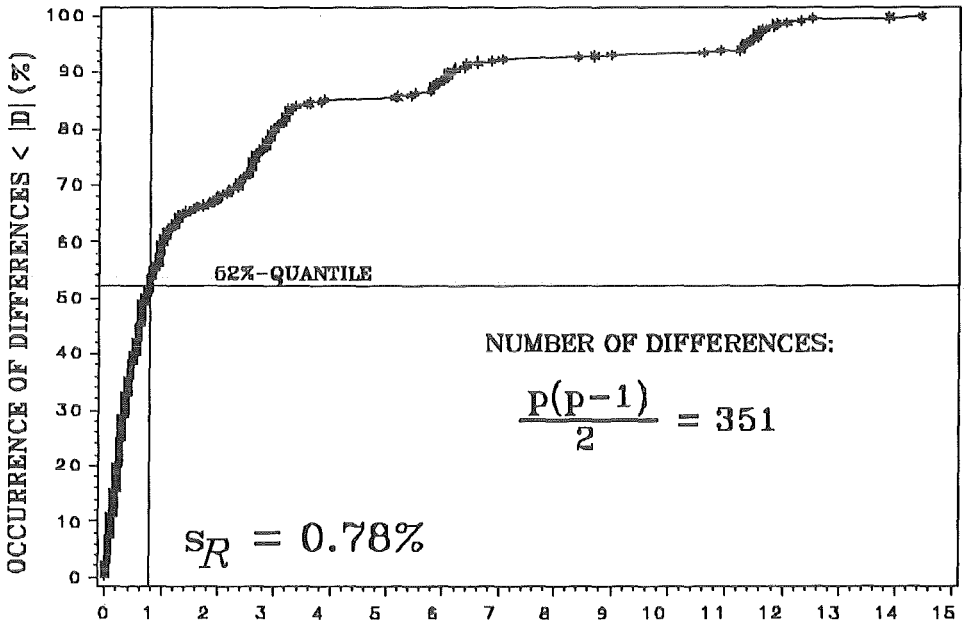
VALUES NOT DISPLAYED IN THE GRAPH: LAB 1: -11.67%; ±3.06%
LAB 2: -6.20%; ±6.12%

INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 1;2
THE DIXON CRITERION, $\alpha \leq 1\%$ (REPEATABILITY): NONE
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 2.70% / 1.03%
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 2.17% / 0.43%

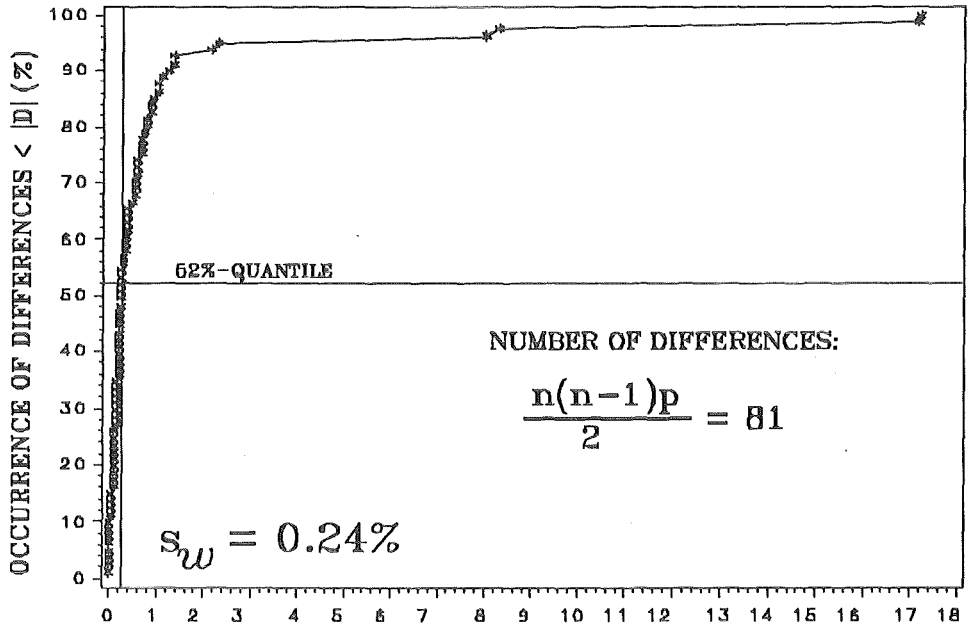
ASSAY: U ELEMENT CONCENTRATION (about 2.0 mg U/g sol.) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: U ELEMENT CONCENTRATION (about 2.0 mg U/g sol.) / IDA-80; PART 1.2

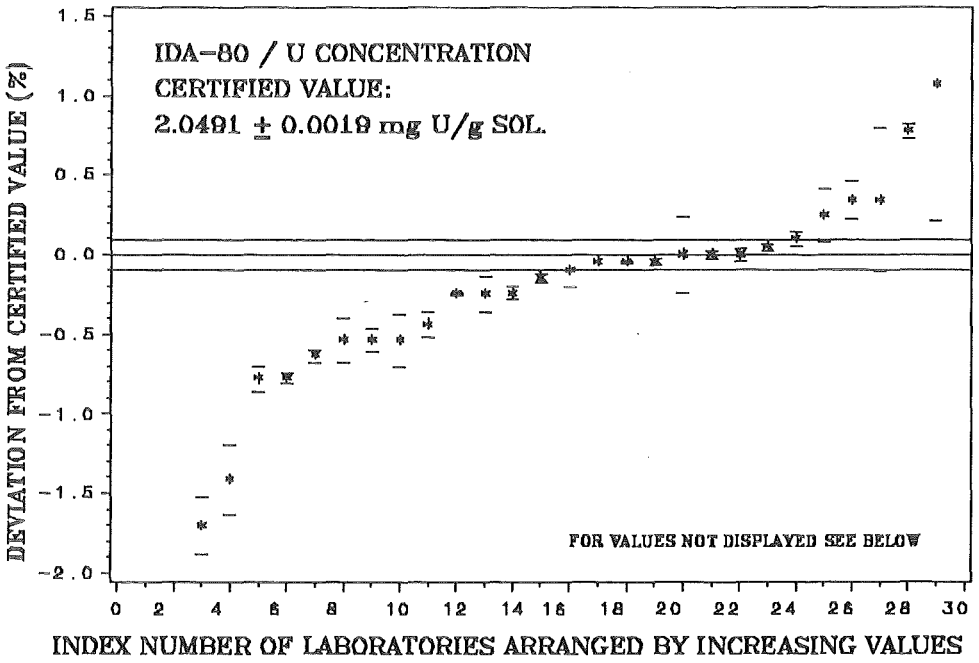
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 70

NUMBER OF PARTICIPATING LABORATORIES: p = 30
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: SPENT FUEL SAMPLE, PRESPIKED

MEASUREMENT DATA



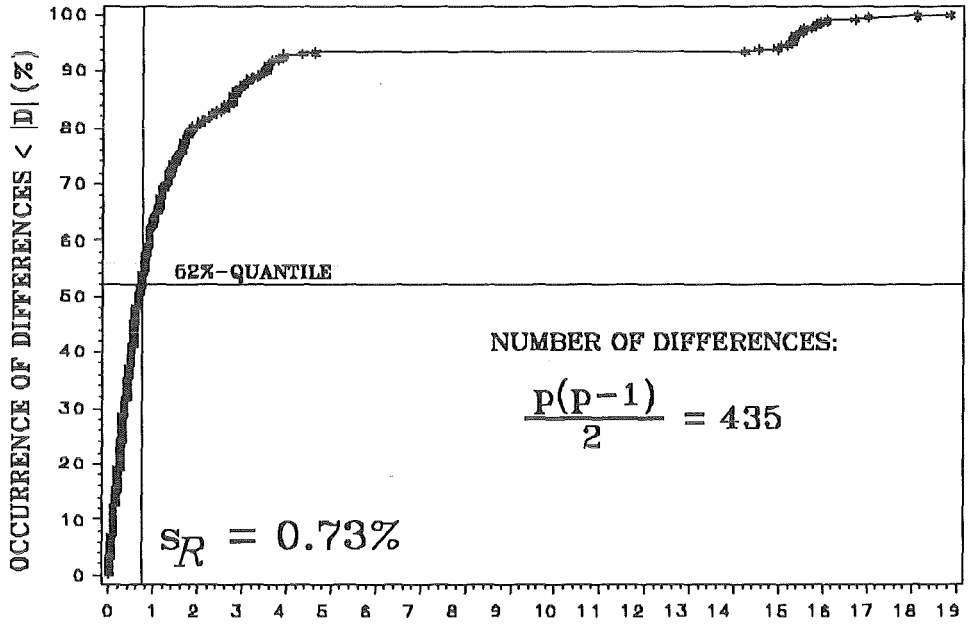
VALUES NOT DISPLAYED IN THE GRAPH:
LAB 1: -3.55%; ±0.46%
LAB 2: -2.82%; ±0.15%
LAB 30: +15.30%; ±1.43%

INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 1;2;30
THE DIXON CRITERION, α≤1% (REPEATABILITY): 27;29
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 3.01% / 0.53%
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 0.64% / 0.18%

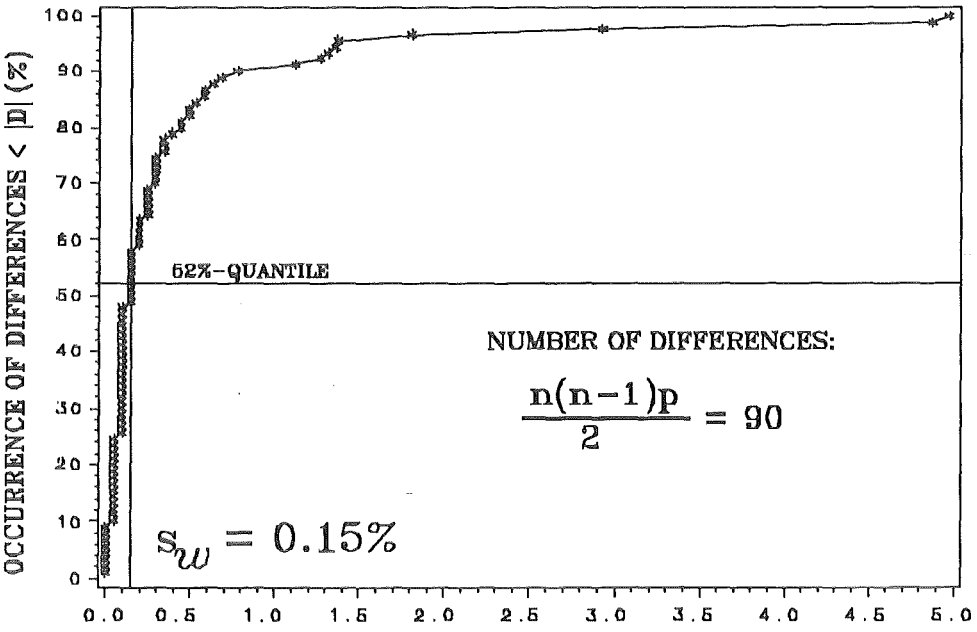
ASSAY: U ELEMENT CONCENTRATION (about 2.0 mg U/g sol.) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: U ELEMENT CONCENTRATION (about 1.7 mg U/g sol.) / IDA-80; PART 2.1

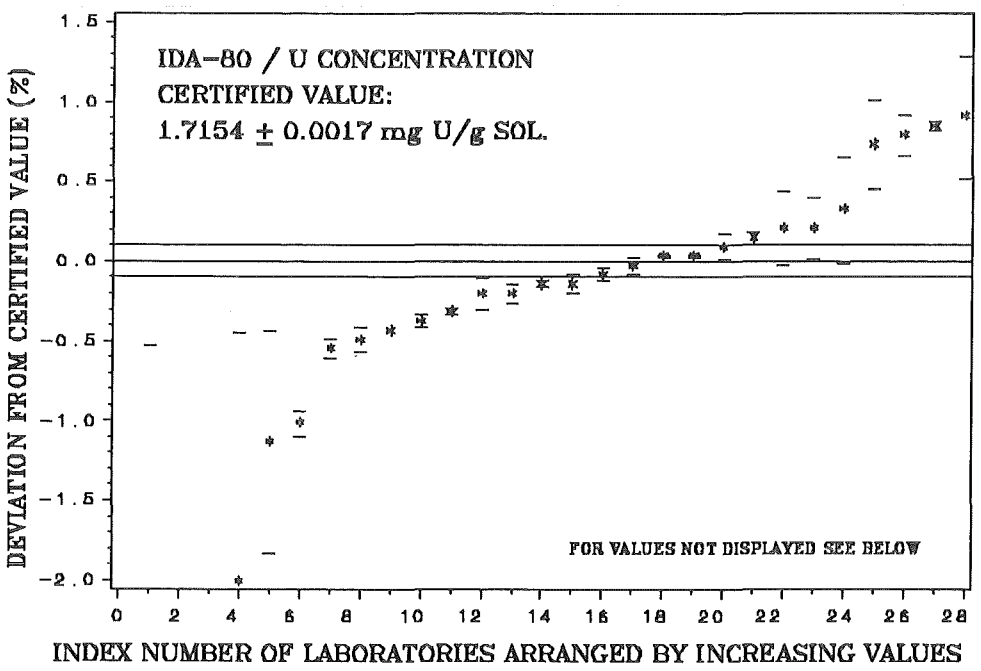
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 71

NUMBER OF PARTICIPATING LABORATORIES: p = 28
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: SYNTHETIC SAMPLE

MEASUREMENT DATA



VALUES NOT DISPLAYED IN THE GRAPH:
LAB 1: -10.75%;±11.45%
LAB 2: -8.59%; ±0.83%
LAB 3: -2.70%; ±0.01%
LAB 9: -0.43%; ±2.28%

INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 1;2;3
THE DIXON CRITERION, $\alpha \leq 1\%$ (REPEATABILITY): 4;5;9

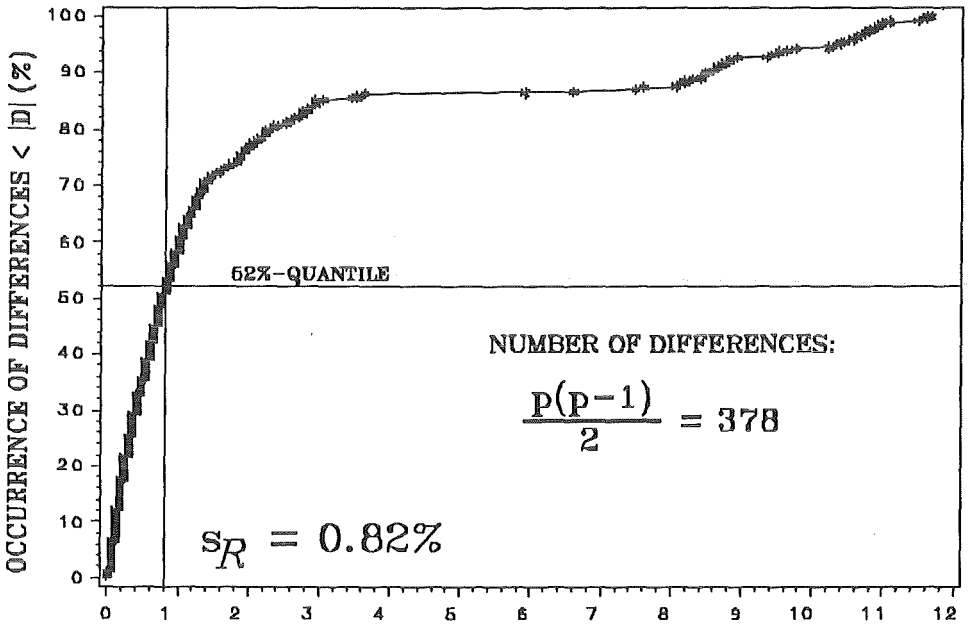
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 2.64% / 0.48%

ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 3.52% / 0.26%

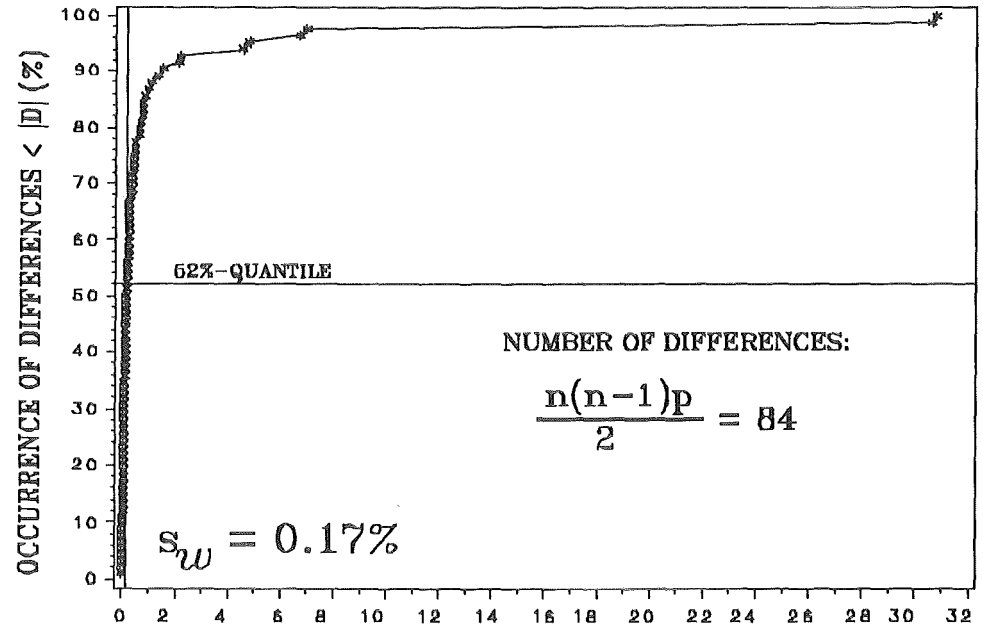
ASSAY: U ELEMENT CONCENTRATION (about 1.7 mg U/g sol.) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: U ELEMENT CONCENTRATION (about 1.7 mg U/g sol.) / IDA-80; PART 2.2

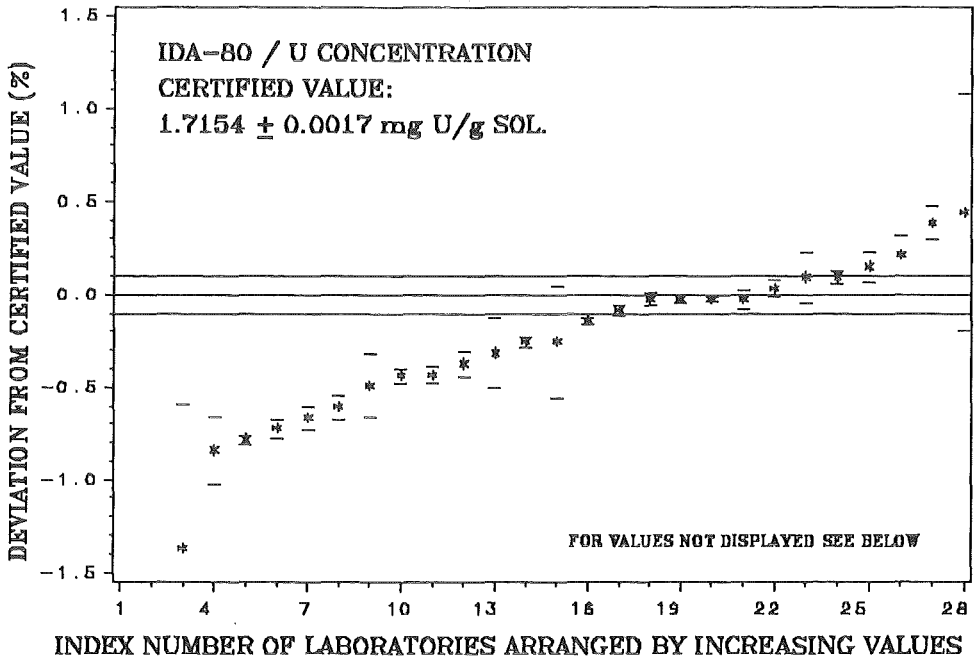
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 72

NUMBER OF PARTICIPATING LABORATORIES: p = 28
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: SYNTHETIC SAMPLE, PRESPIKED

MEASUREMENT DATA



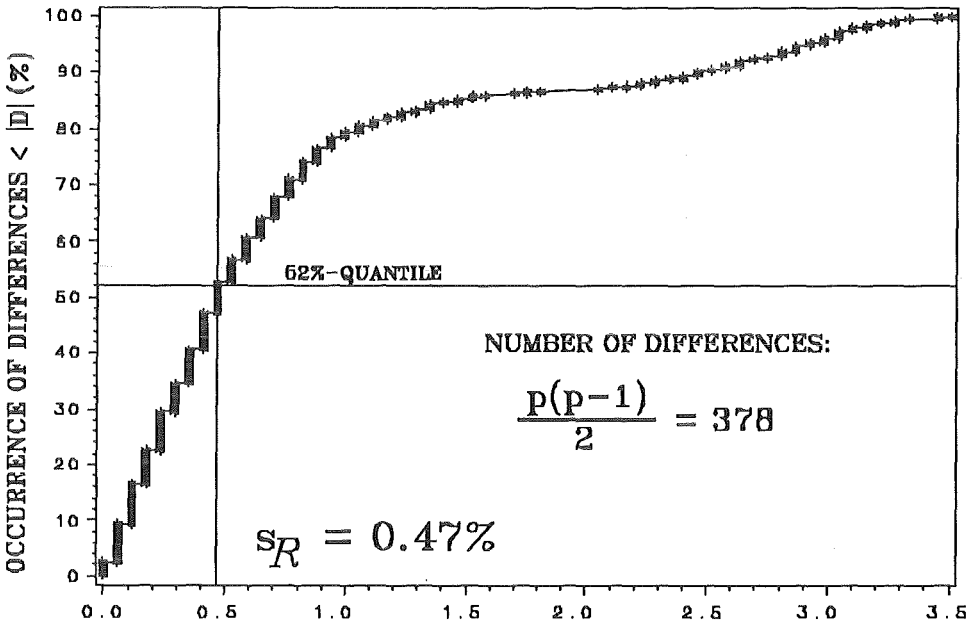
VALUES NOT DISPLAYED IN THE GRAPH: LAB 1: -3.06%; ±0.13%
LAB 2: -2.89%; ±0.60%

INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 1;2
THE DIXON CRITERION, α≤1% (REPEATABILITY): 3;28
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 0.82% / 0.34%
ESTIMATED WITHIN-LAB. COMPONENT s_W
BEFORE / AFTER EXCLUSION: 0.41% / 0.18%

