

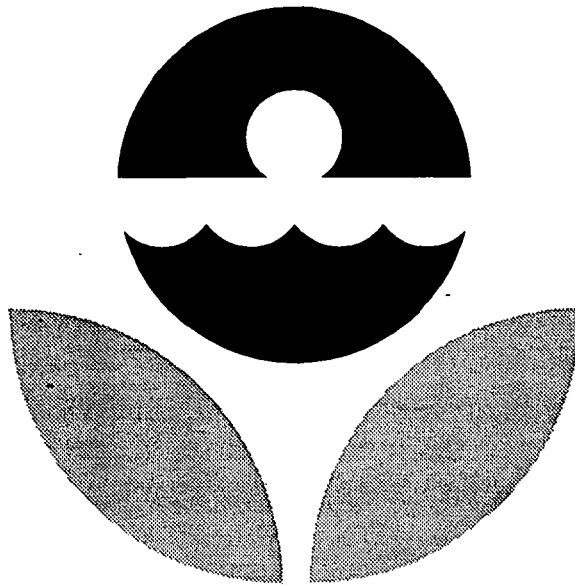


Radium in Water Intercomparison Study

A Statistical Evaluation of the March 5, 1993 Data



Radium in Water
Intercomparison Study
March 5, 1993



Environmental Protection Agency
Environmental Monitoring Systems Laboratory
Las Vegas, Nevada



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
ENVIRONMENTAL MONITORING SYSTEMS LABORATORY-LAS VEGAS
P.O. BOX 93478
LAS VEGAS, NEVADA 89193-3478
(702/798-2100)

Dear Participant,

Enclosed are the results of the Nuclear Radiation Assessment Division (EMSL-LV) Intercomparison Study for *Radium in Water*; **March 5, 1993**.

The known value for each analysis was determined by gravimetric methods, checked by chemical analyses performed by EMSL-LV's Radiochemistry Laboratory, and compared to the participating laboratories' grand average.

The expected precision, determined by the known value, was taken from "Table 3. Laboratory Precision: One Standard Deviation Values and Control Limits for Various Analyses", which is based on data accumulated over the years by the Intercomparison Program, and can be found in the Environmental Radioactivity Laboratory Intercomparison Studies Program and Radioactive Standards Distribution Program information brochure.

Please take a few minutes to review this report and the analytical data your laboratory submitted to us. If there are any apparent discrepancies, please notify us immediately.

We encourage you to make use of the computer-automated data-entry system that has been in place for some time now. As the number of participants increases, and it becomes unrealistic for us to receive results by mail or FAX, the computer system will be our only avenue for accepting data.

If you have any questions or comments, please send a message via the data-entry system or contact Frank Novielli at 702/798-2159 or Patricia Honsa at 702/798-2141.

Sincerely,

A handwritten signature in cursive script that reads "Frank Novielli".

Frank Novielli
Senior Chemist
Radioanalysis Branch

Enclosure

NOTICE

This material has been funded wholly by the U.S. Environmental Protection Agency. It has been subject to the Agency's review, and has been approved for publication as an EPA document.

The following pages consist of separate sections for each of the nuclides in this study with four parts per section. After the first, each part is separated from the next by a new page or a thick horizontal bar. The first page of each section is a statistical summary for the nuclide and starts with a statement of the known value, the control limits, and the warning limits.

The warning limits are placed at two normalized standard deviations above and below the known value and the control limits are three normalized standard deviations above and below the known value. If you keep control charts, these values will be useful for anticipating problems with the accuracy of your analytical methods.

The coin shaped pie chart at the top of the summary page shows the fate of all the samples sent out in number and percentage terms. The pie chart starts at the top and rotates clockwise. The first sector represents those participants who submitted analytical results within both the warning and control limits. The next sector represents those who are in the warning region but not out of control. The third sector represents those who are out of control, but have passed the outlier test. The fourth sector represents those who have failed the outlier test. The last sector represents those participants who have failed to respond properly. This is the case if no analytical results were returned, or less than three determinations were reported, or if the results were received too late. The reeding on the edge of the coin is spaced at one percent intervals, and the sector shading becomes darker as the data reliability decreases. Sectors with zero width are not shown.