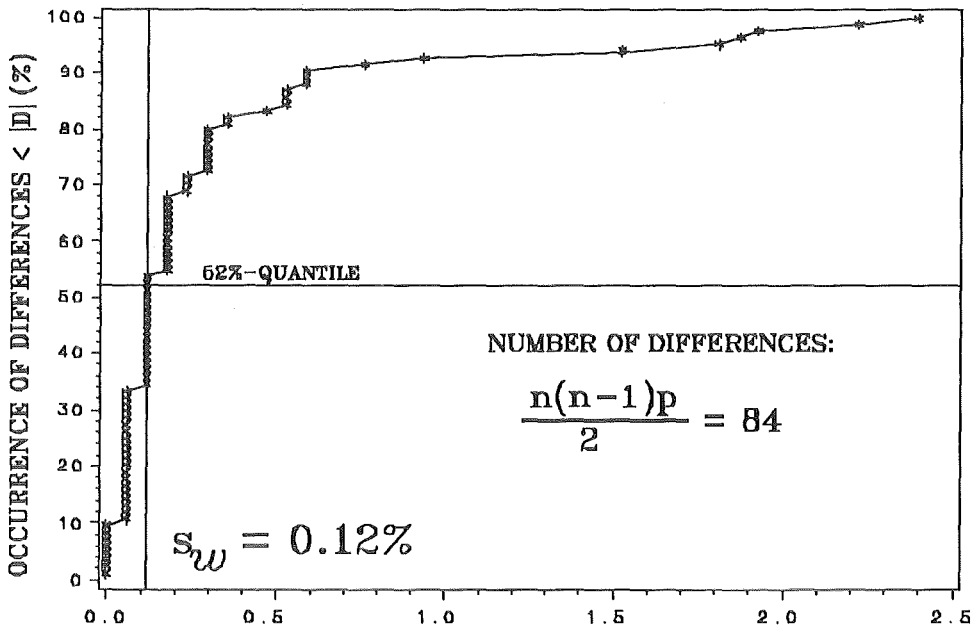
ASSAY: U ELEMENT CONCENTRATION (about 1.7 mg U/g sol.) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: U ELEMENT CONCENTRATION (about 1.7 mg U/g sol.) / IDA-80; PART 2.3

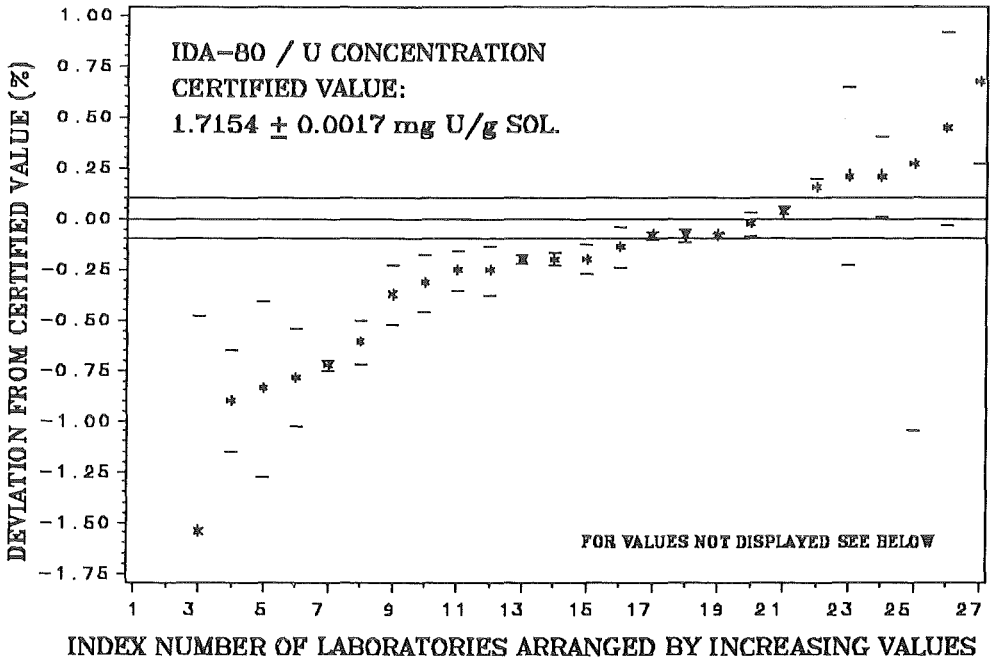
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 73

NUMBER OF PARTICIPATING LABORATORIES: p = 27
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: SYNTHETIC SAMPLE, COMMON SPIKE

MEASUREMENT DATA



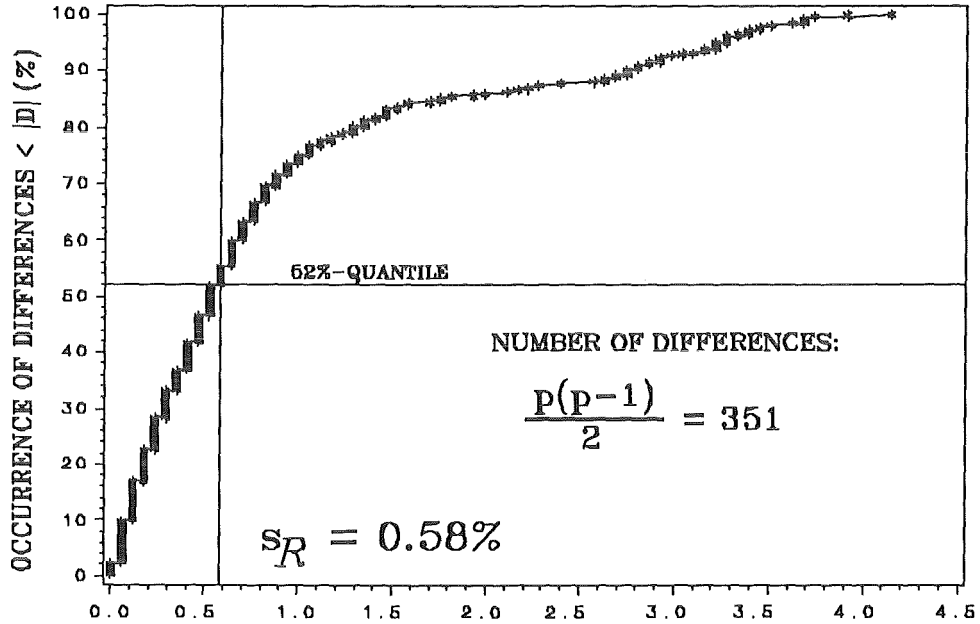
VALUES NOT DISPLAYED IN THE GRAPH: LAB 1: -3.46%; ±0.77%
LAB 2: -3.00%; ±0.22%

INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 1;2
THE DIXON CRITERION, $\alpha \leq 1\%$ (REPEATABILITY): 3;25
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 0.93% / 0.40%
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 0.71% / 0.37%

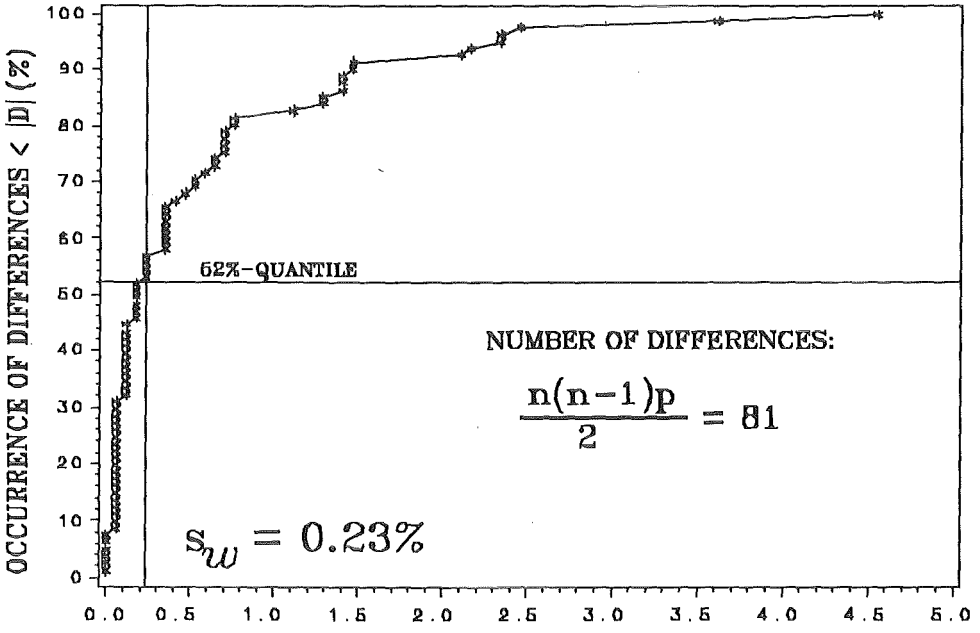
ASSAY: U ELEMENT CONCENTRATION (about 1.7 mg U/g sol.) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: Pu ELEMENT CONCENTRATION (about 7.2 μg Pu/g sol.) / IDA-80; PART 1.11

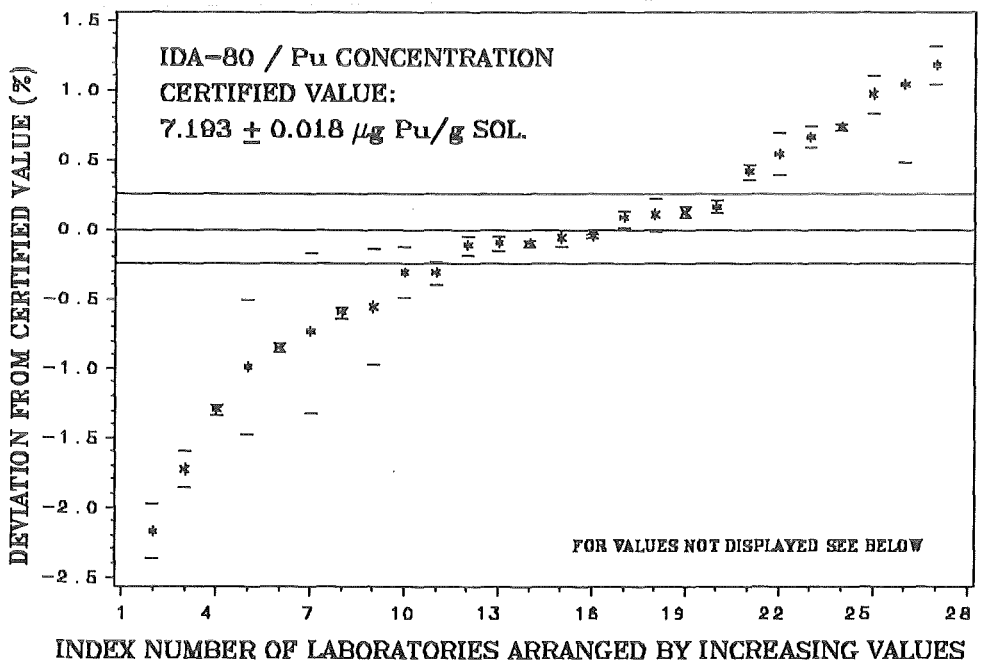
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 77

NUMBER OF PARTICIPATING LABORATORIES: p = 28
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: SPENT FUEL SAMPLE

MEASUREMENT DATA



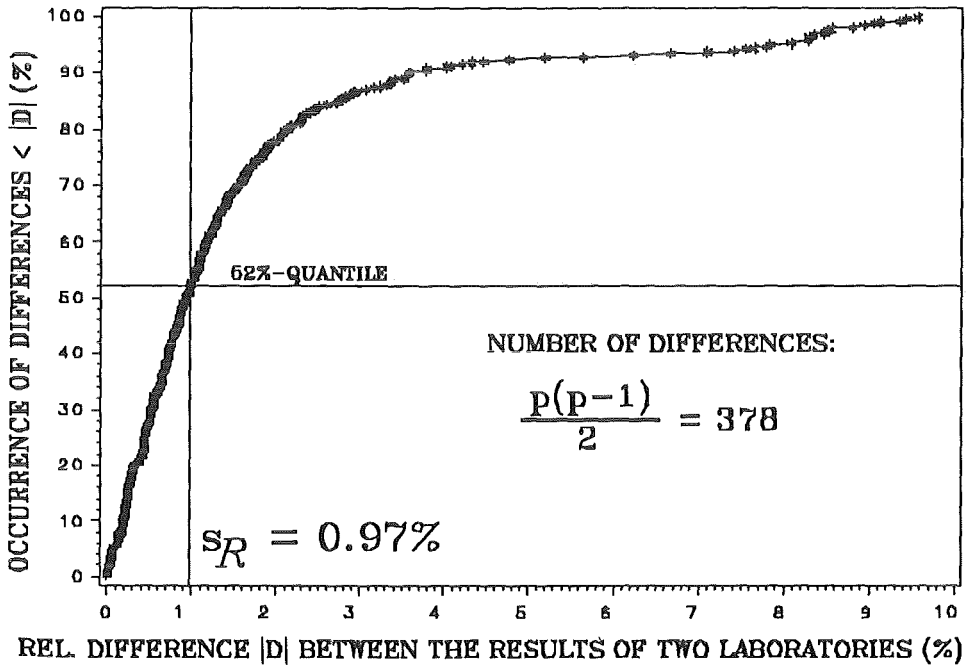
VALUES NOT DISPLAYED IN THE GRAPH: LAB 1: -8.38%; ±0.07%
LAB 28: +3.46%; ±0.15%

INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 1;28
THE DIXON CRITERION, α≤1% (REPEATABILITY): NONE
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 1.90% / 0.82%
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 0.37% / 0.38%

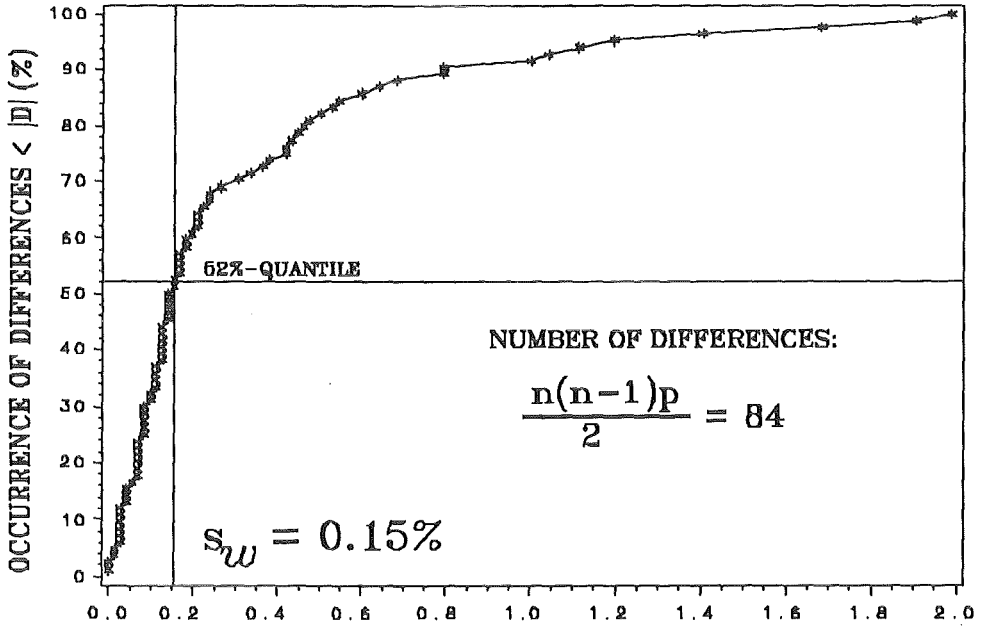
ASSAY: Pu ELEMENT CONCENTRATION (about 7.2 μg Pu/g sol.) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: Pu ELEMENT CONCENTRATION (about 7.2 μg Pu/g sol.) / IDA-80; PART 1.12

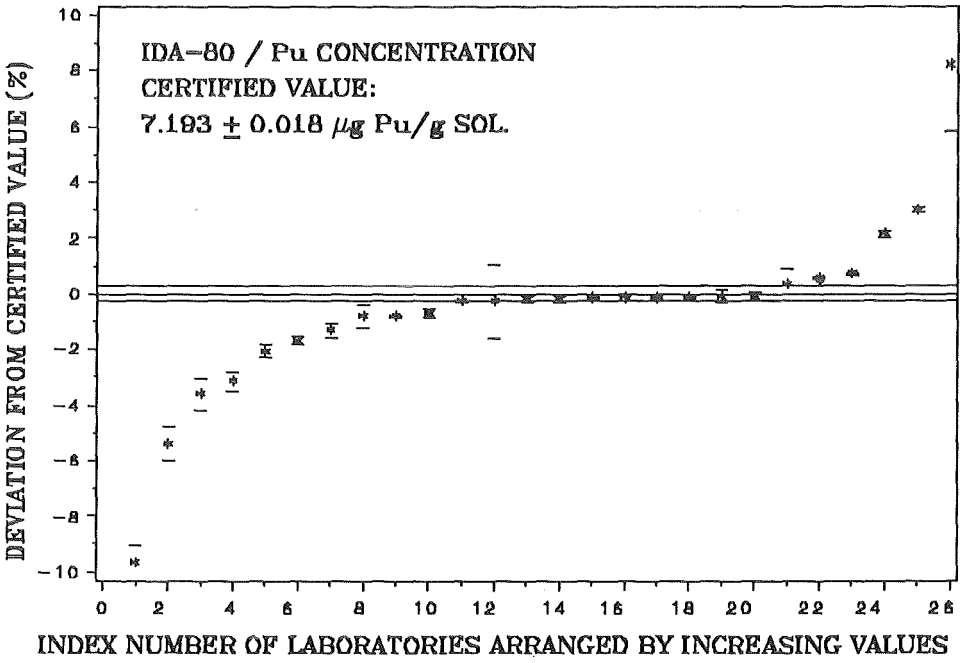
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 79

NUMBER OF PARTICIPATING LABORATORIES: p = 26
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: SPENT FUEL SAMPLE, DRIED

MEASUREMENT DATA

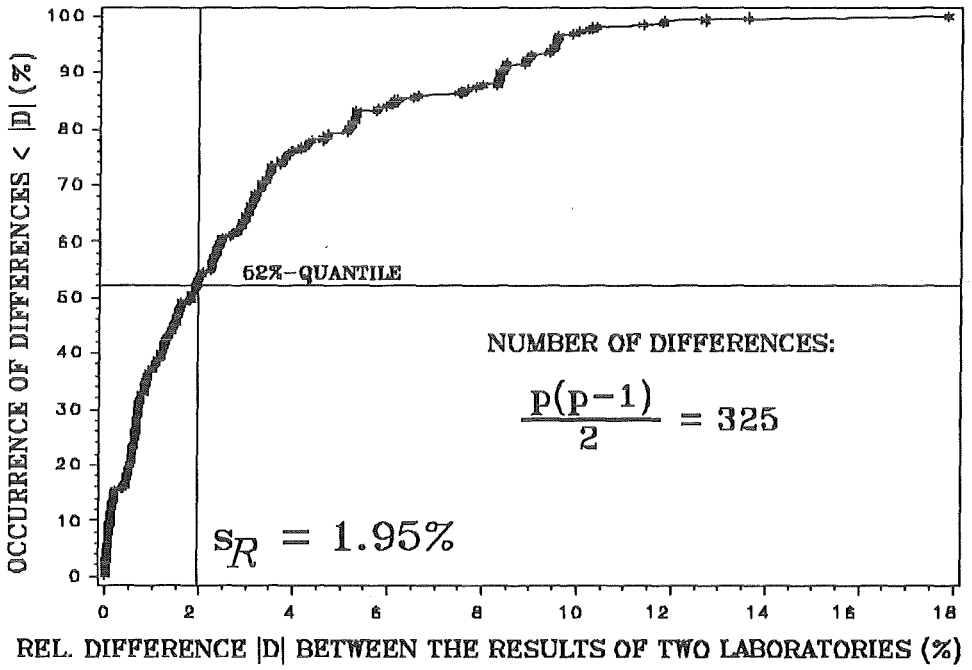


INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): NONE
THE DIXON CRITERION, α≤1% (REPEATABILITY): 12;26
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 3.04% / 2.56%
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 1.05% / 0.50%

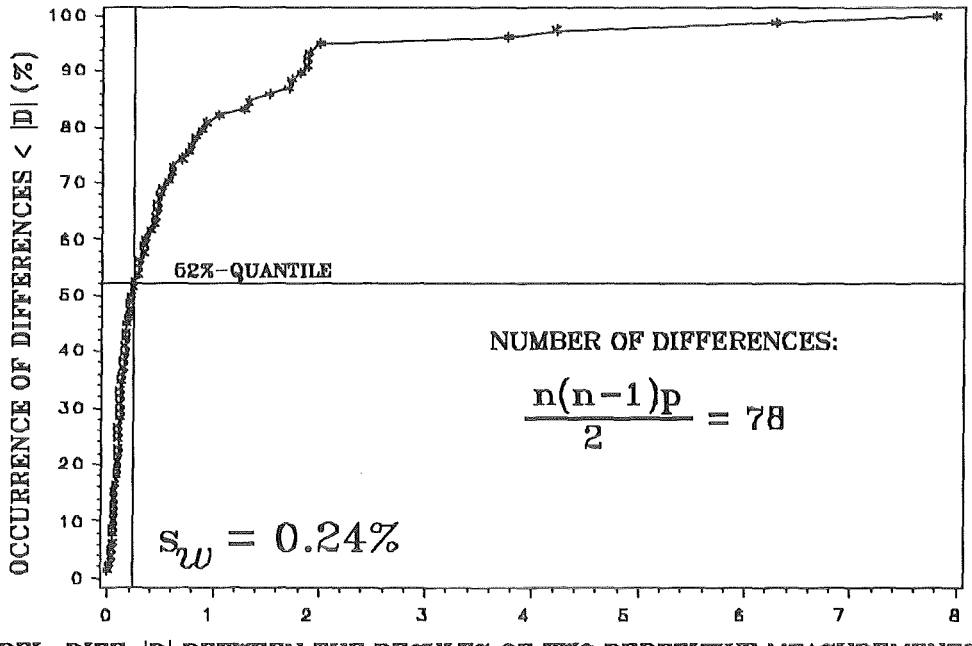
ASSAY: Pu ELEMENT CONCENTRATION (about 7.2 μg Pu/g sol.) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: Pu ELEMENT CONCENTRATION (about 7.2 μg Pu/g sol.) / IDA-80; PART 1.2