The table in the center shows a number of statistical quantities calculated from the submitted data based on the mean and median values in relation to the known value, both before and after outlier removal. The lower pie chart uses the same construction as the upper chart and shows the distribution of properly submitted data in terms of deviation from the known value divided into sectors representing one, two, three, and greater than three normalized standard deviations.

The second part is an alphabetical listing, in lab-code order, of submitted data and several calculated quantities. An entry that is shaded has been rejected because of one of the reasons listed above or failure of the outlier test. The fifth and sixth columns are a measure of laboratory precision. The Range analysis is a normalized value that you may use to keep precision control charts. If this value is between 2.0 and 3.0, your analytical process precision is in the warning zone; if it exceeds 3.0 it is out of control. The eighth and ninth columns are the differences from the mean of all non-outliers and from the known value, respectively. A tag symbol may appear in the last column. Each page with tags has a symbol definition summary at the bottom. If there is no tag symbol, the data is within the control limits, but it may be in the warning zone.

The third part is a three-column listing of result average, tag symbol, and lab-code in average order excluding those labs not responding properly. In this order, all outliers and out-of-control results appear at the top or bottom of the list.

The last part is two bar chart displays showing frequency distributions of responding participants. The first chart places the known value at the center and a bar at each 0.2 unit of expected precision. The second chart places the mean of the reported measurements at the center and a bar at each 0.2 unit of standard deviation. In both cases, a bar includes those results within 0.1 unit up to the maximum of six. Any results more than six units from the center value are shown cumulatively by a shaded bar one past the sixth unit. If the central tendency of the known value distribution falls away from the center, an error in accuracy is indicated. If the distribution is broad, poor precision is indicated. The mean value distribution is similar but uses the average and standard deviation of reported results as its basis.

The Range Analysis($R + SR$) is calculated from the range, mean range and standard error of the range values. The range is the difference between the maximum and minimum results for the laboratory. The mean range is calculated by multiplying the expected precision by 1.693(for three results). The standard error of the range is calculated by multiplying the mean range by 2.575(for three results), subtracting the mean range from this product, and dividing the result by 3. If the range is greater than the mean range, then the range analysis is calculated by subtracting the mean range from the range, dividing the result by the standard error of the range and adding 1. If the mean range is greater than or equal to the range, then the range analysis is calculated by dividing the range by the mean range.

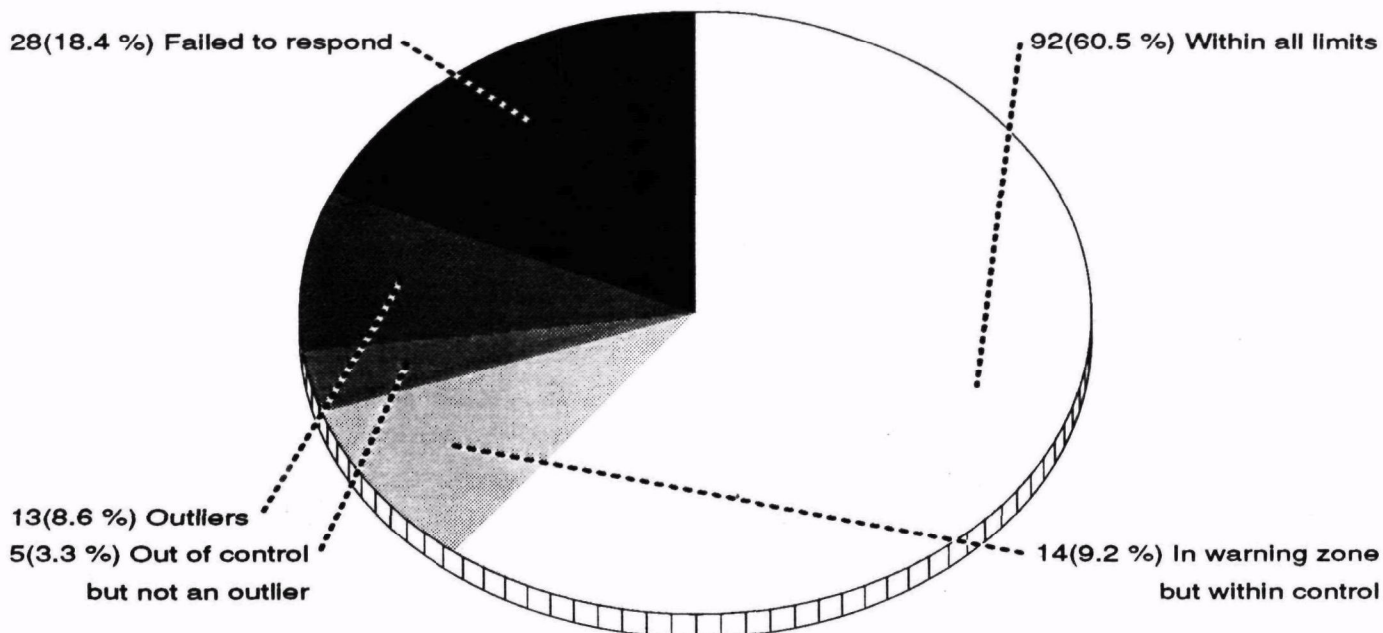
The normalized deviation of the mean from the grand average is calculated from the deviation of the mean from the grand average and the standard error of the mean values. The deviation of the mean from the grand average is calculated by subtracting the grand average from the average of the laboratory's three results. The standard error of the mean is calculated by dividing the expected precision by the square root of 3(the number of results). The normalized deviation of the mean from the grand average is calculated by dividing the deviation of the mean from the grand average by the standard error of the mean.

The normalized deviation of the mean from the known value is calculated from the deviation of the mean from the known value and the standard error of the mean values. The deviation of the mean from the known value is calculated by subtracting the known value from the average of the laboratory's three results. The standard error of the mean is calculated by dividing the expected precision by the square root of 3(the number of results). The normalized deviation of the mean from the known value is calculated by dividing the deviation of the mean from the known value by the standard error of the mean.

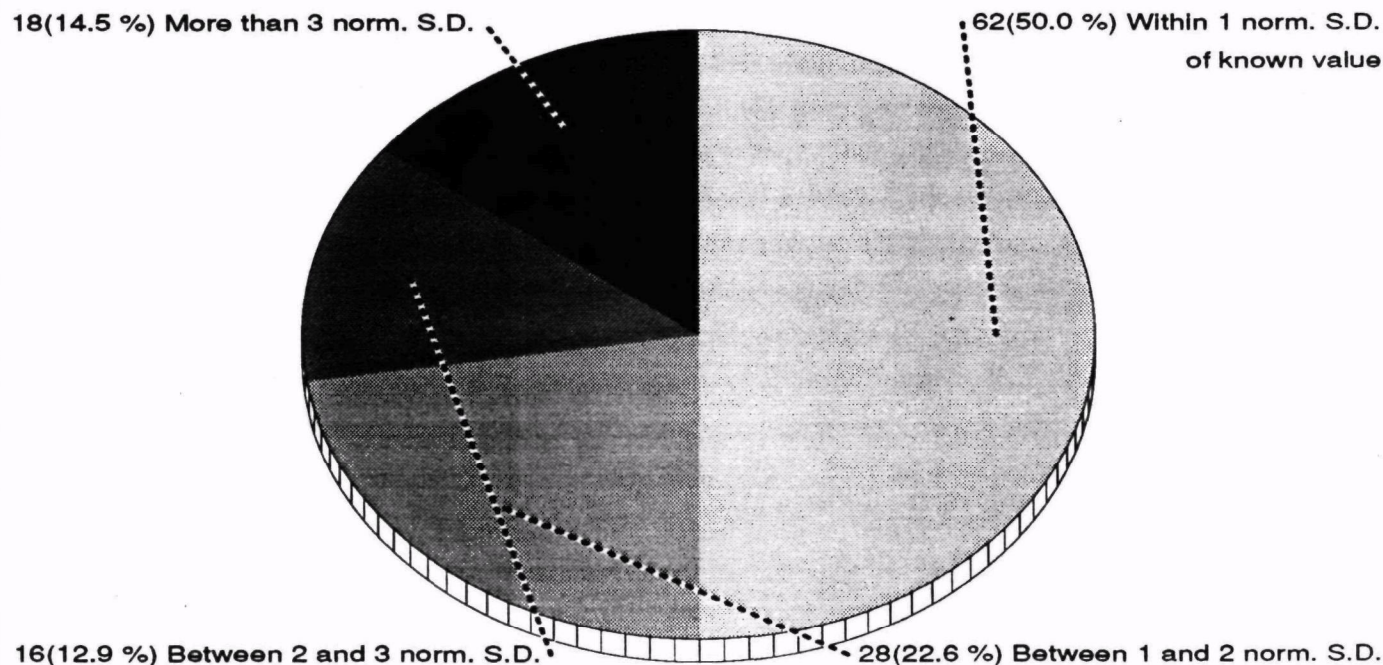
A complete explanation of the statistical calculations involved in the report may be found in the Environmental Radioactivity Laboratory Intercomparison Studies Program information brochure [Draft Revision of EPA-600/4-81-004], available from Frank Novielli, EMSL-LV, 702/798-2159.