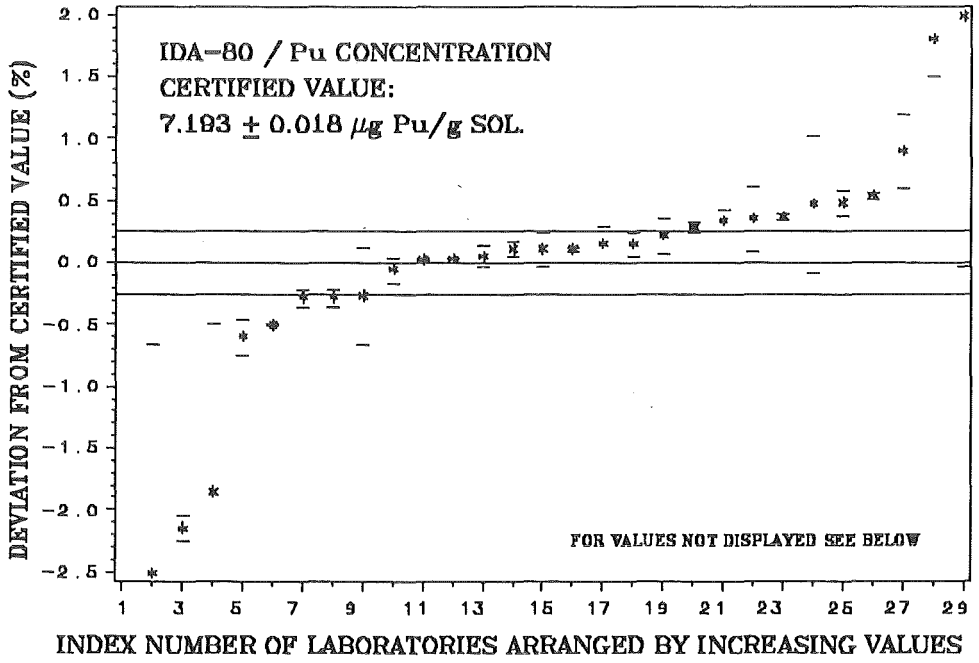
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 81

NUMBER OF PARTICIPATING LABORATORIES: p = 29
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: SPENT FUEL SAMPLE, PRESPIKED

MEASUREMENT DATA



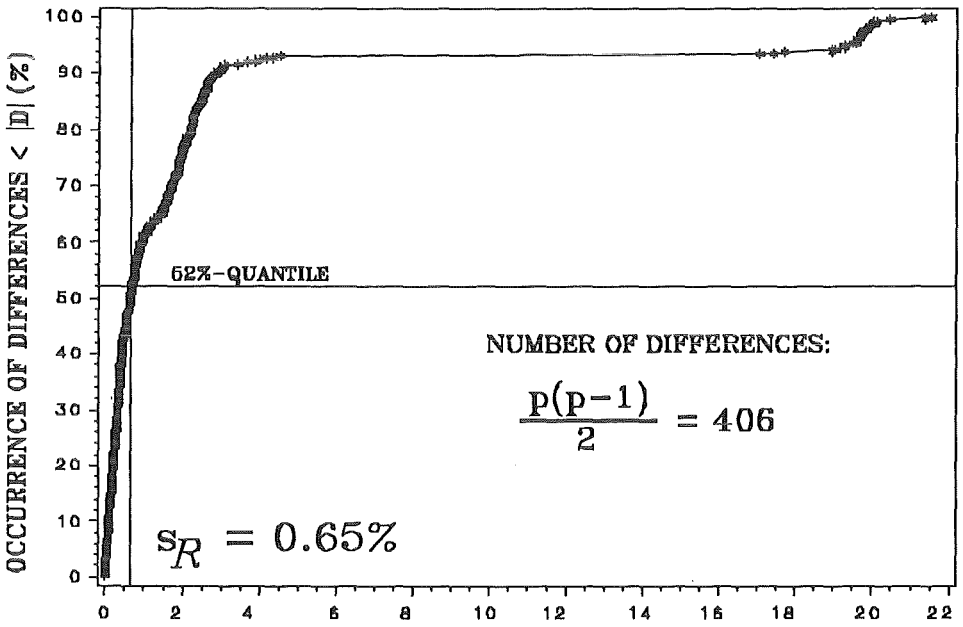
VALUES NOT DISPLAYED IN THE GRAPH: LAB 1: -19.55%; ±1.32%

INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 1;3;28
THE DIXON CRITERION, α≤1% (REPEATABILITY): 2;4;29
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 3.77% / 0.35%
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 1.09% / 0.31%

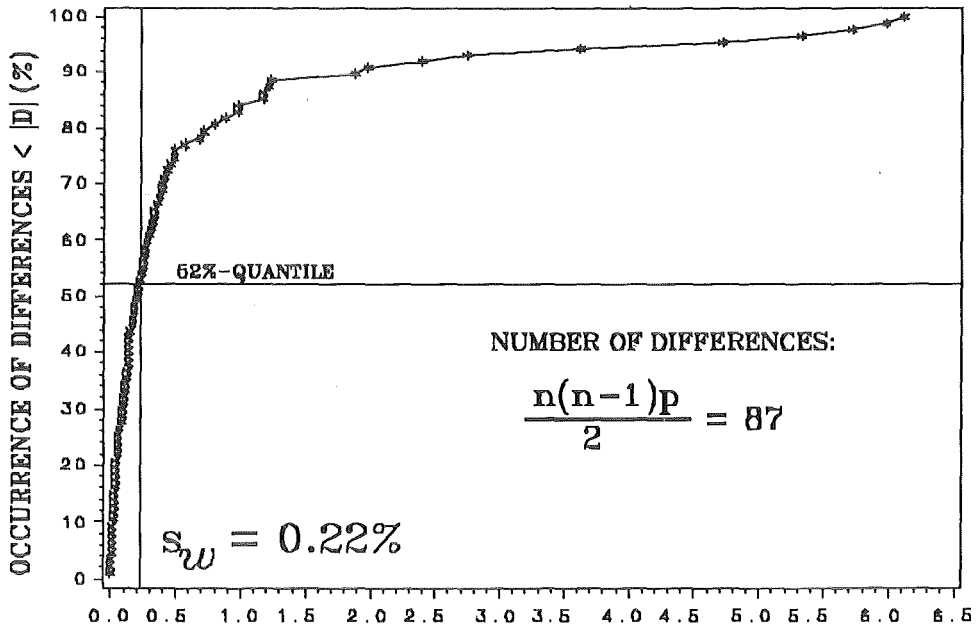
ASSAY: Pu ELEMENT CONCENTRATION (about 7.2 μg Pu/g sol.) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: Pu ELEMENT CONCENTRATION (about 8.0 μg Pu/g sol.) / IDA-80; PART 2.1

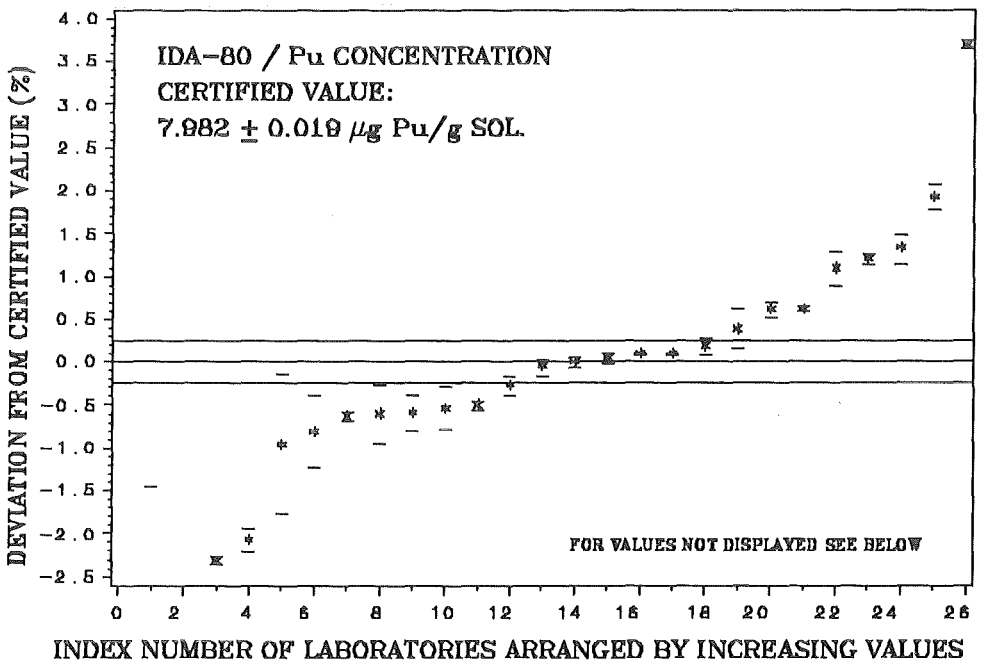
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 83

NUMBER OF PARTICIPATING LABORATORIES: p = 26
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: SYNTHETIC SAMPLE

MEASUREMENT DATA



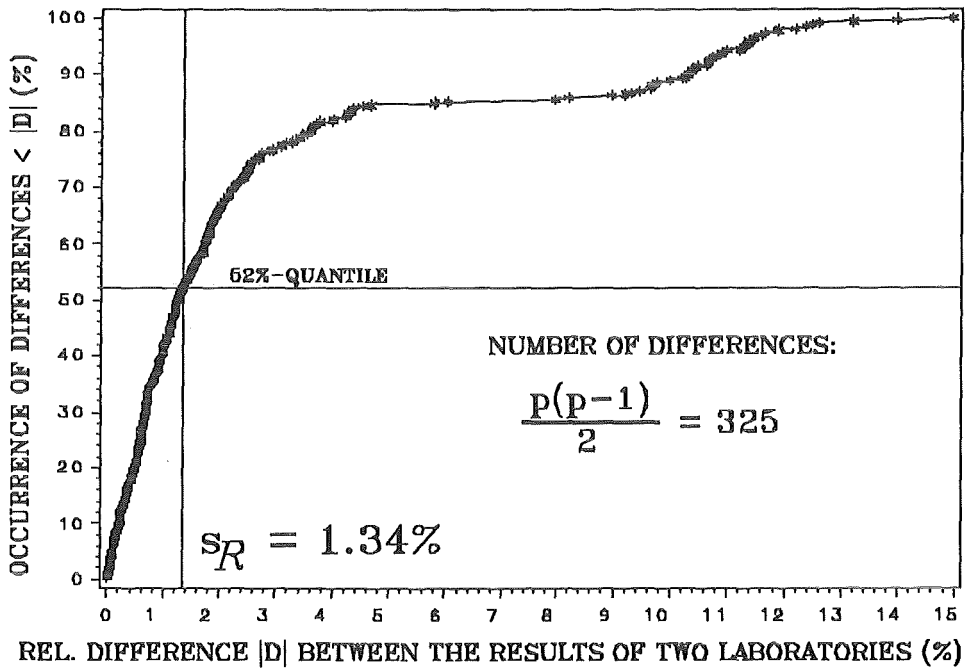
VALUES NOT DISPLAYED IN THE GRAPH: LAB 1: −11.25%;±11.05%
LAB 2: −10.25%; ±2.11%

INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 1;2
THE DIXON CRITERION, α≤1% (REPEATABILITY): 5
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 3.20% / 1.25%
ESTIMATED WITHIN-LAB. COMPONENT s_W
BEFORE / AFTER EXCLUSION: 3.44% / 0.28%

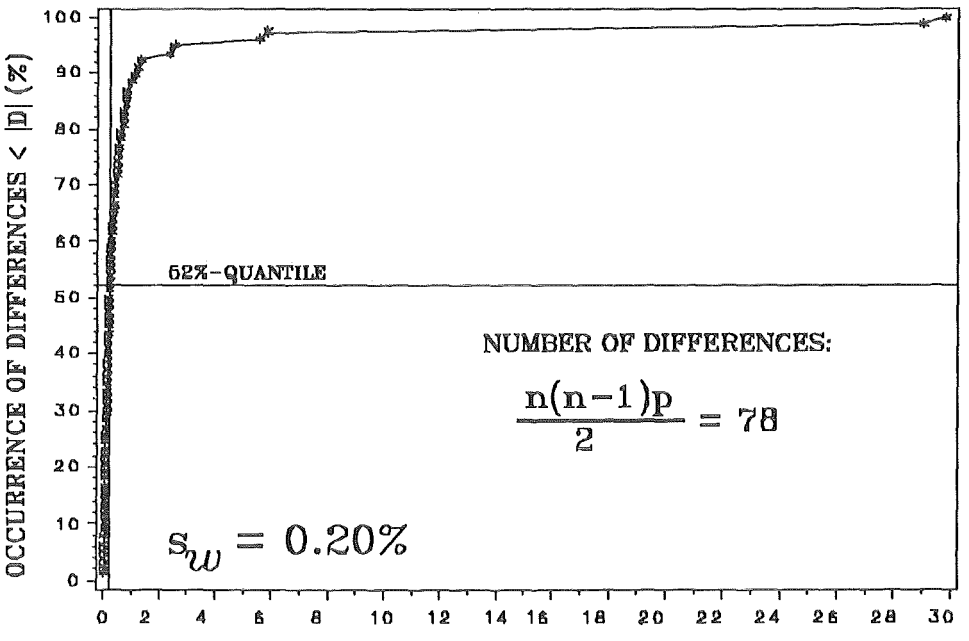
ASSAY: Pu ELEMENT CONCENTRATION (about 8.0 μg Pu/g sol.) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: Pu ELEMENT CONCENTRATION (about 8.0 μg Pu/g sol.) / IDA-80; PART 2.2

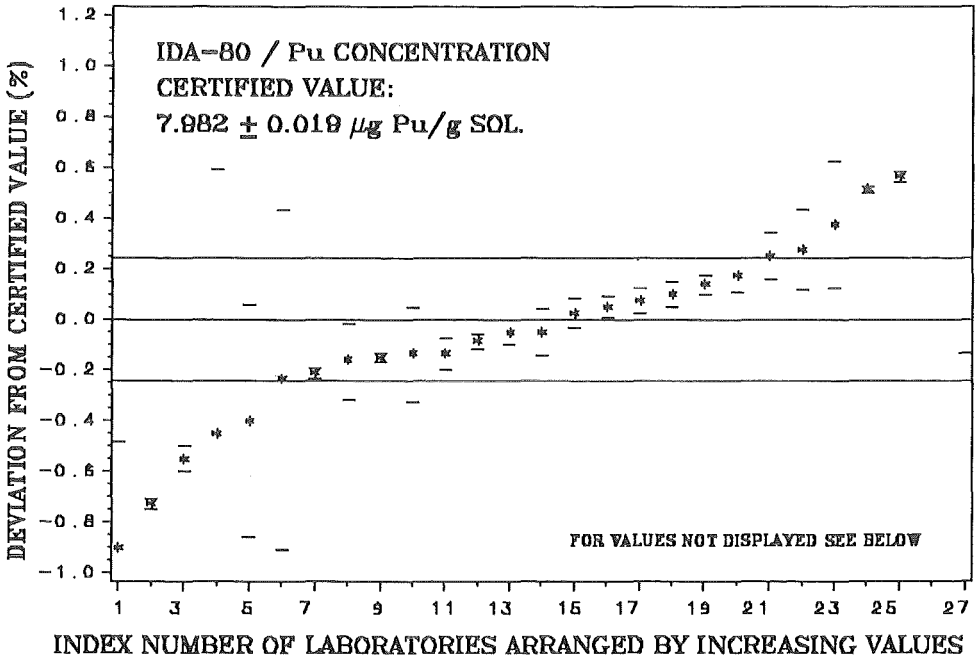
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 85

NUMBER OF PARTICIPATING LABORATORIES: p = 27
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: SYNTHETIC SAMPLE, PRESPIKED

MEASUREMENT DATA



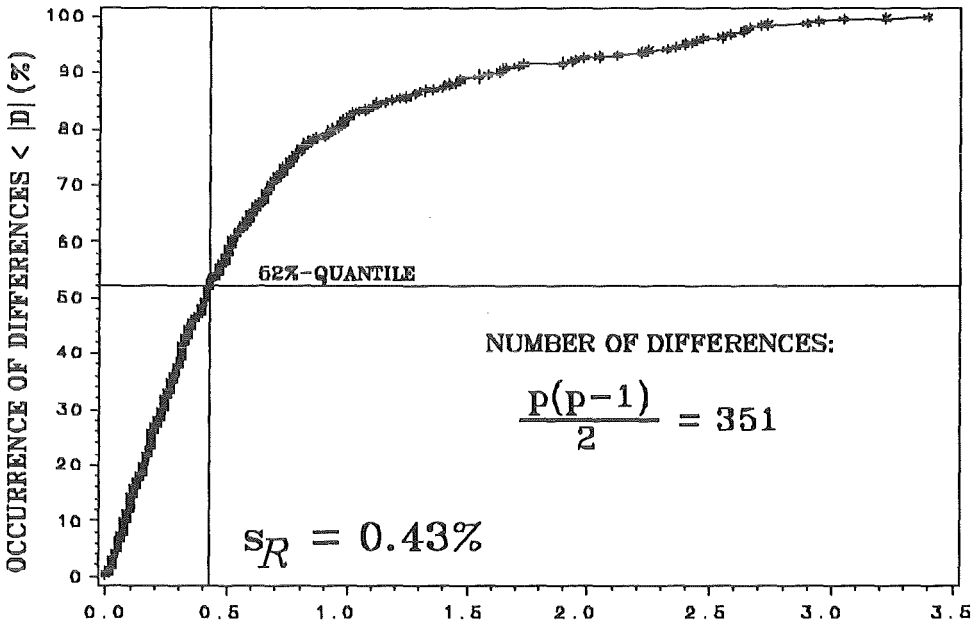
VALUES NOT DISPLAYED IN THE GRAPH: LAB 26: +1.49%; ±0.09%
LAB 27: +2.49%; ±2.56%

INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 26;27
THE DIXON CRITERION, $\alpha \leq 1\%$ (REPEATABILITY): 4
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 0.66% / 0.35%
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 1.00% / 0.36%

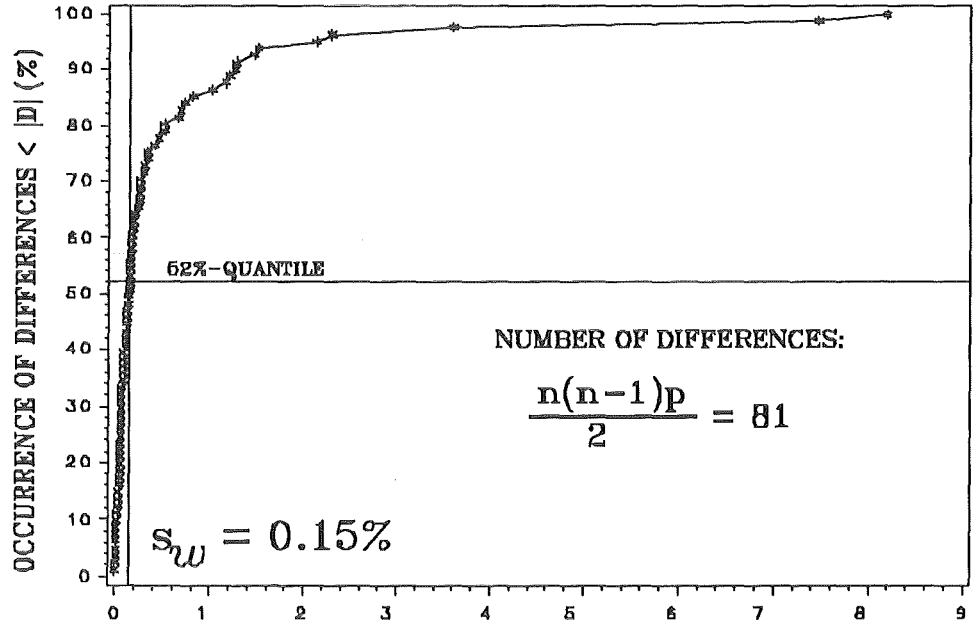
ASSAY: Pu ELEMENT CONCENTRATION (about 8.0 μg Pu/g sol.) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: Pu ELEMENT CONCENTRATION (about 8.0 μg Pu/g sol.) / IDA-80; PART 2.3

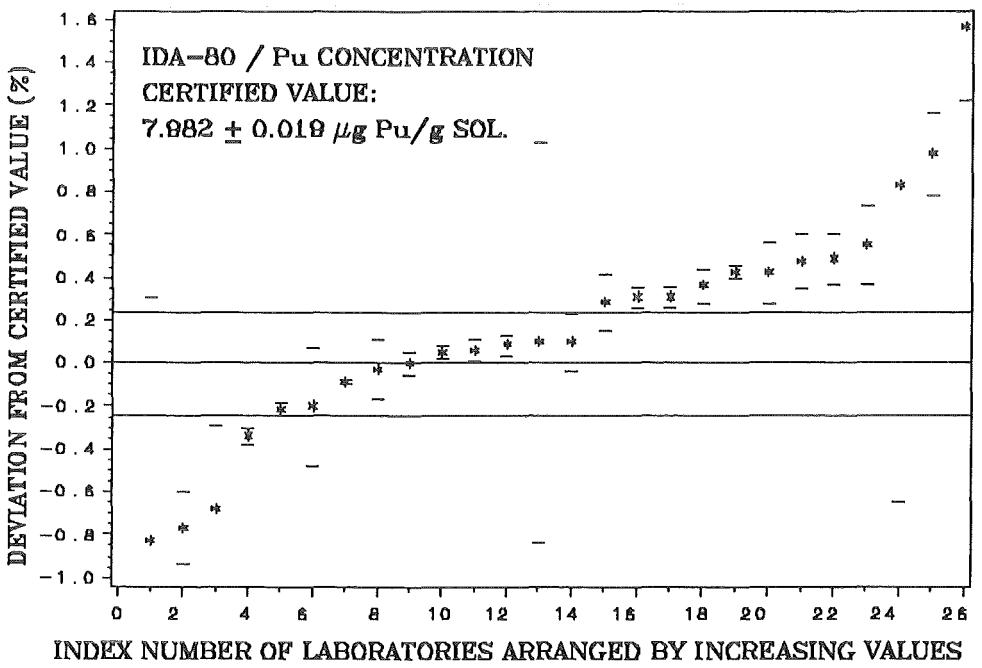
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 87

NUMBER OF PARTICIPATING LABORATORIES: p = 26
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: SYNTHETIC SAMPLE, COMMON SPIKE

MEASUREMENT DATA

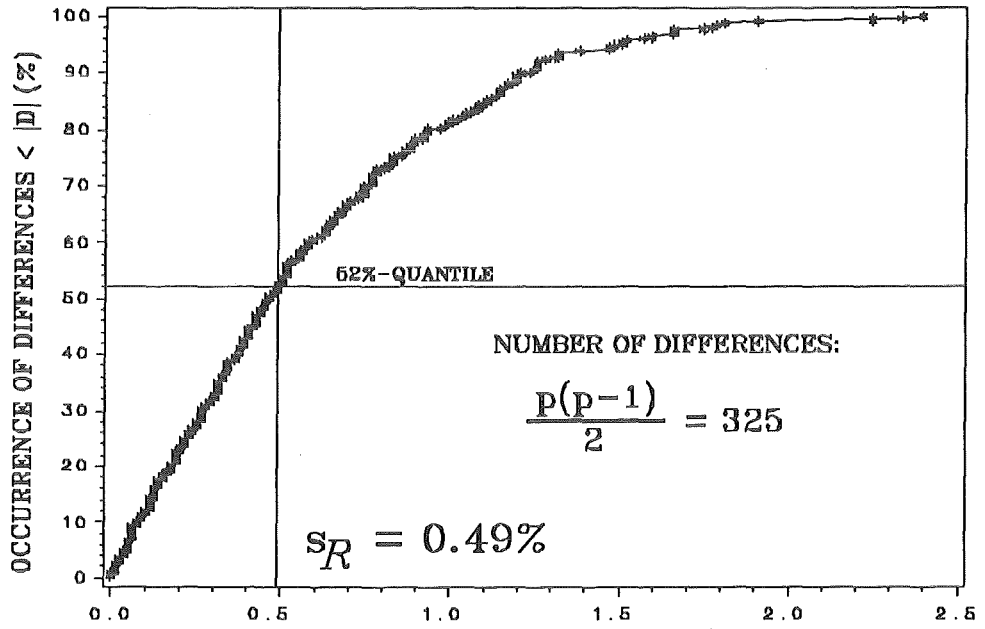


INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): NONE
THE DIXON CRITERION, $\alpha \leq 1\%$ (REPEATABILITY): 1;13;24
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 0.52% / 0.50%
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 0.75% / 0.27%

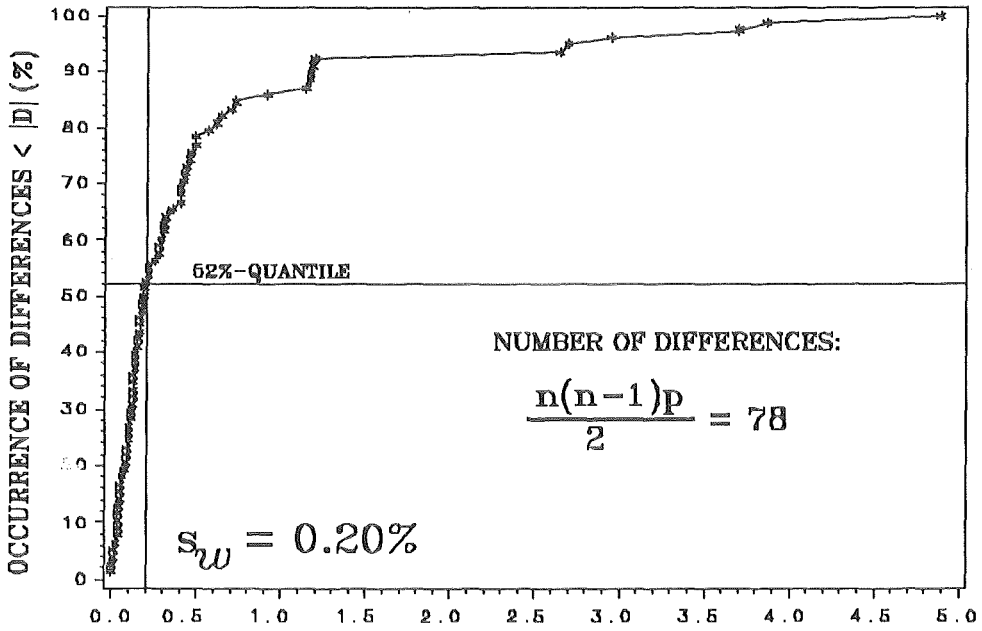
ASSAY: Pu ELEMENT CONCENTRATION (about 8.0 μg Pu/g sol.) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: U-234 ABUNDANCE (about 0.01%) / IDA-80; PART 1.11

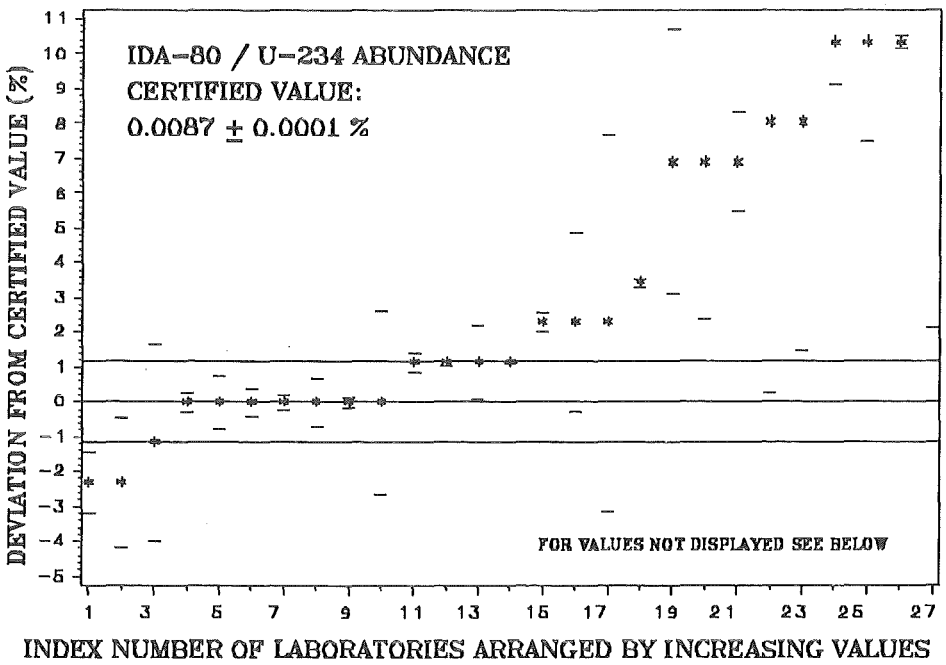
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 45

NUMBER OF PARTICIPATING LABORATORIES: p = 27
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: NONE

MEASUREMENT DATA



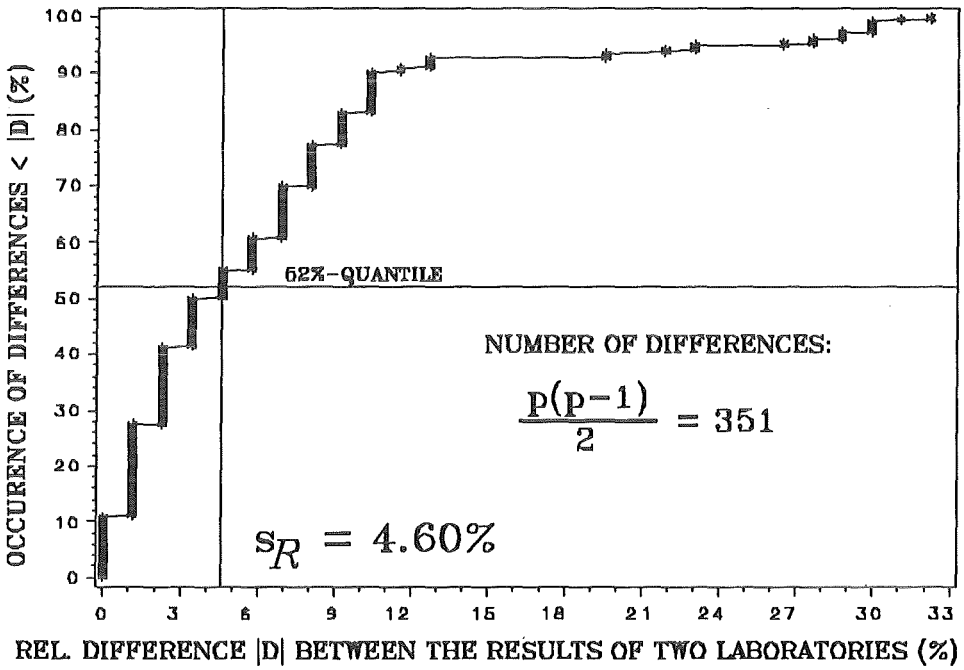
VALUES NOT DISPLAYED IN THE GRAPH: LAB 27: +29.89%; ±21.37%

INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 27
THE DIXON CRITERION, $\alpha \leq 1\%$ (REPEATABILITY): NONE
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 6.36% / 4.01%
ESTIMATED WITHIN-LAB. COMPONENT s_W
BEFORE / AFTER EXCLUSION: 10.01% / 4.77%

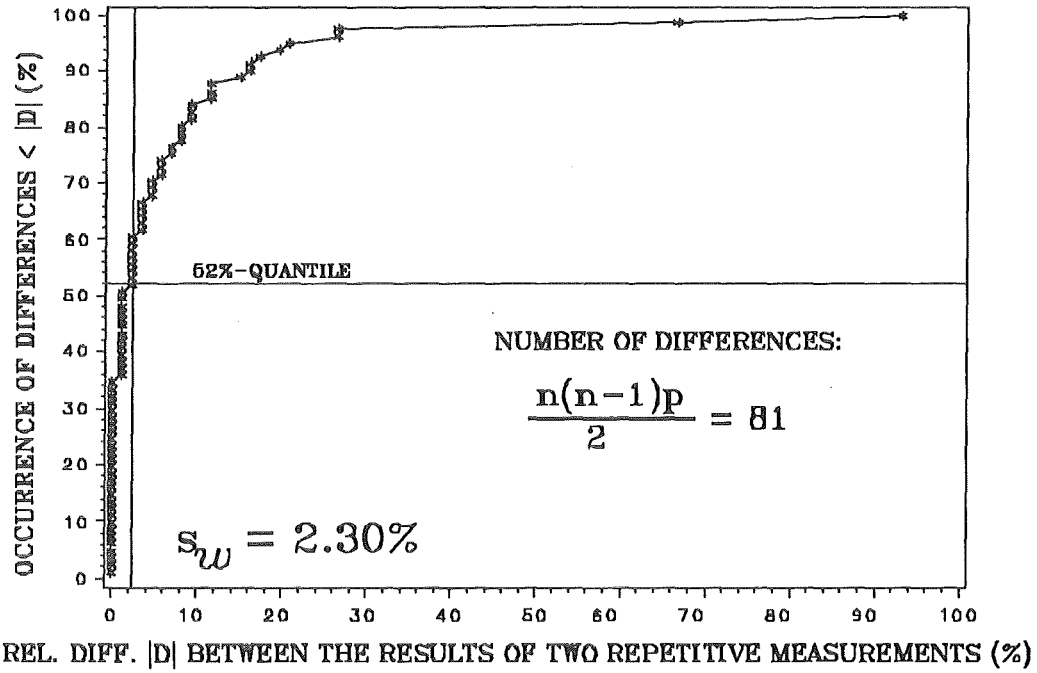
ASSAY: U-234 ABUNDANCE (about 0.01%) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: U-234 ABUNDANCE (about 0.01%) / IDA-80; PART 2.1

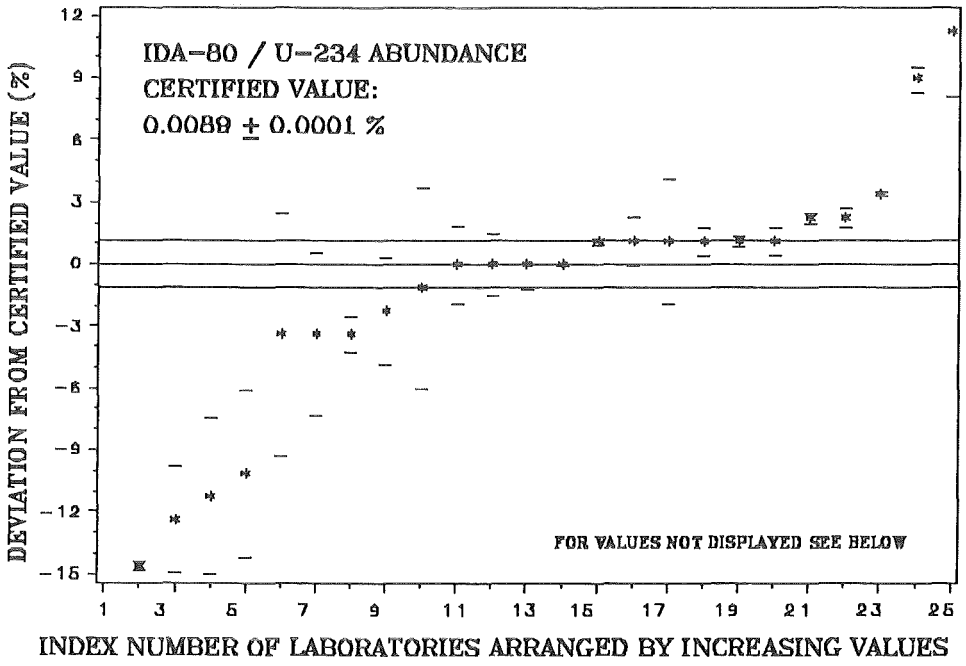
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 49

NUMBER OF PARTICIPATING LABORATORIES: p = 25
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: NONE

MEASUREMENT DATA



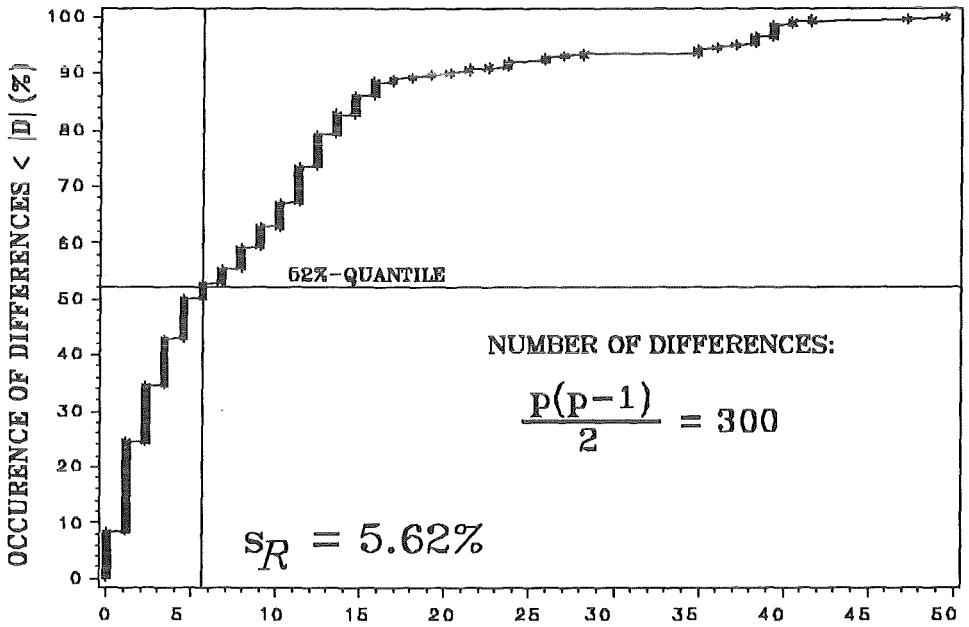
VALUES NOT DISPLAYED IN THE GRAPH: LAB 1: -38.20%; ±14.80%

INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 1
THE DIXON CRITERION, $\alpha \leq 1\%$ (REPEATABILITY): NONE
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 9.70% / 6.08%
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 5.39% / 4.33%

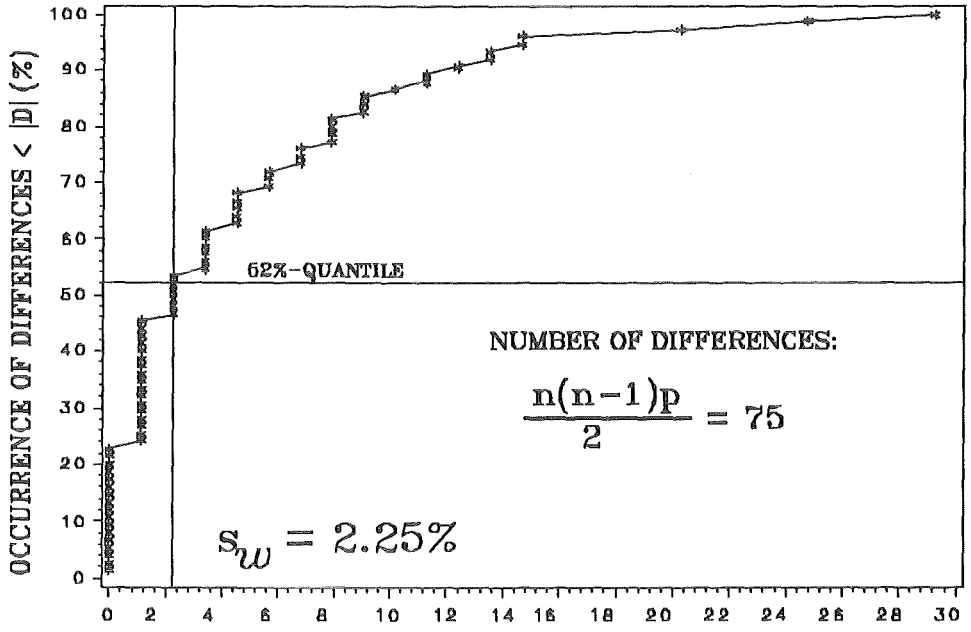
ASSAY: U-234 ABUNDANCE (about 0.01%) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: U-235 ABUNDANCE (about 0.6%) / IDA-80; PART 1.11

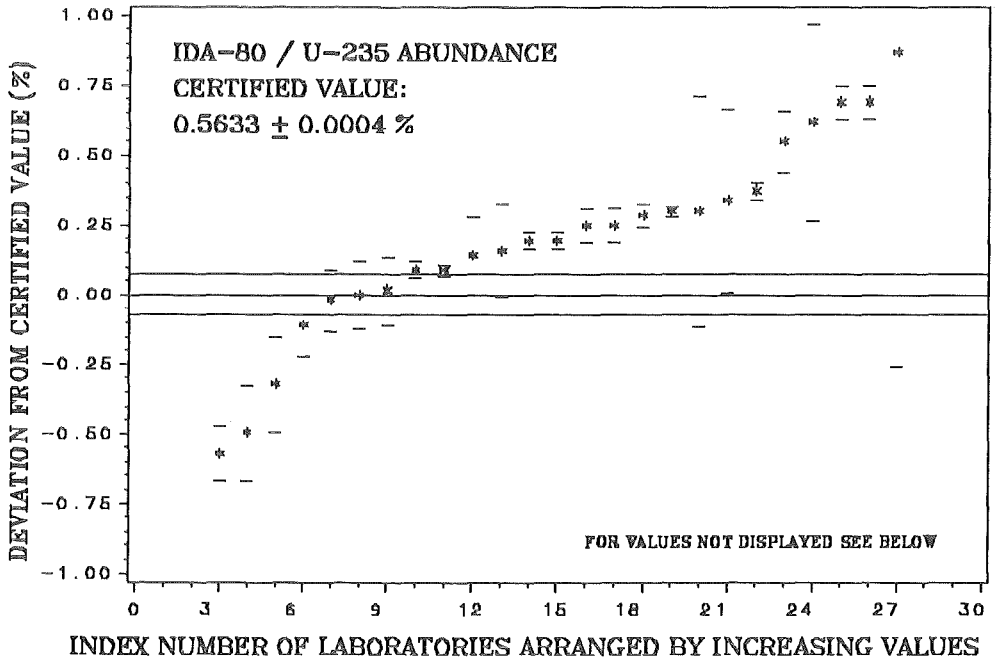
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 46

NUMBER OF PARTICIPATING LABORATORIES: p = 30
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: NONE

MEASUREMENT DATA



VALUES NOT DISPLAYED IN THE GRAPH:

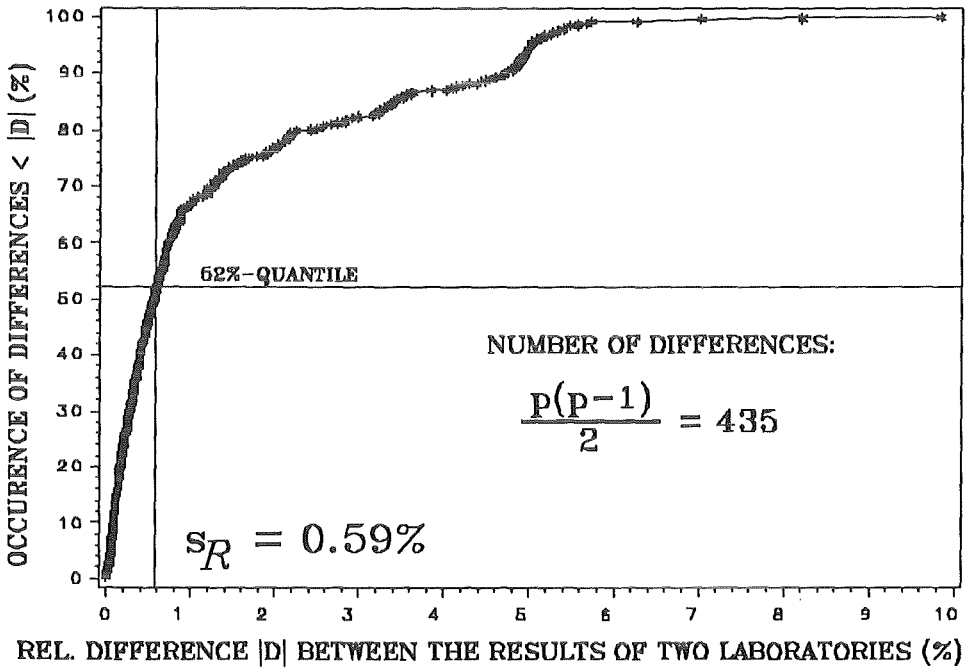
LAB 1:	-4.69%;	±0.39%
LAB 2:	-1.86%;	±0.74%
LAB 28:	+1.56%;	±0.13%
LAB 29:	+3.52%;	±0.33%
LAB 30:	+5.15%;	±0.11%

INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 1;2;28;29;30
THE DIXON CRITERION, $\alpha \leq 1\%$ (REPEATABILITY): 27
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 1.53% / 0.33%
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 0.52% / 0.27%

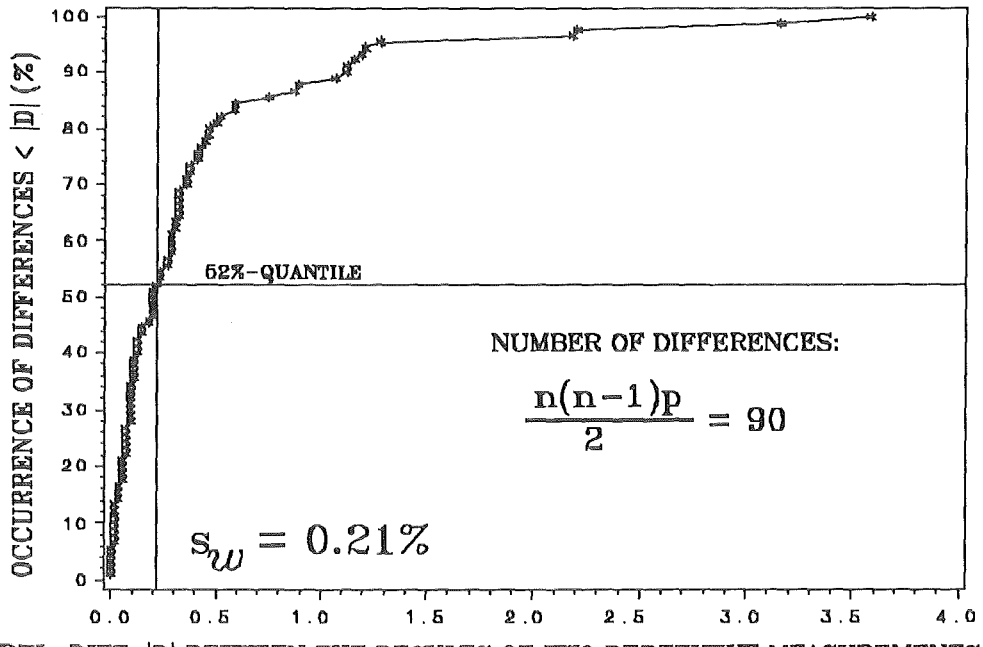
ASSAY: U-235 ABUNDANCE (about 0.6%) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: U-235 ABUNDANCE (about 1.2%) / IDA-80; PART 2.1