Radium-226
Statistical Summary
152 Participants

The known value of this nuclide is **9.8 pCi/l** with an expected precision of **1.5**; the control limits are **7.2 to 12.4**; the warning regions are **7.2 to 8.1** and **11.5 to 12.4**



Statistic	Respondents	Non-outliers
Mean	11.27	Grand Avg 9.81
Std. Dev.	8.66	1.26
Variance	74.97	1.58
% Coef. of Var.	76.83	12.81
% deviation of mean from known value	15.00	0.10
Norm. dev. of mean from known value	0.17	0.01
Median	9.80	9.73
% deviation of median from known value	0.00	-0.68
Norm. dev. of median from known value	0.00	-0.05



Radium-226

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known) Tag	
A	9.4	9.5	9.6	0.10	0.079	9.50	-0.36	-0.35
AE	10.5	10.7	10.9	0.20	0.158	10.70	1.03	1.04
AF	8.7	8.6	8.9	0.15	0.118	8.73	-1.24	-1.23
AI	10.0	9.4	9.9	0.32	0.236	9.77	-0.05	-0.04
AJ	11.3	11.0	11.4	0.21	0.158	11.23	1.64	1.66
AK	9.8	9.0	10.4	0.70	0.551	9.73	-0.09	-0.08
AL	9.1	8.8	9.4	0.30	0.236	9.10	-0.82	-0.81
AP	11.6	10.8	11.2	0.40	0.315	11.20	1.60	1.62
AW	7.9	7.6	8.3	0.35	0.276	7.93	-2.17	-2.16
AZ	10.6	8.7	9.5	0.95	0.748	9.60	-0.24	-0.23
BA	9.7	10.4	9.7	0.40	0.276	9.93	0.14	0.15
BC	11.0	11.0	11.8	0.46	0.315	11.27	1.68	1.69
BG	11.1	10.7	10.9	0.20	0.158	10.90	1.26	1.27
BH	8.2	8.4	9.0	0.42	0.315	8.53	-1.47	-1.46
BK	9.7	9.6	9.7	0.06	0.039	9.67	-0.17	-0.15
BL	9.2	9.4	9.8	0.31	0.236	9.47	-0.40	-0.38
BM	10.1	10.4	10.3	0.15	0.118	10.27	0.53	0.54
BN	9.6	9.7	9.5	0.10	0.079	9.60	-0.24	-0.23
BO	9.0	9.1	8.8	0.15	0.118	8.97	-0.97	-0.96
C	12.3	11.3	12.1	0.53	0.394	11.90	2.41	2.42
CA	9.2	8.7	10.0	0.66	0.512	9.30	-0.59	-0.58
CE	7.3	8.8	8.6	0.81	0.591	8.23	-1.82	-1.81
CG	9.0	10.7	10.3	0.89	0.669	10.00	0.22	0.23
CJ	7.8	7.6	7.6	0.12	0.079	7.67	-2.48	-2.46
CK	9.4	10.0	10.0	0.35	0.236	9.80	-0.01	0.00
CS	10.2	11.2	9.7	0.76	0.591	10.37	0.64	0.65
DB	8.3	8.6	9.3	0.51	0.394	8.73	-1.24	-1.23
DE	8.0	8.0	8.0	0.00	0.000	8.00	-2.09	-2.08
DT	10.7	10.9	10.5	0.20	0.158	10.70	1.03	1.04
DZ	9.2	9.6	9.4	0.20	0.158	9.40	-0.47	-0.46
E	11.1	10.9	11.1	0.12	0.079	11.03	1.41	1.42
EB	10.5	10.5	10.0	0.29	0.197	10.33	0.60	0.62
EH								
EO	9.0	9.7	9.3	0.35	0.276	9.33	-0.55	-0.54
ER	10.3	9.7	10.2	0.32	0.236	10.07	0.30	0.31
FE	9.0	9.7	8.9	0.44	0.315	9.20	-0.70	-0.69
FN	9.1	8.5	8.9	0.31	0.236	8.83	-1.13	-1.12
FP	25.0	18.4	20.5	3.37	4.046	21.30	13.27	13.28
FZ	20.0	17.0	18.0	1.53	1.345	18.33	9.84	9.85
GG								
GN	15.8	13.2	16.2	1.63	1.345	15.07	6.07	6.08
GO	10.6	10.2	11.0	0.40	0.315	10.60	0.91	0.92
GQ	27.8	28.3	28.3	0.29	0.197	28.13	21.16	21.17
HE	9.3	10.3	10.2	0.55	0.394	9.93	0.14	0.15
HK	9.4	9.2	9.5	0.15	0.118	9.37	-0.51	-0.50