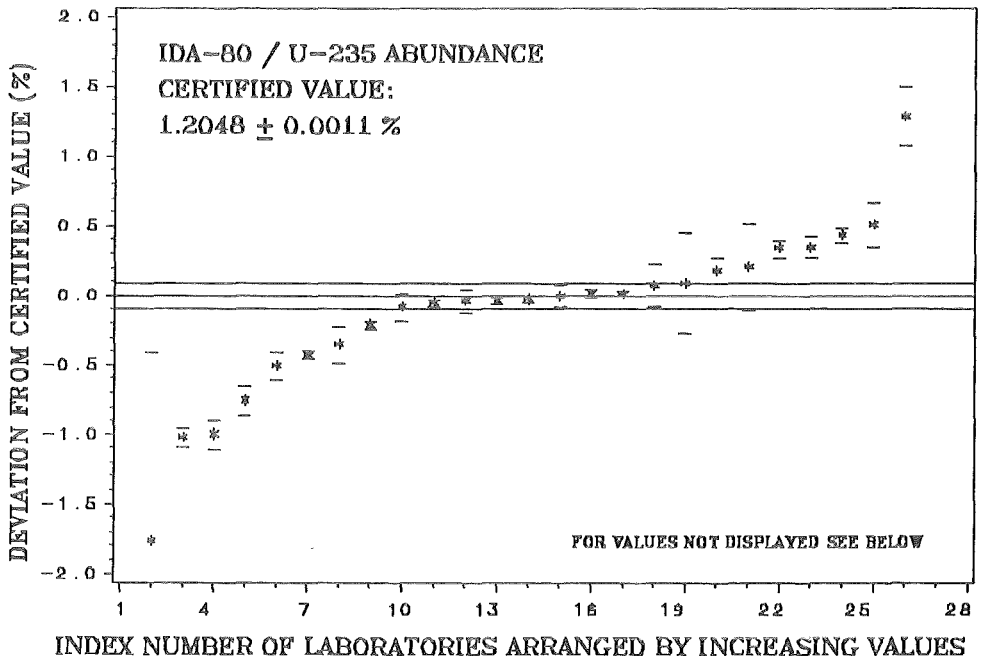
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 50

NUMBER OF PARTICIPATING LABORATORIES: p = 28
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: NONE

MEASUREMENT DATA



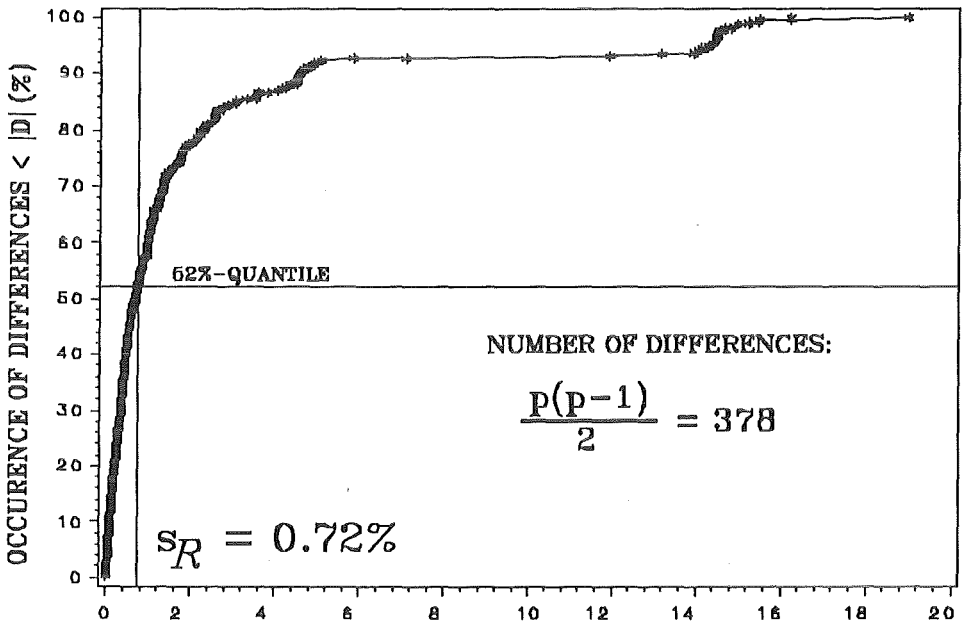
VALUES NOT DISPLAYED IN THE GRAPH:
LAB 1: -4.54%; ±0.66%
LAB 27: +2.53%; ±0.35%
LAB 28: +14.45%; ±1.87%

INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 1;27;28
THE DIXON CRITERION, α≤1% (REPEATABILITY): 2;19;21
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 2.98% / 0.51%
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 0.88% / 0.16%

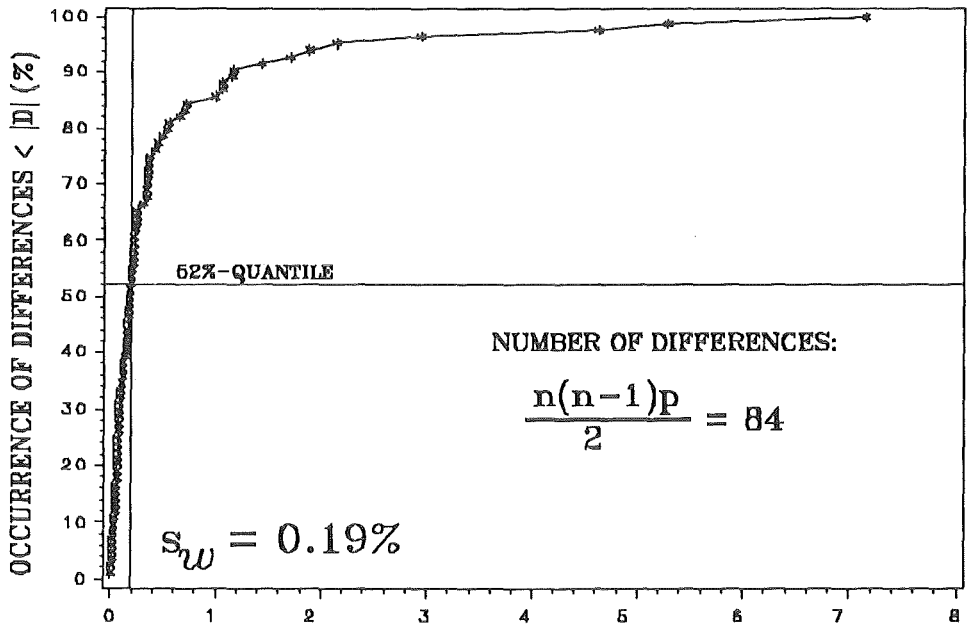
ASSAY: U-235 ABUNDANCE (about 1.2%) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: U-236 ABUNDANCE (about 0.2%) / IDA-80; PART 1.11

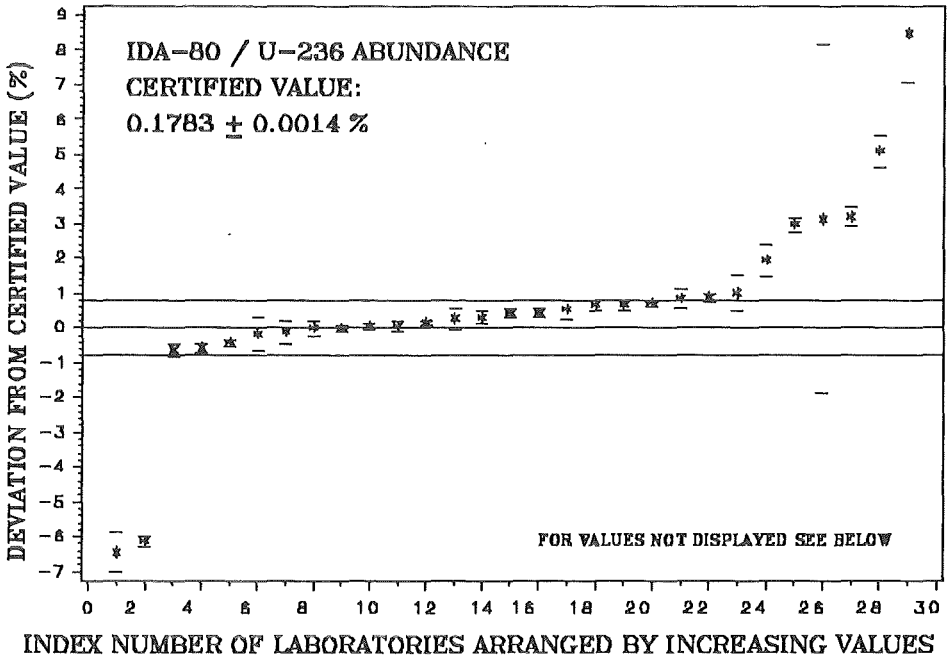
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 47

NUMBER OF PARTICIPATING LABORATORIES: p = 30
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: NONE

MEASUREMENT DATA



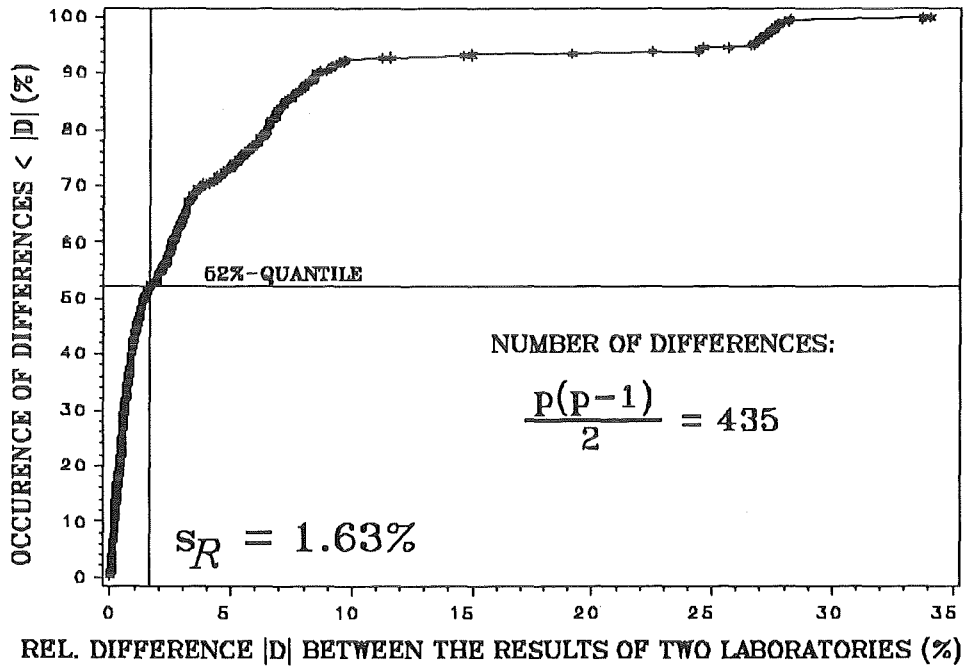
VALUES NOT DISPLAYED IN THE GRAPH: LAB 30: +27.59%; ±0.92%

INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 30
THE DIXON CRITERION, $\alpha \leq 1\%$ (REPEATABILITY): 26;29
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 5.52% / 2.26%
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 1.71% / 0.47%

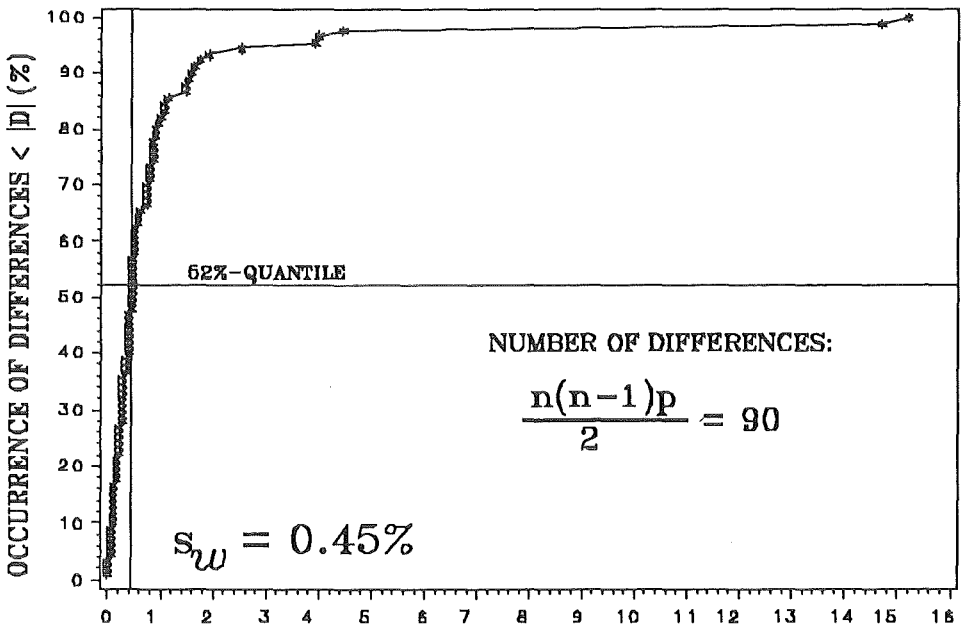
ASSAY: U-236 ABUNDANCE (about 0.2%) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: U-236 ABUNDANCE (about 0.01%) / IDA-80; PART 2.1

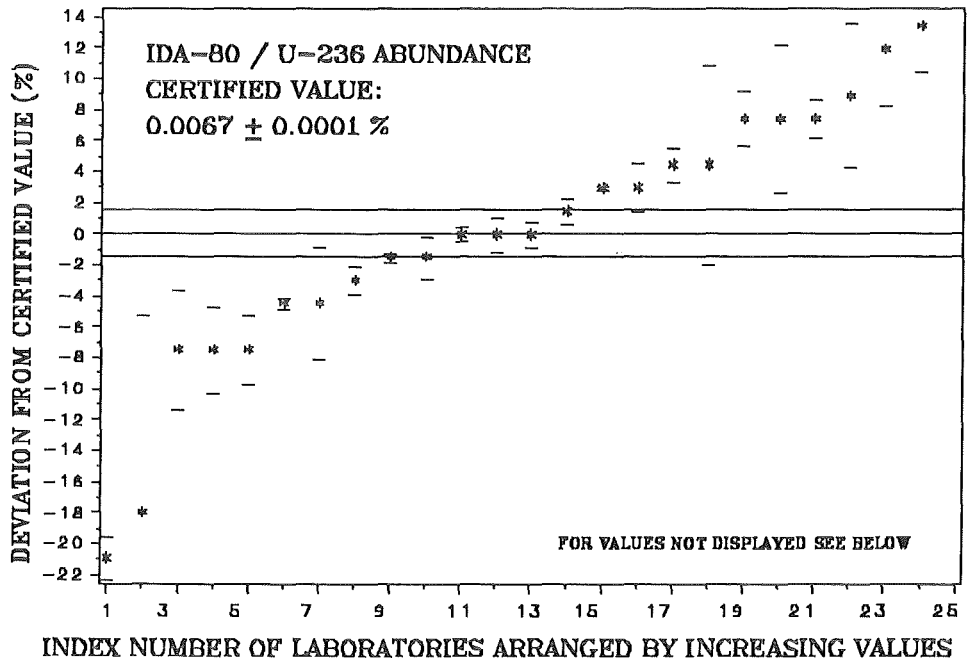
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 51

NUMBER OF PARTICIPATING LABORATORIES: p = 25
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: NONE

MEASUREMENT DATA



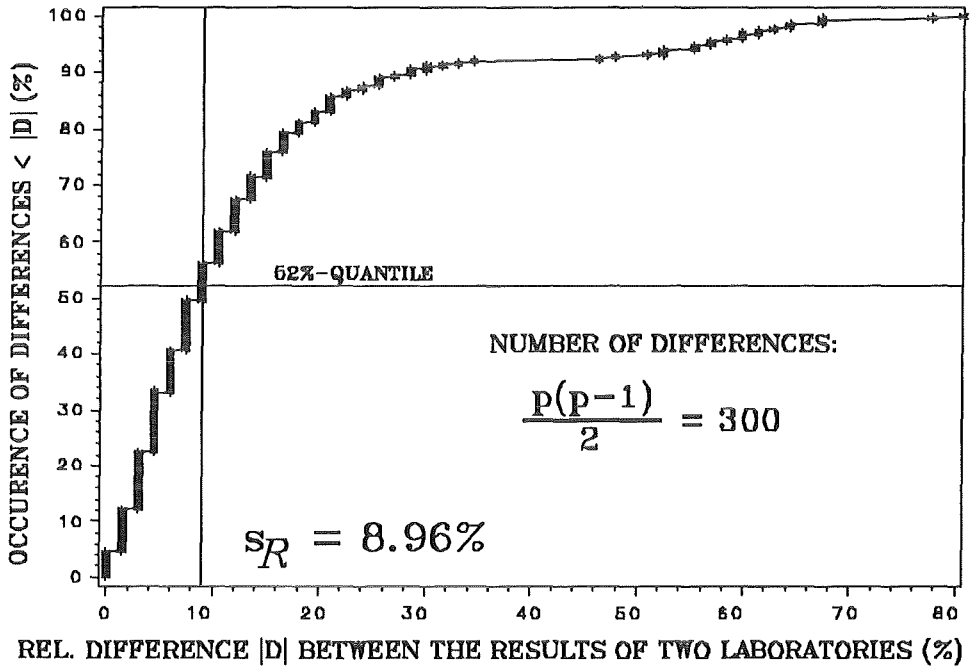
VALUES NOT DISPLAYED IN THE GRAPH: LAB 25: +59.70%; ±4.69%

INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 25
THE DIXON CRITERION, $\alpha \leq 1\%$ (REPEATABILITY): 2
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 14.2% / 7.42%
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 6.61% / 4.67%

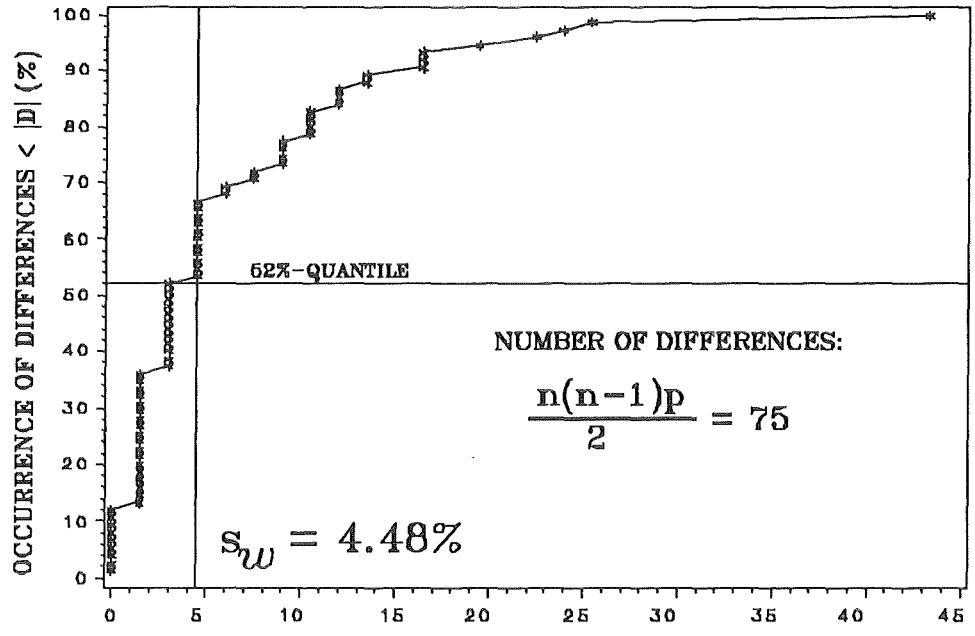
ASSAY: U-236 ABUNDANCE (about 0.01%) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: **Pu-238 ABUNDANCE (about 0.2%) / IDA-80; PART 1.11**

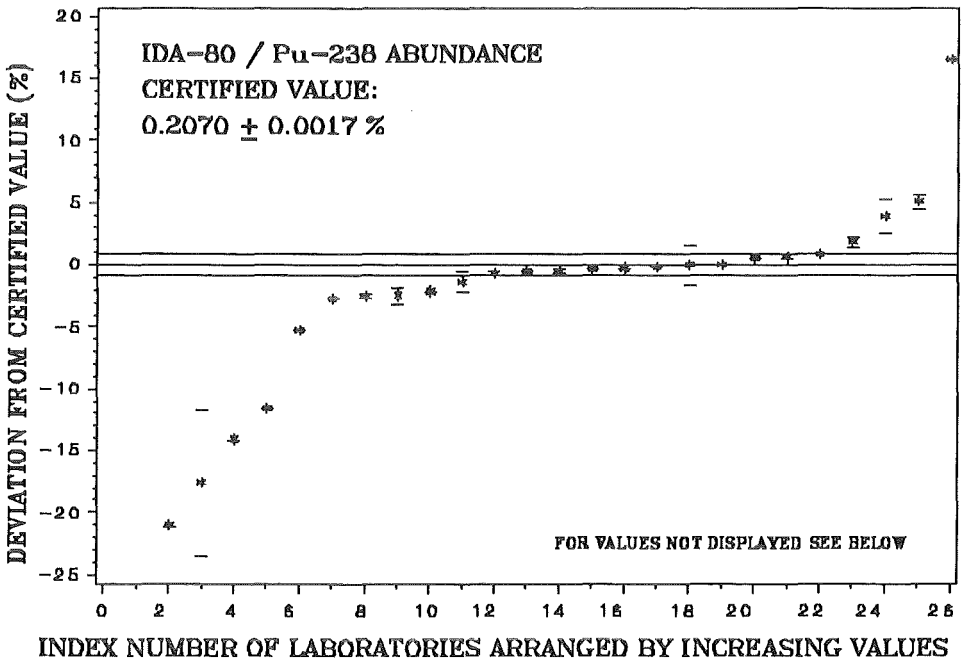
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 53

NUMBER OF PARTICIPATING LABORATORIES: p = 26
NUMBER OF REPETITIVE DETERMINATIONS PER LAB.: n = 1 OR 3

REMARK: NUMBER OF REPETITIONS DEPENDS ON ANALYTICAL METHOD USED (ALPHA OR MASS SPECTROMETRY)

MEASUREMENT DATA



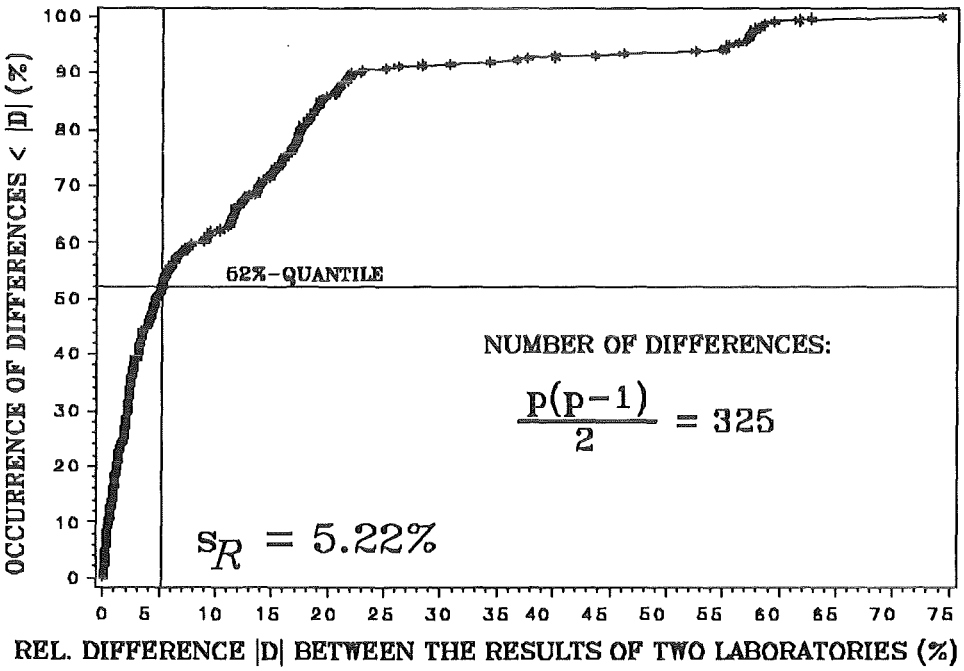
VALUES NOT DISPLAYED IN THE GRAPH: LAB 1: -57.58%; ±0.03%

INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 1
THE DIXON CRITERION, $\alpha \leq 1\%$ (REPEATABILITY): 3
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 13.7% / 7.01%
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: SEE PAGE 56

ASSAY: Pu-238 ABUNDANCE (about 0.2%) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



FOR THE 'WITHIN-LAB. COMPONENT' SEE PAGE 56 AND 57

ASSAY: Pu-238 ABUNDANCE (about 0.2%) / IDA-80; PART 1.11

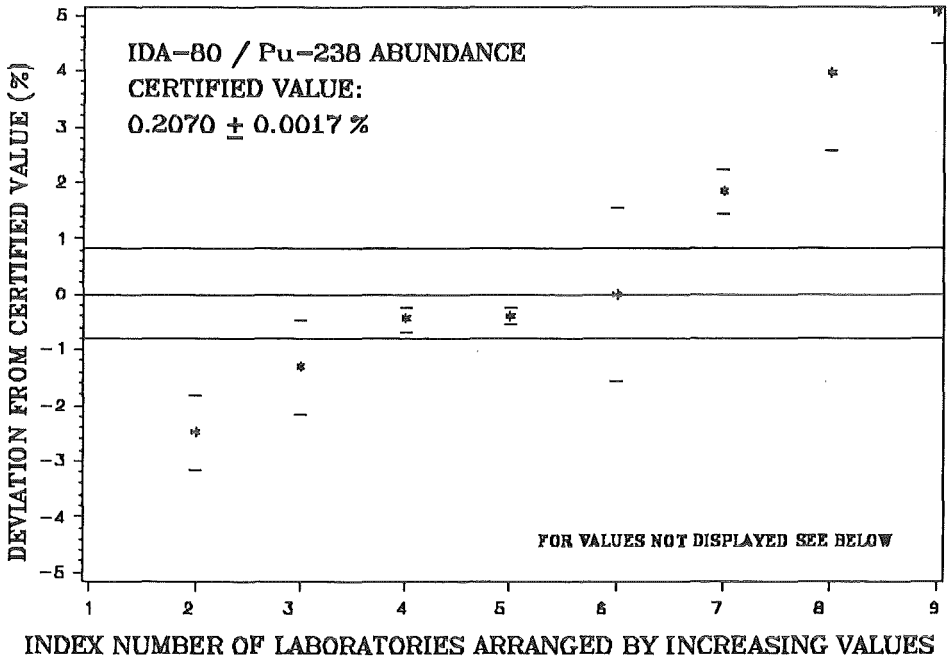
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 55

NUMBER OF PARTICIPATING LABORATORIES: p = 9
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: MASS SPECTROMETRIC DETERMINATIONS

MEASUREMENT DATA



VALUES NOT DISPLAYED IN THE GRAPH: LAB 1: -17.58%; ±7.20%

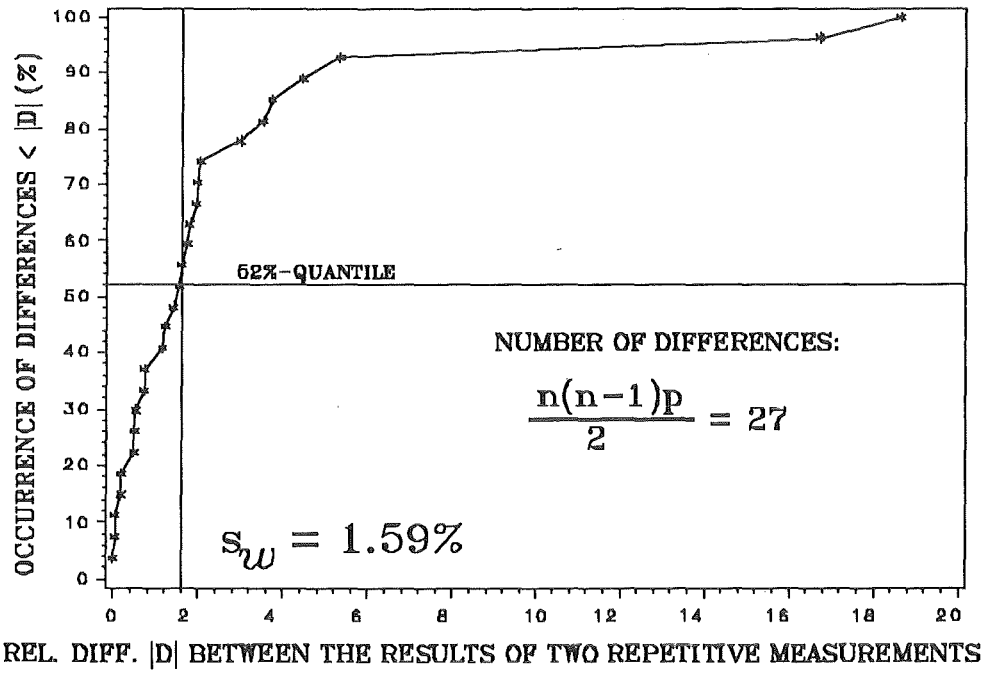
INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 1
THE DIXON CRITERION, $\alpha \leq 1\%$ (REPEATABILITY): NONE
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: SEE PAGE 54
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 3.75% / 1.50%

ASSAY: Pu-238 ABUNDANCE (about 0.2%) / Continued

SECTION B: DoD EVALUATION

FOR THE 'INTERLABORATORY SPREAD' SEE PAGE 54 AND 55

DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: Pu-238 ABUNDANCE (about 0.1%) / IDA-80; PART 2.1

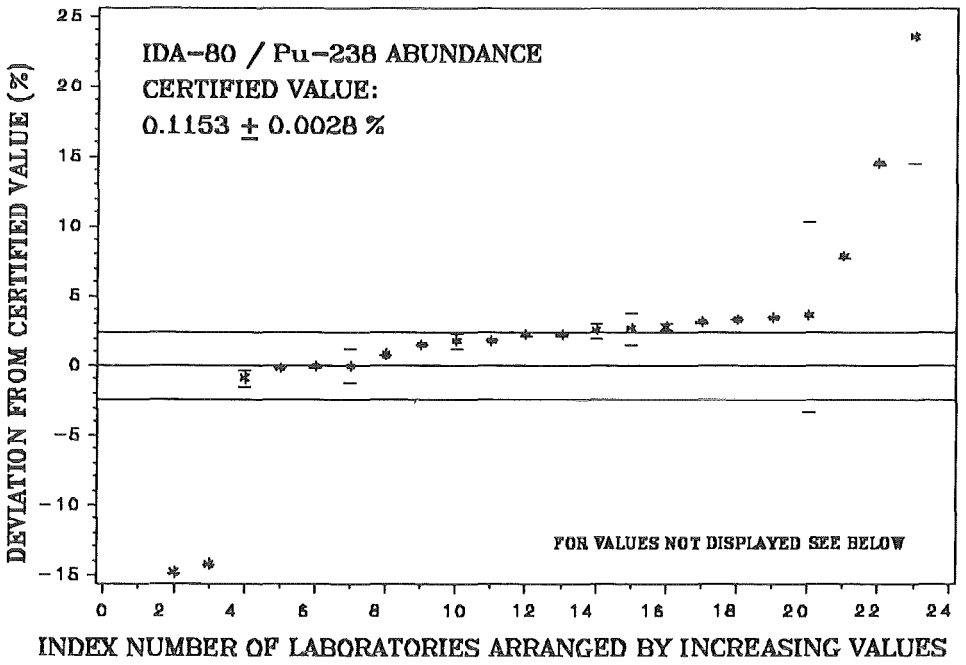
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 60

NUMBER OF PARTICIPATING LABORATORIES: p = 24
NUMBER OF REPETITIVE DETERMINATIONS PER LAB.: n = 1 OR 3

REMARK: NUMBER OF REPETITIONS DEPENDS ON ANALYTICAL METHOD USED (ALPHA OR MASS SPECTROMETRY)

MEASUREMENT DATA



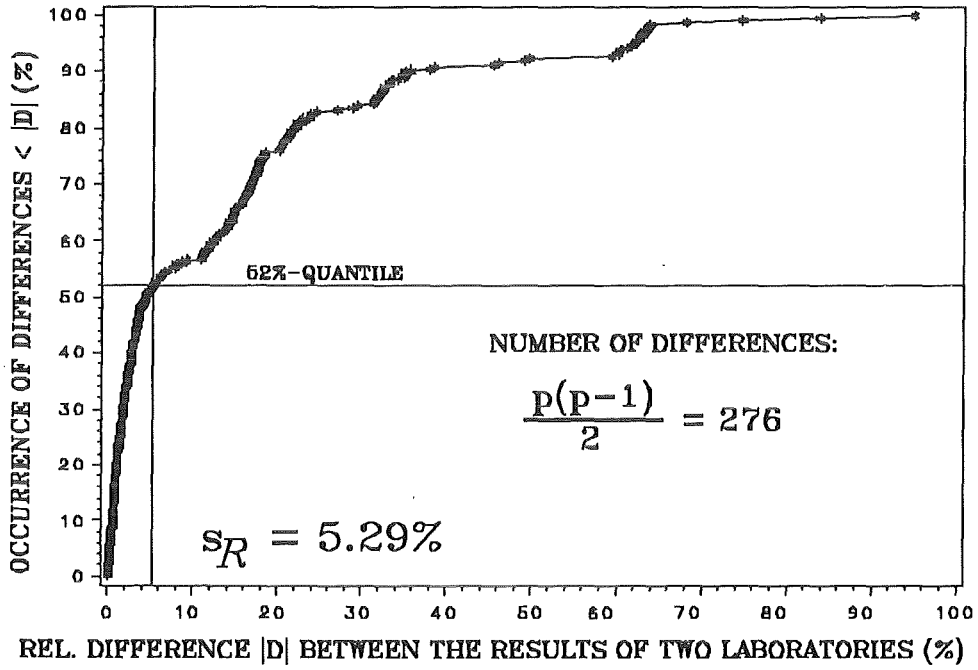
VALUES NOT DISPLAYED IN THE GRAPH: LAB 1: -60.19%; ±0.02%
LAB 24: +34.78%; ±0.01%

INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 1;24
THE DIXON CRITERION, $\alpha \leq 1\%$ (REPEATABILITY): 20;23
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 16.2% / 6.21%
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: SEE PAGE 60

ASSAY: Pu-238 ABUNDANCE (about 0.1%) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



FOR THE 'WITHIN-LAB. COMPONENT' SEE PAGE 60 AND 61

ASSAY: Pu-238 ABUNDANCE (about 0.1%) / IDA-80; PART 2.1

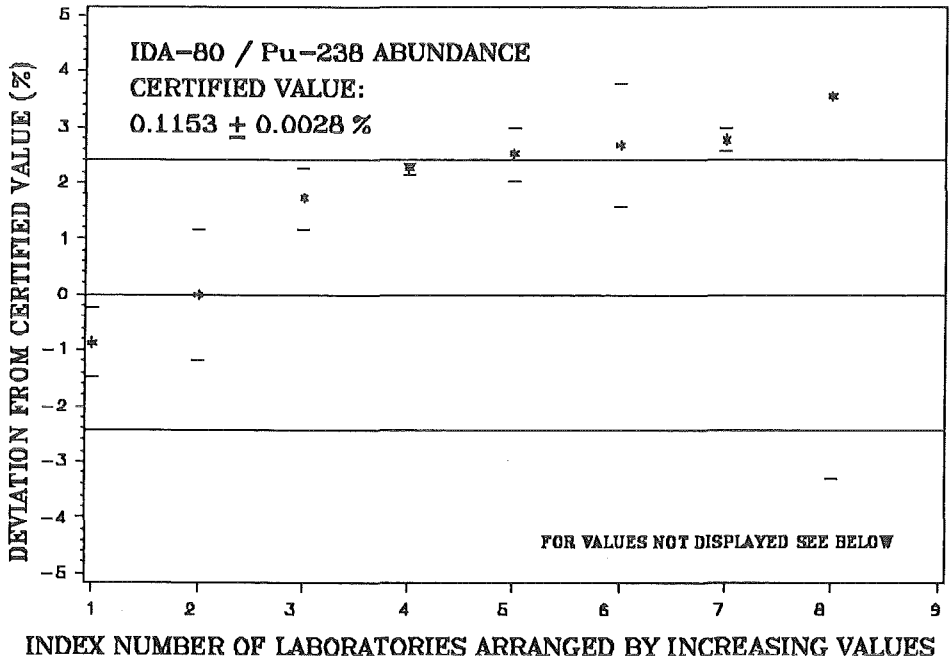
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 62

NUMBER OF PARTICIPATING LABORATORIES: p = 9
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: MASS SPECTROMETRIC DETERMINATIONS

MEASUREMENT DATA



VALUES NOT DISPLAYED IN THE GRAPH: LAB 9: +23.59%; ±7.31%

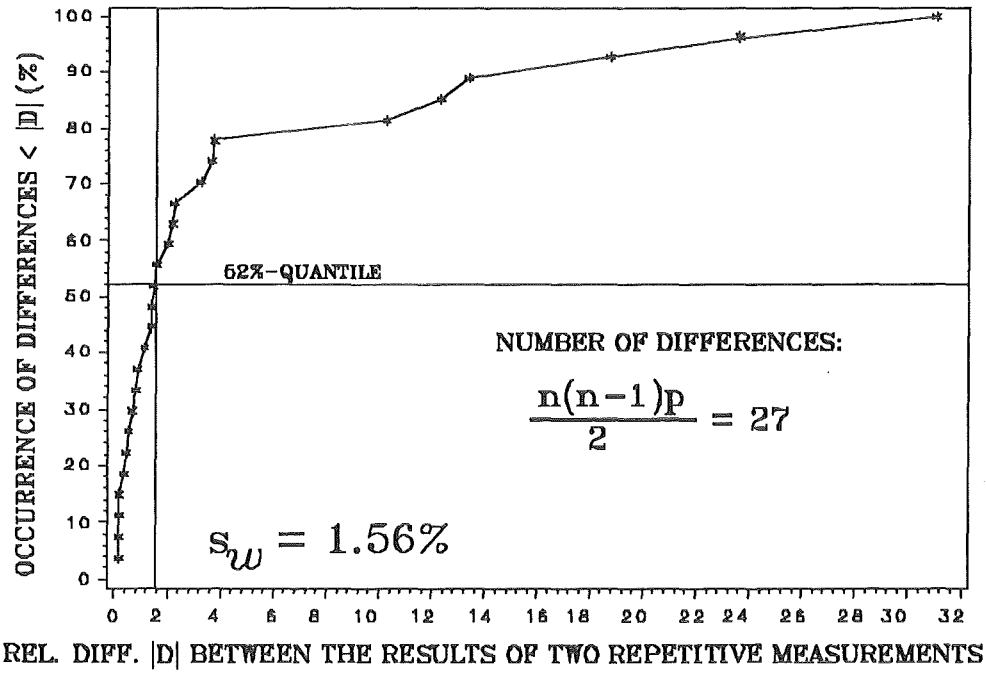
INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 9
THE DIXON CRITERION, α≤1% (REPEATABILITY): 8
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: SEE PAGE 58
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 6.35% / 1.21%

ASSAY: **Pu-238 ABUNDANCE (about 0.1%) / Continued**

SECTION B: **DoD EVALUATION**

FOR THE 'INTERLABORATORY SPREAD' SEE PAGE 58 AND 59

DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: Pu-239 ABUNDANCE (about 69%) / IDA-80; PART 1.11

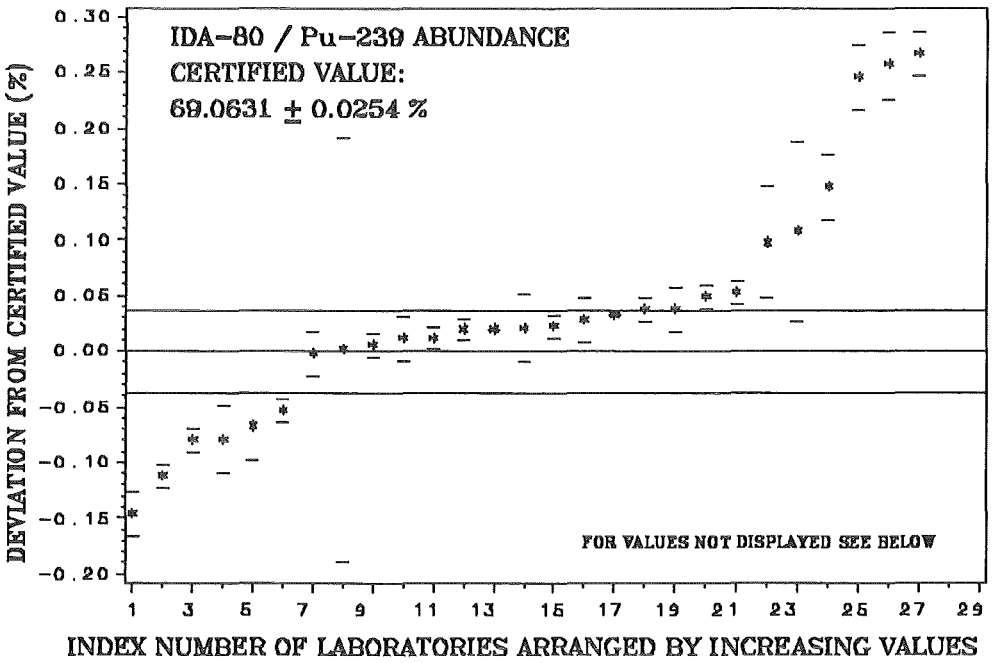
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 56

NUMBER OF PARTICIPATING LABORATORIES: p = 29
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: NONE

MEASUREMENT DATA



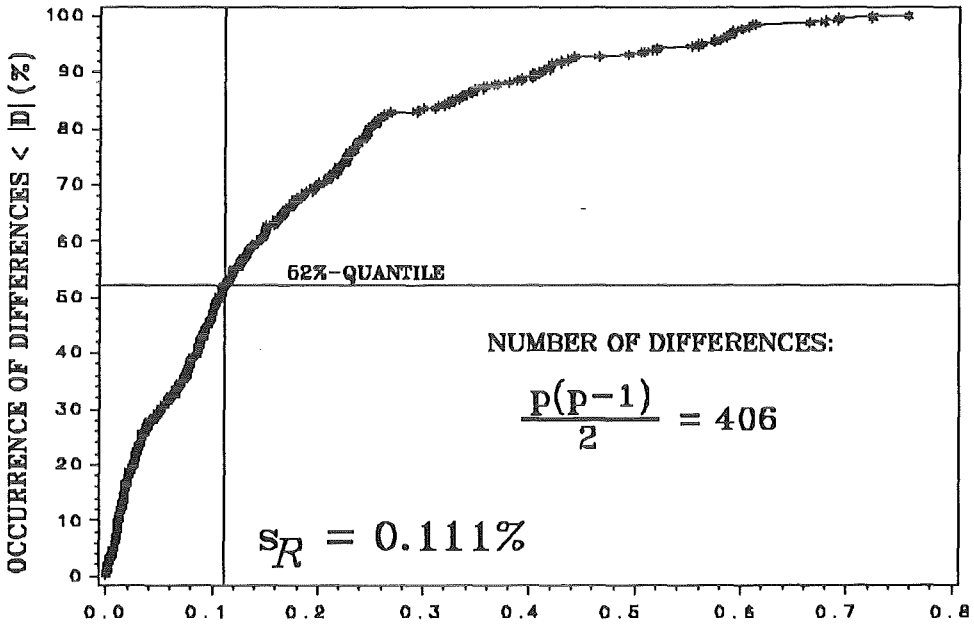
VALUES NOT DISPLAYED IN THE GRAPH: LAB 28: +0.44%; ±0.02%
LAB 29: +0.61%; ±0.28%

INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 29
THE DIXON CRITERION, $\alpha \leq 1\%$ (REPEATABILITY): 8;23
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 0.16% / 0.13%
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 0.12% / 0.035%

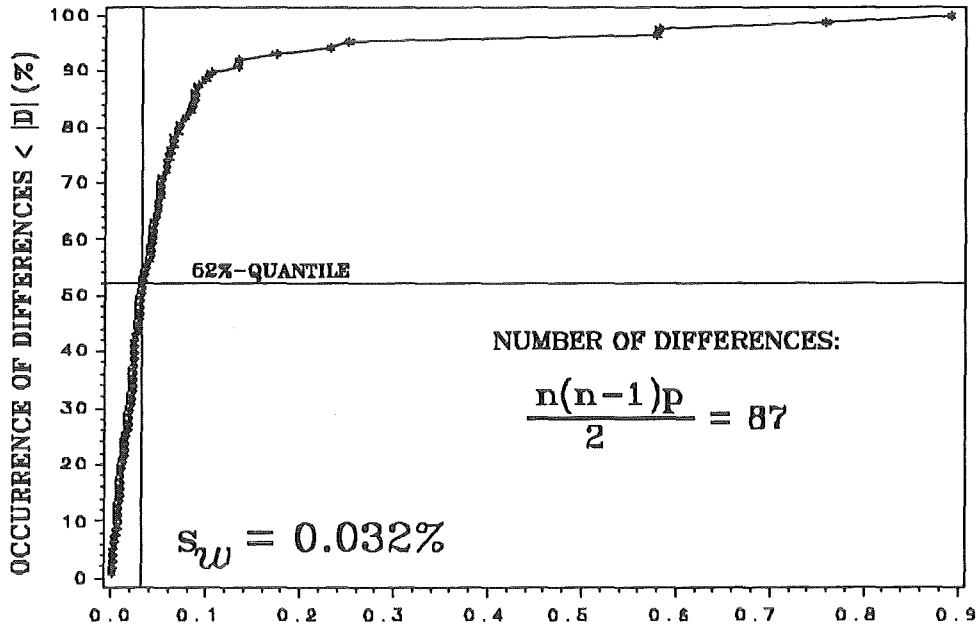
ASSAY: Pu-239 ABUNDANCE (about 69%) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: Pu-239 ABUNDANCE (about 77%) / IDA-80; PART 2.1