• = No data submitted

TAG SYMBOLS

↑ = Above control limit

∅ = Insufficient data

× = Determined to be an outlier

↓ = Below control limit

Radium-226

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known)		Tag
HL	8.7	8.9	7.8	0.59	0.433	8.47	-1.55	-1.54	
HP	11.6	12.7	13.4	0.91	0.709	12.57	3.18	3.19	↑
HU									•
HY	9.4	8.3	9.4	0.64	0.433	9.03	-0.90	-0.89	
I	13.6	11.5	9.5	2.05	2.170	11.53	1.99	2.00	
LA									•
ID	6.0	7.2	6.9	0.62	0.473	6.70	-3.59	-3.58	↓
J	9.1	9.1	9.6	0.29	0.197	9.27	-0.63	-0.62	
JE	12.6	12.4	12.9	0.25	0.197	12.63	3.26	3.27	↑
JG	9.4	8.9	11.1	1.15	0.866	9.80	-0.01	0.00	
JN	21.4	21.3	22.6	0.72	0.512	21.77	13.81	13.82	×
JS	12.0	11.0	11.0	0.58	0.394	11.33	1.76	1.77	
JX	9.6	9.8	9.9	0.15	0.118	9.77	-0.05	-0.04	
JY	2.3	2.5	2.5	0.12	0.079	2.43	-8.52	-8.51	×
K	8.8	7.5	7.8	0.68	0.512	8.03	-2.05	-2.04	
KF									•
KH	9.5	9.2	9.4	0.15	0.118	9.37	-0.51	-0.50	
KL	11.1	8.0	9.9	1.56	1.420	9.67	-0.17	-0.15	
KZ	8.1	8.2	8.3	0.10	0.079	8.20	-1.86	-1.85	
L	12.1	12.1	12.7	0.35	0.236	12.30	2.87	2.89	
LA									•
LB	10.0	12.3	13.0	1.57	1.345	11.77	2.26	2.27	
LM									•
LS	4.9	7.3	6.0	1.20	0.945	6.07	-4.32	-4.31	↓
LT	9.6	9.8	9.4	0.20	0.158	9.60	-0.24	-0.23	
LZ	10.4	10.6	10.5	0.10	0.079	10.50	0.80	0.81	
M	9.5	10.0	12.5	1.61	1.345	10.67	0.99	1.00	
ME	9.9	10.2	10.5	0.30	0.236	10.20	0.45	0.46	
MN									•
MO									•
MS	11.0	10.3	11.0	0.40	0.276	10.77	1.10	1.12	
MY	14.0	3.1	12.1	5.82	7.271	9.73	-0.09	-0.08	
N	9.9	10.5	9.7	0.42	0.315	10.03	0.26	0.27	
NG	10.2	9.8	10.6	0.40	0.315	10.20	0.45	0.46	
NH	9.6	9.3	9.9	0.30	0.236	9.60	-0.24	-0.23	
NO	10.3	10.0	9.9	0.21	0.158	10.07	0.30	0.31	
NT	9.9	9.7	9.5	0.20	0.158	9.70	-0.13	-0.12	
OB	8.8	8.8	8.8	0.00	0.000	8.80	-1.17	-1.15	
OF	8.2	10.4	12.4	2.10	2.245	10.33	0.60	0.62	
OK									•
OS	102.8	103.2	90.8	7.05	8.396	98.93	102.91	102.92	×
OX	10.2	10.6	10.1	0.26	0.197	10.30	0.57	0.58	
OY	7.9	8.2	8.6	0.35	0.276	8.23	-1.82	-1.81	
P	10.7	7.2	9.2	1.76	1.720	9.03	-0.90	-0.89	
PB	11.0	10.9	11.4	0.26	0.197	11.10	1.49	1.50	