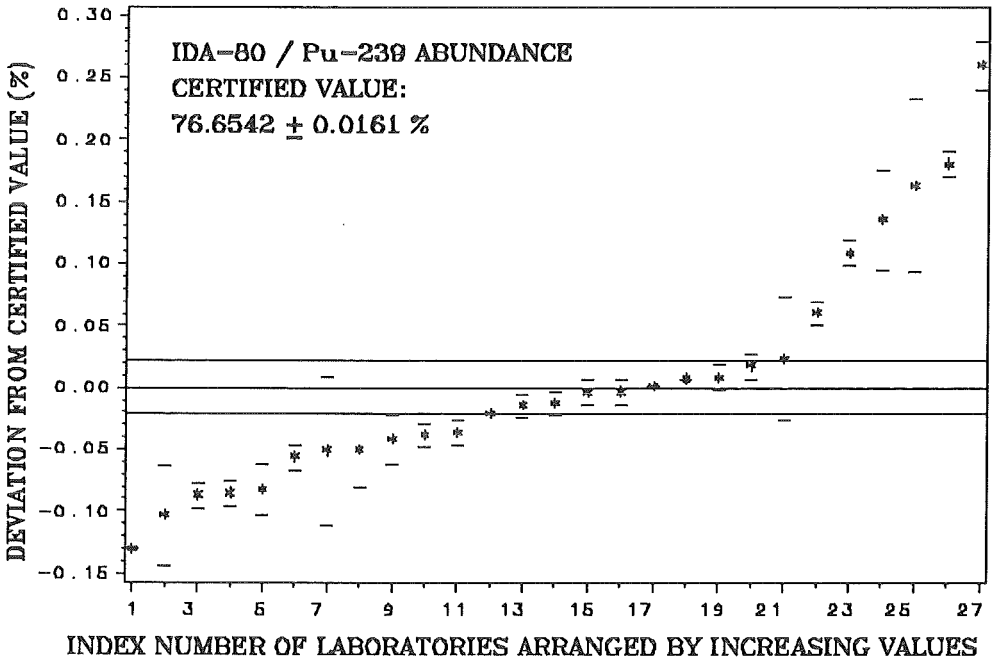
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 63

NUMBER OF PARTICIPATING LABORATORIES: p = 27
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: NONE

MEASUREMENT DATA

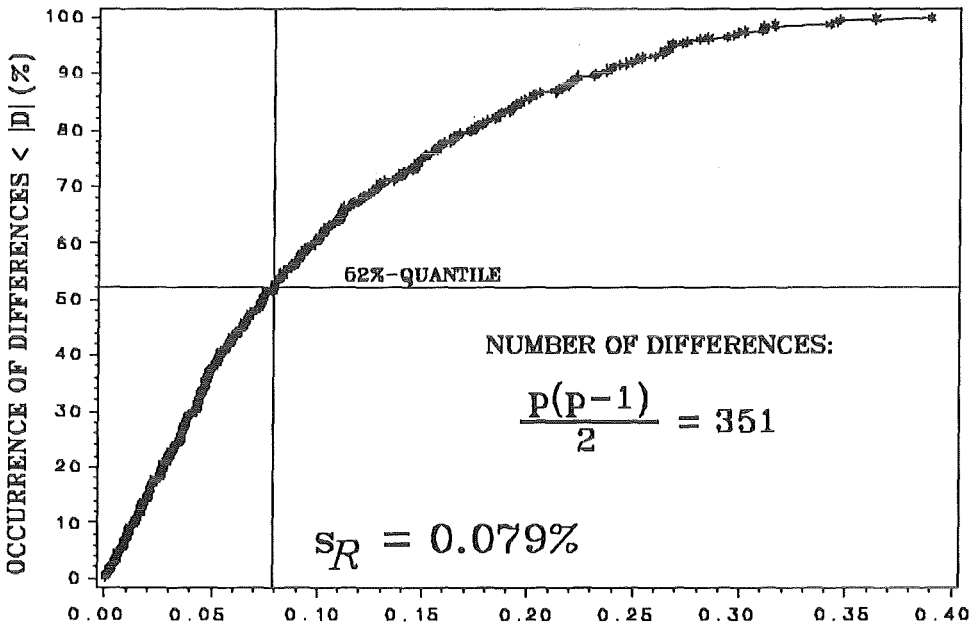


INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): NONE
THE DIXON CRITERION, $\alpha \leq 1\%$ (REPEATABILITY): NONE
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 0.093% / 0.093%
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 0.045% / 0.045%

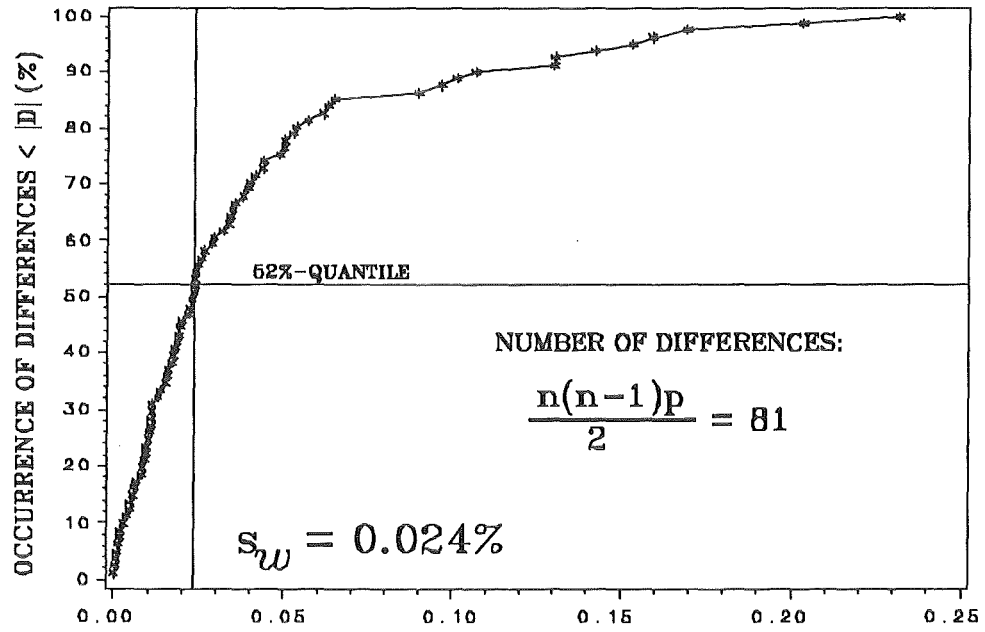
ASSAY: Pu-239 ABUNDANCE (about 77%) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: **Pu-240 ABUNDANCE (about 26%) / IDA-80; PART 1.11**

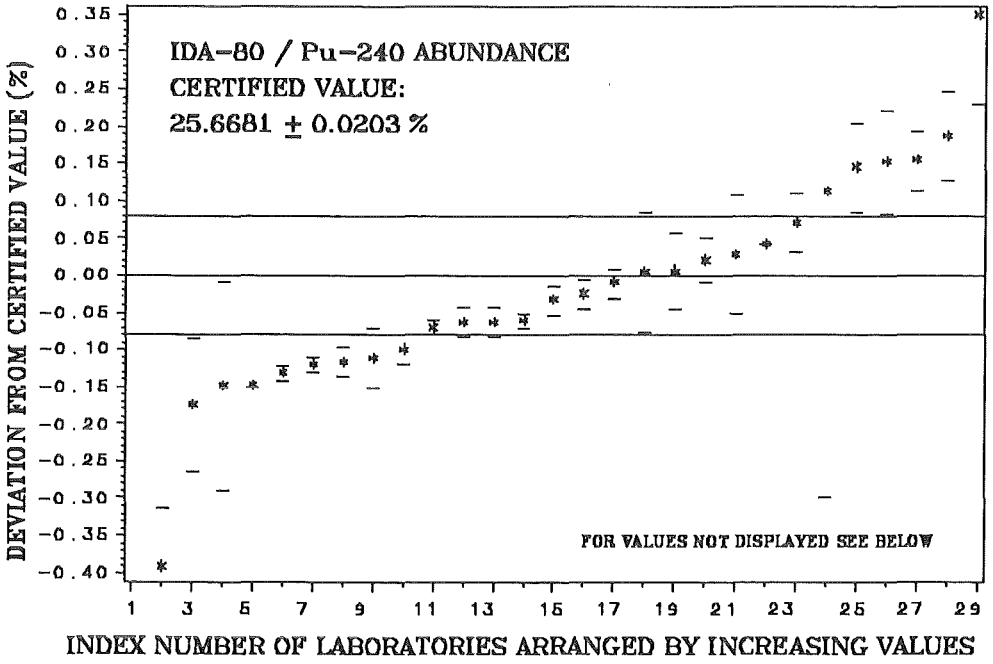
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 57

NUMBER OF PARTICIPATING LABORATORIES: p = 29
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: NONE

MEASUREMENT DATA



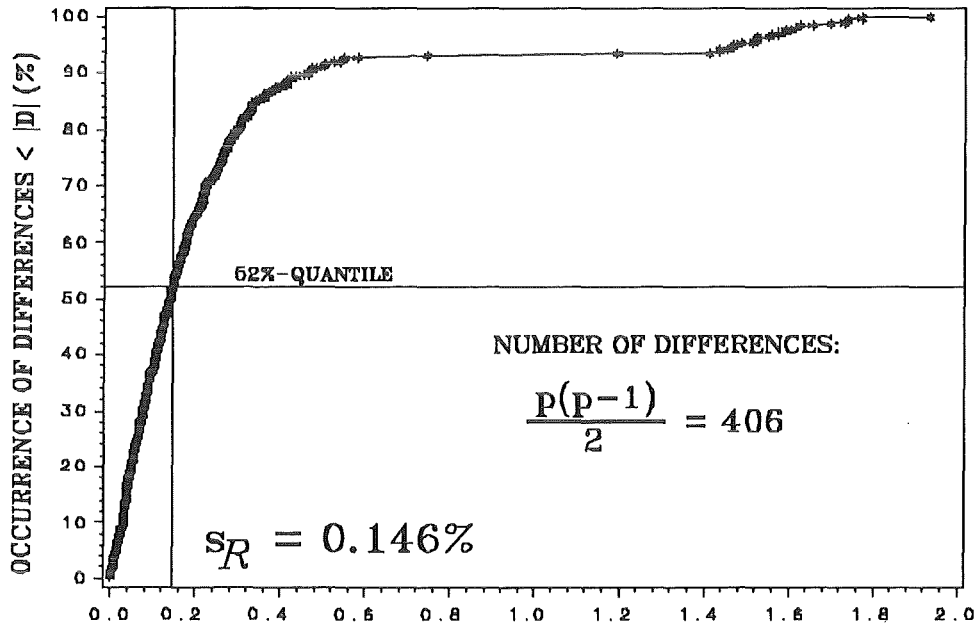
VALUES NOT DISPLAYED IN THE GRAPH: LAB 1: -1.58%; ±0.60%

INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 1
THE DIXON CRITERION, $\alpha \leq 1\%$ (REPEATABILITY): 24
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 0.32% / 0.14%
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 0.25% / 0.097%

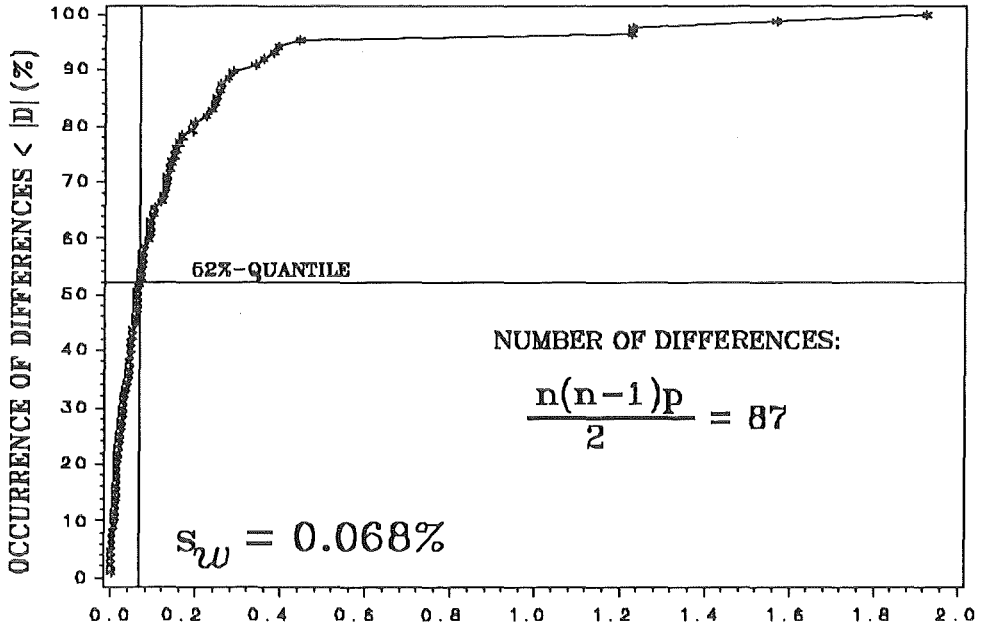
ASSAY: Pu-240 ABUNDANCE (about 26%) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: Pu-240 ABUNDANCE (about 20%) / IDA-80; PART 2.1

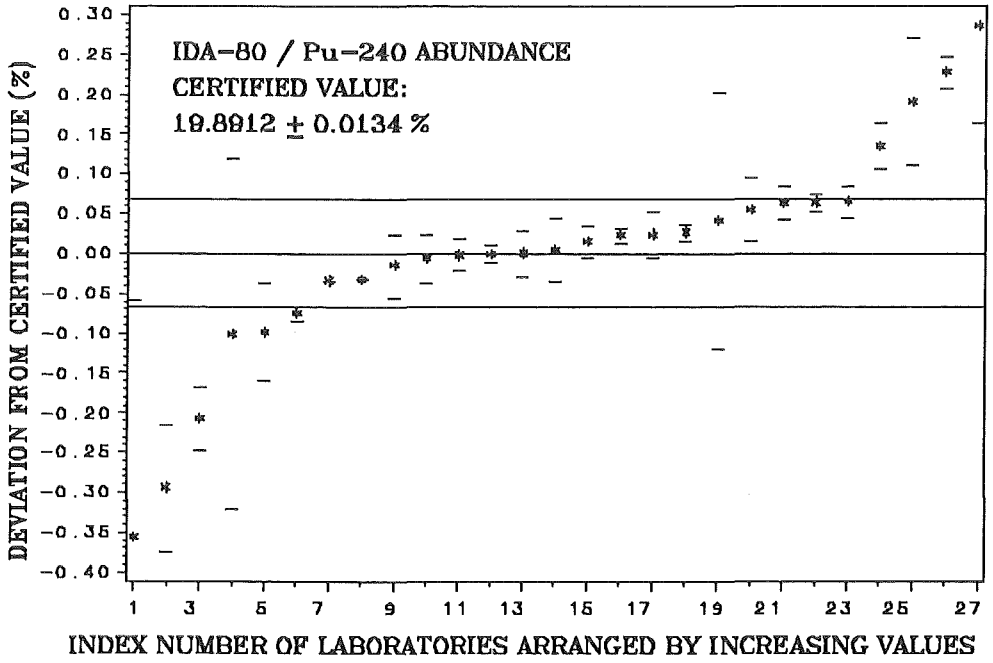
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 64

NUMBER OF PARTICIPATING LABORATORIES: p = 27
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: NONE

MEASUREMENT DATA



INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): NONE
THE DIXON CRITERION, $\alpha \leq 1\%$ (REPEATABILITY): NONE

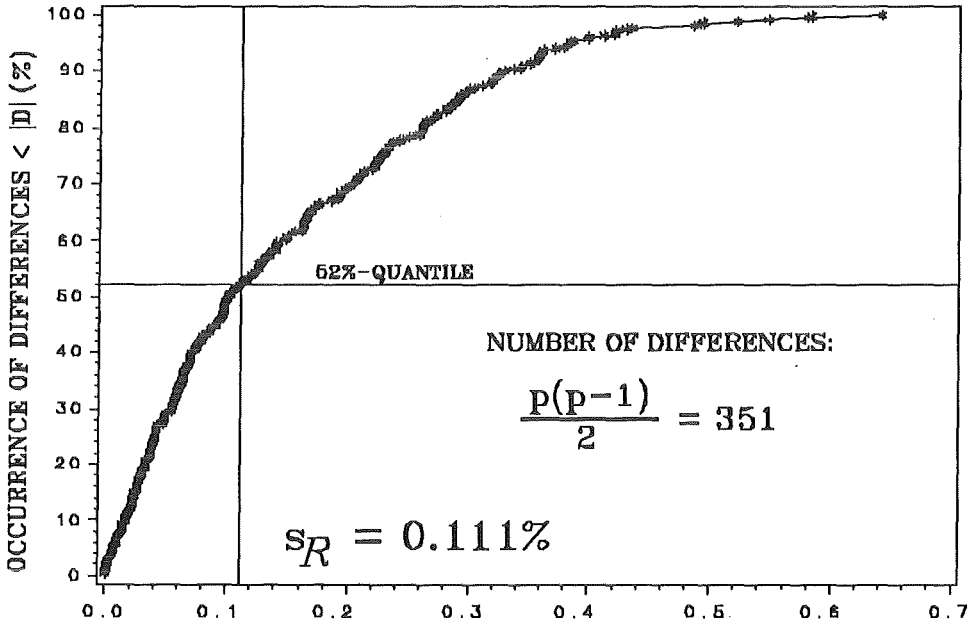
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 0.14% / 0.14%

ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 0.15% / 0.15%

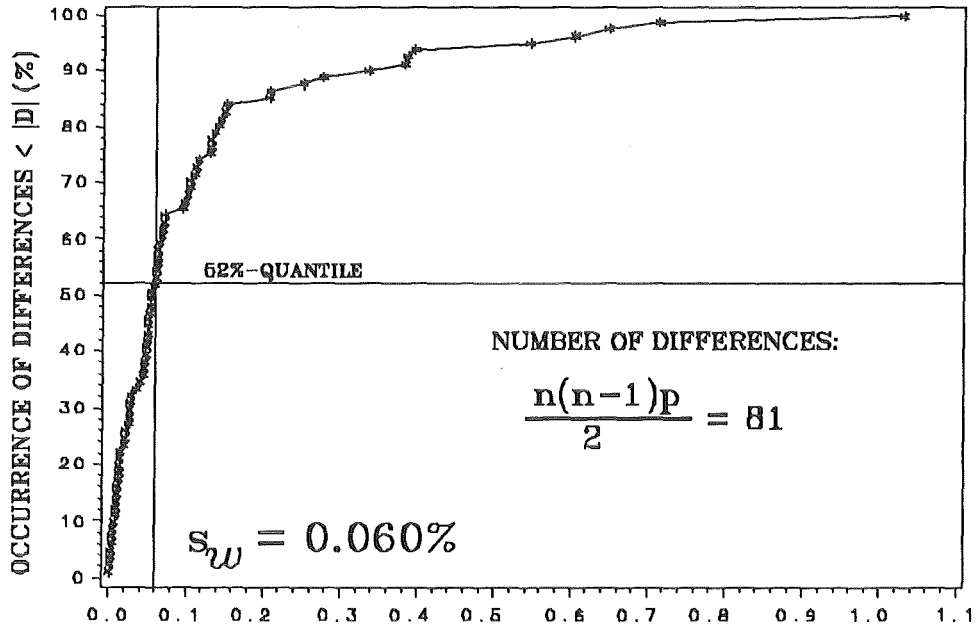
ASSAY: Pu-240 ABUNDANCE (about 20%) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: Pu-241 ABUNDANCE (about 3.3%) / IDA-80; PART 1.11

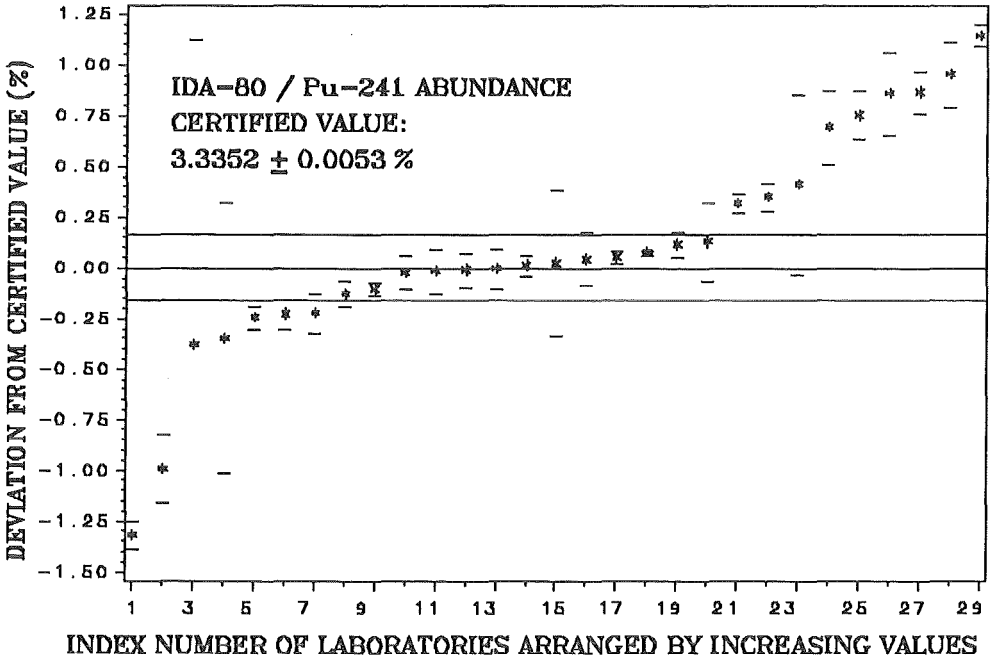
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 58

NUMBER OF PARTICIPATING LABORATORIES: p = 29
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: NONE

MEASUREMENT DATA

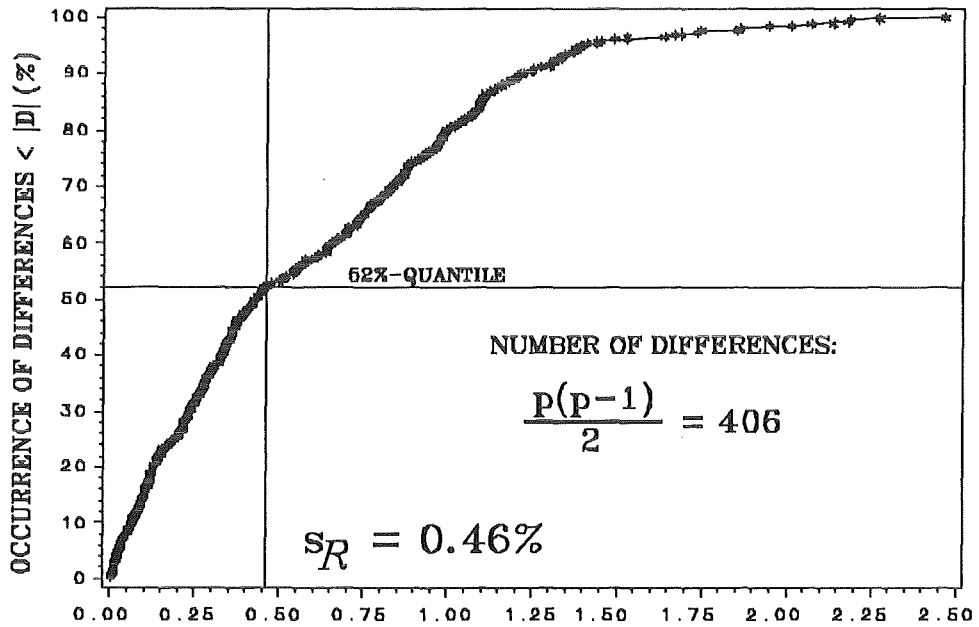


INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): NONE
THE DIXON CRITERION, $\alpha \leq 1\%$ (REPEATABILITY): 3;4;15;23
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 0.54% / 0.56%
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 0.59% / 0.18%

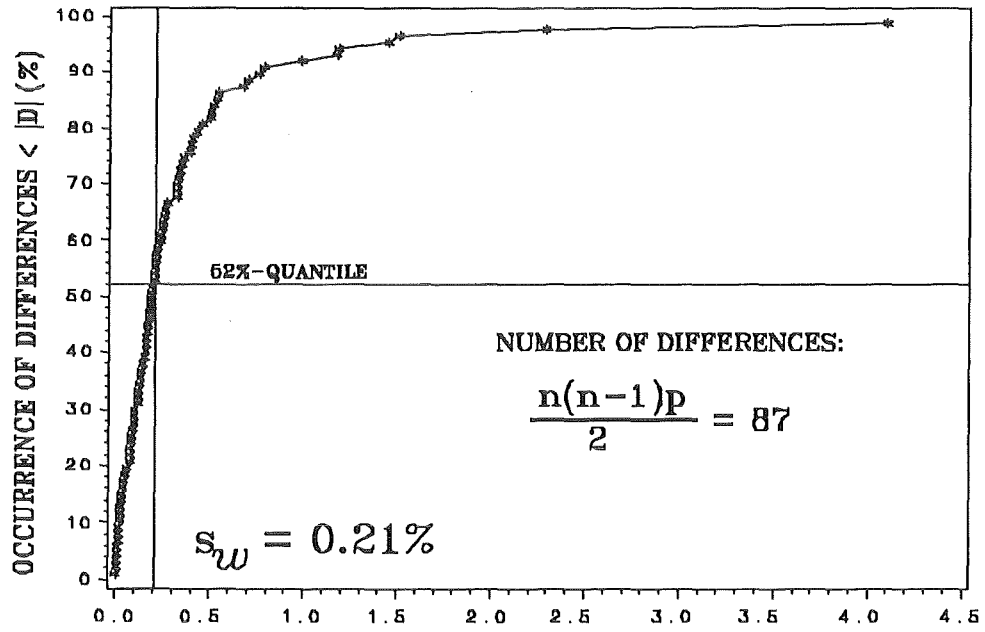
ASSAY: Pu-241 ABUNDANCE (about 3.3%) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: Pu-241 ABUNDANCE (about 2.7%) / IDA-80; PART 2.1

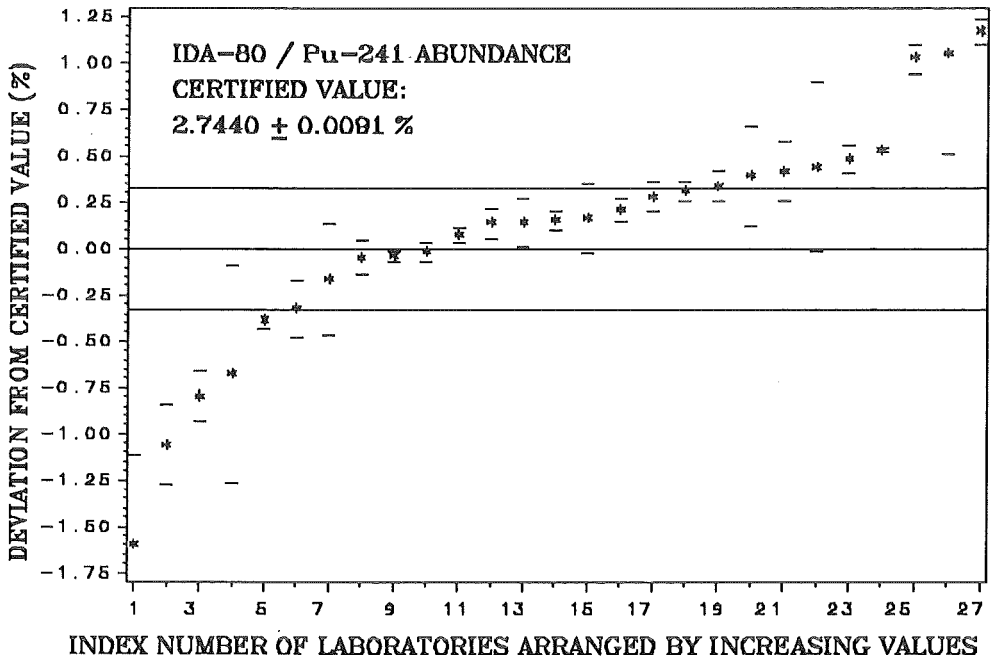
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 65

NUMBER OF PARTICIPATING LABORATORIES: p = 27
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: NONE

MEASUREMENT DATA

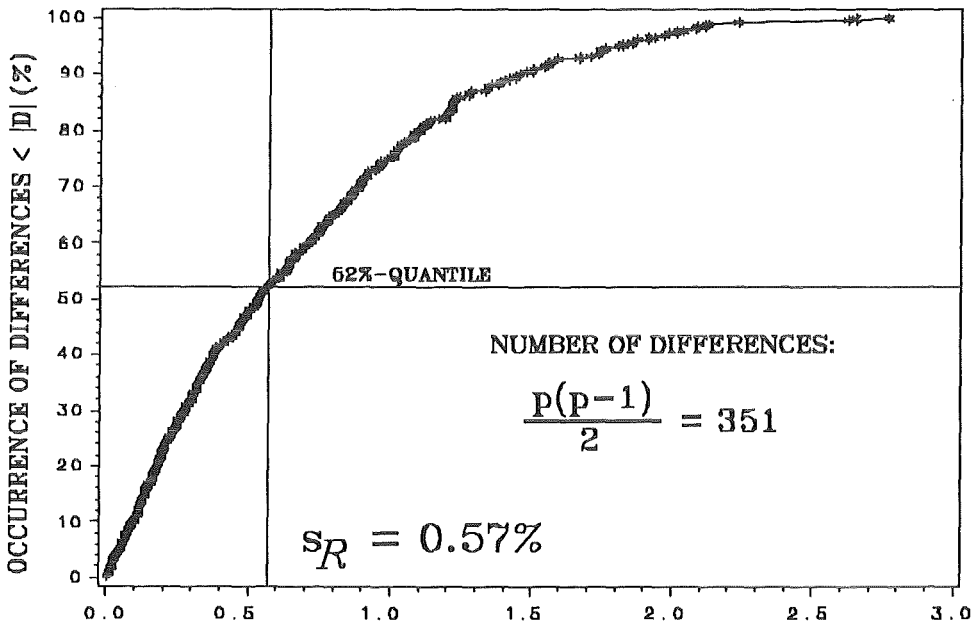


INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): NONE
THE DIXON CRITERION, $\alpha \leq 1\%$ (REPEATABILITY): NONE
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 0.62% / 0.62%
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 0.40% / 0.40%

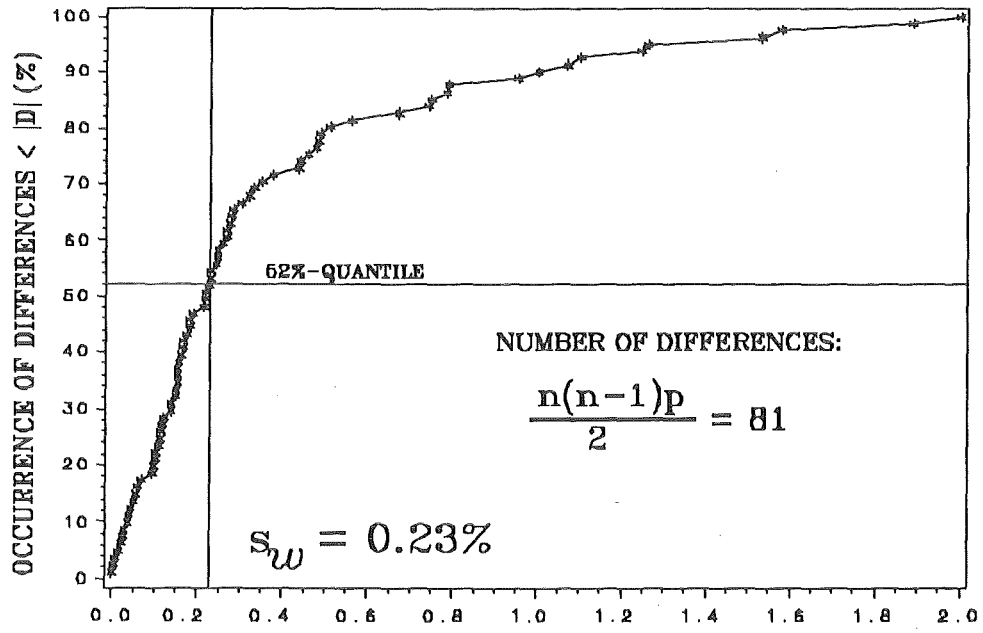
ASSAY: Pu-241 ABUNDANCE (about 2.7%) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: Pu-242 ABUNDANCE (about 1.7%) / IDA-80; PART 1.11

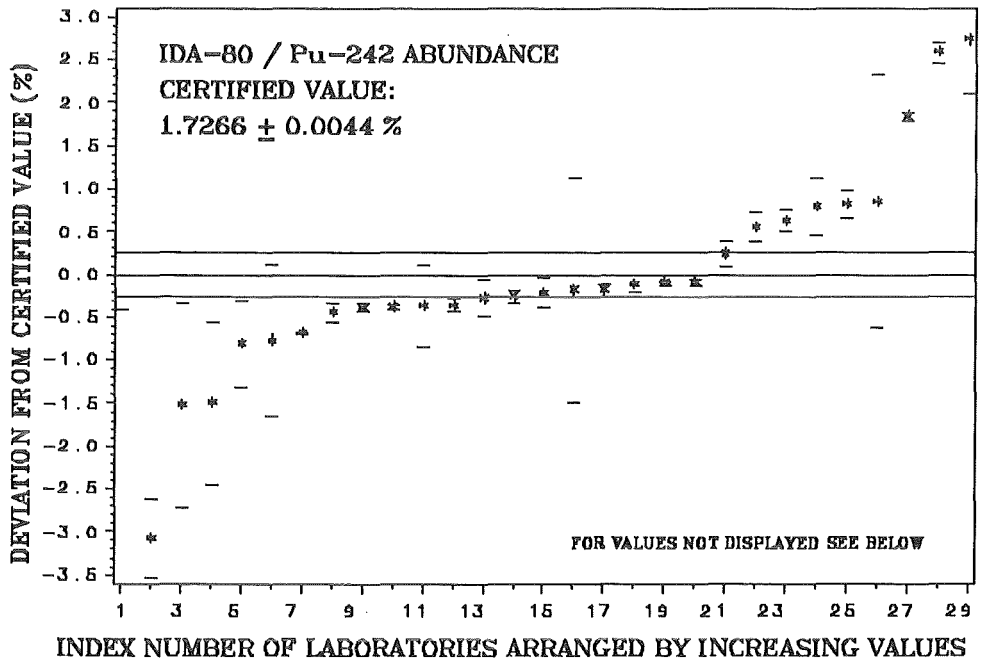
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 59

NUMBER OF PARTICIPATING LABORATORIES: p = 29
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: NONE

MEASUREMENT DATA



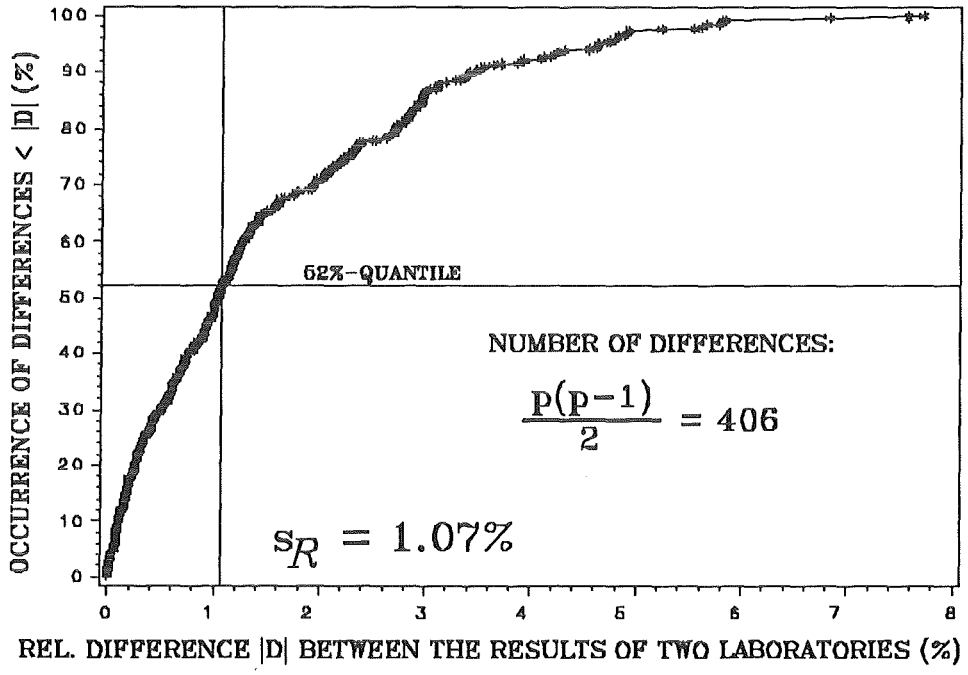
VALUES NOT DISPLAYED IN THE GRAPH: LAB 1: -4.98%; ±4.82%

INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 1
THE DIXON CRITERION, $\alpha \leq 1\%$ (REPEATABILITY): NONE
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 1.48% / 1.17%
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 1.75% / 0.95%

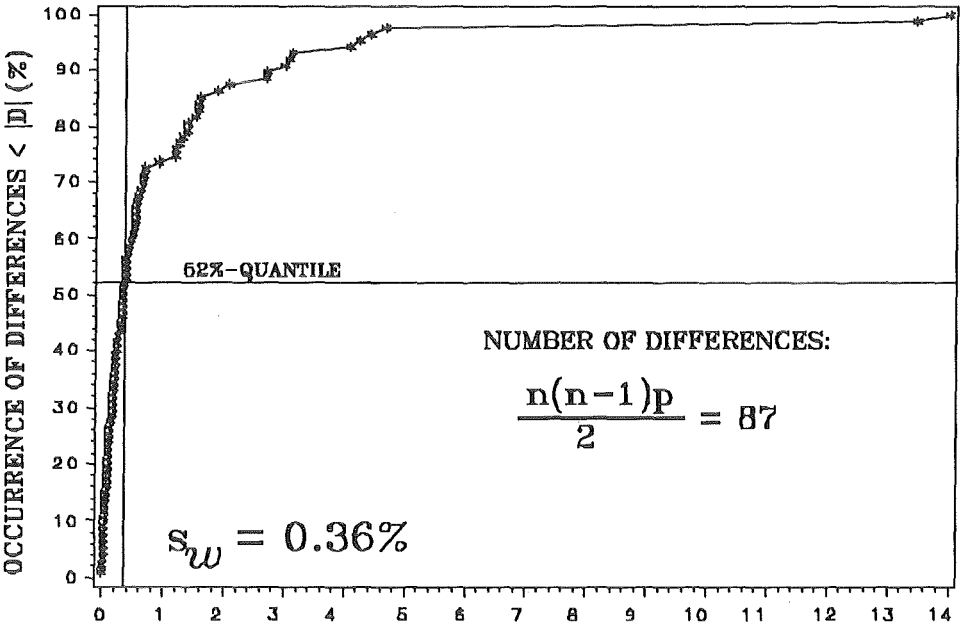
ASSAY: Pu-242 ABUNDANCE (about 1.7%) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT



ASSAY: Pu-242 ABUNDANCE (about 0.6%) / IDA-80; PART 2.1

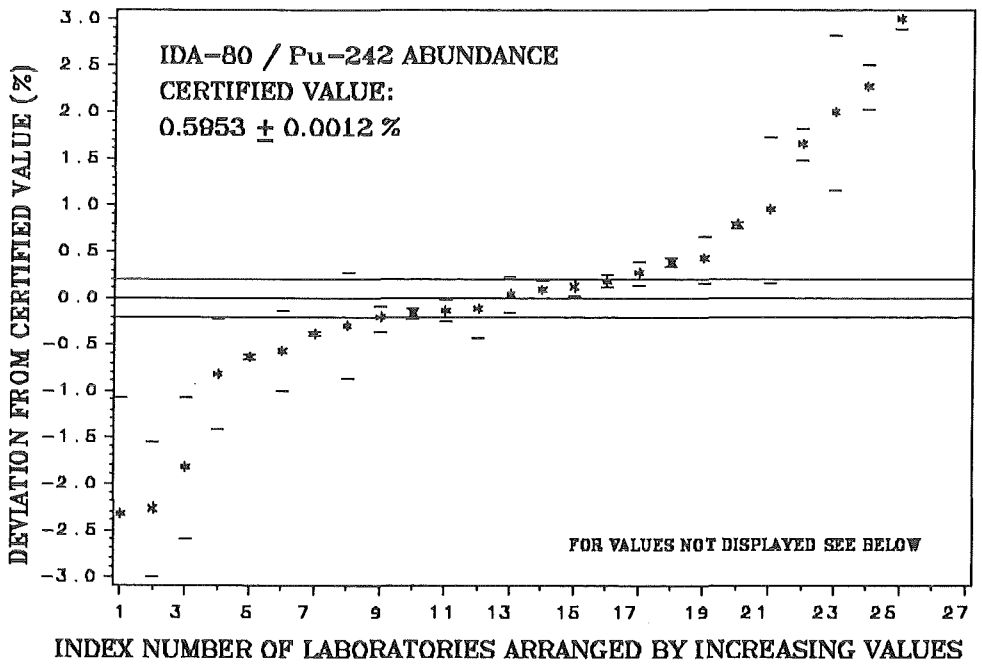
SECTION A: MEASUREMENT DATA AND CONVENTIONAL EVALUATION

ORIGIN OF DATA: REF. /7/; EVAL. SHEET 66

NUMBER OF PARTICIPATING LABORATORIES: p = 27
NUMBER OF REPETITIVE DETERMINATIONS PER LABORATORY: n = 3

REMARK: NONE

MEASUREMENT DATA



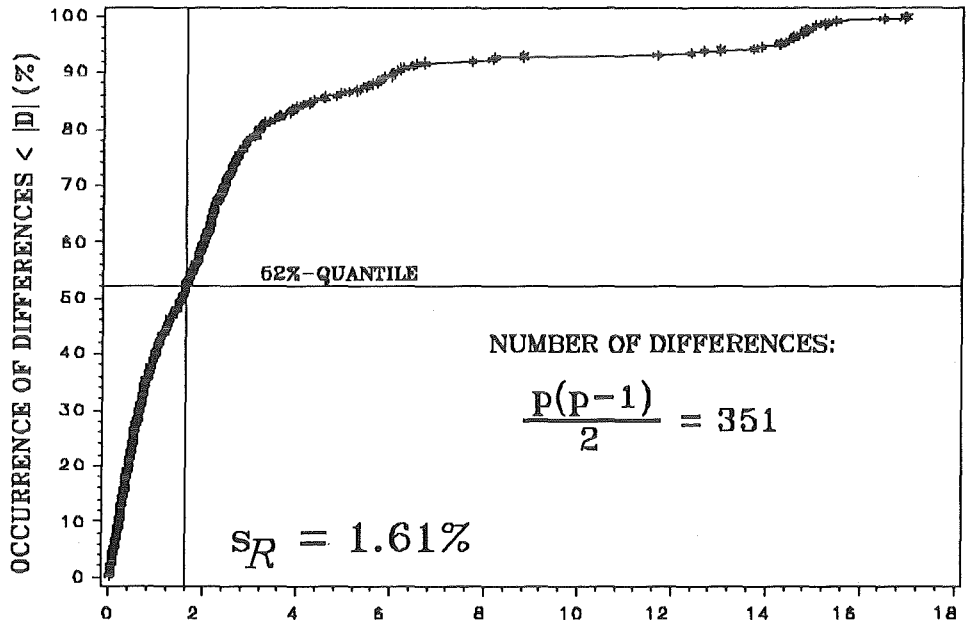
VALUES NOT DISPLAYED IN THE GRAPH: LAB 26: +5.86%; ±1.15%
LAB 27: +14.65%; ±0.06%

INDEX NUMBERS OF LABORATORIES EXCLUDED ACCORDING TO
THE BARTSCH CRITERION (LAB MEAN): 26;27
THE DIXON CRITERION, $\alpha \leq 1\%$ (REPEATABILITY): NONE
ESTIMATED INTERLABORATORY SPREAD s_R
BEFORE / AFTER EXCLUSION: 3.18% / 1.26%
ESTIMATED WITHIN-LAB. COMPONENT s_w
BEFORE / AFTER EXCLUSION: 0.86% / 0.79%

ASSAY: Pu-242 ABUNDANCE (about 0.6%) / Continued

SECTION B: DoD EVALUATION

DoD DISPLAY / INTERLABORATORY SPREAD



DoD DISPLAY / WITHIN-LAB. COMPONENT