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Radium-226

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known)		Tag
PC									•
PG	10.7	10.0	11.5	0.75	0.591	10.73	1.07	1.08	
PP	10.5	10.7	10.7	0.12	0.079	10.63	0.95	0.96	
PT									•
PV	9.2	10.3	8.6	0.86	0.669	9.37	-0.51	-0.50	
PW									•
PX	9.8	10.2	10.4	0.31	0.236	10.13	0.37	0.38	
PY									•
Q	11.1	12.1	12.9	0.90	0.709	12.03	2.57	2.58	
QB	10.1	10.2	10.9	0.44	0.315	10.40	0.68	0.69	
QJ									•
QQ									•
QU									•
QX	25.6	28.9	29.5	2.10	2.020	28.00	21.00	21.02	×
QZ	9.3	9.2	8.6	0.38	0.276	9.03	-0.90	-0.89	
R	9.4	9.2	9.3	0.10	0.079	9.30	-0.59	-0.58	
RC									•
RD	18.6	18.9	18.6	0.17	0.118	18.70	10.27	10.28	×
RF	12.8	10.8	12.7	1.13	0.788	12.10	2.64	2.66	
RL	12.1	11.7	11.0	0.56	0.433	11.60	2.07	2.08	
RM	11.8	12.7	12.2	0.45	0.354	12.23	2.80	2.81	
RN	11.9	9.6	10.2	1.19	0.906	10.57	0.87	0.89	
RV	7.9	8.3	8.4	0.26	0.197	8.20	-1.86	-1.85	
RW	9.7	8.7	10.0	0.68	0.512	9.47	-0.40	-0.38	
RZ	9.3	9.0	9.1	0.15	0.118	9.13	-0.78	-0.77	
S	9.7	9.7	10.0	0.17	0.118	9.80	-0.01	0.00	
SA									•
SC	9.1	9.2	9.5	0.21	0.158	9.27	-0.63	-0.62	
SD	9.3	9.3	10.2	0.52	0.354	9.60	-0.24	-0.23	
SF	10.4	12.9	11.3	1.27	0.984	11.53	1.99	2.00	
SI	7.4	7.3	7.2	0.10	0.079	7.30	-2.90	-2.89	
SM	4.9	4.9	4.9	0.00	0.000	4.90	-5.67	-5.66	×
SS	8.7	8.5	8.3	0.20	0.158	8.50	-1.51	-1.50	
ST	9.8	9.8	9.6	0.12	0.079	9.73	-0.09	-0.08	
SW	22.9	15.5	8.8	7.05	9.671	15.73	6.84	6.85	×
SX									•
SZ	10.2	9.7	8.7	0.76	0.591	9.53	-0.32	-0.31	
T	9.7	9.6	9.8	0.10	0.079	9.70	-0.13	-0.12	
TA	10.5	10.8	10.5	0.17	0.118	10.60	0.91	0.92	
TD									•
TG	15.8	16.0	13.5	1.39	0.984	15.10	6.11	6.12	×
TH									•
TI	12.1	11.2	13.0	0.90	0.709	12.10	2.64	2.66	
TK									•
TL	8.1	7.3	5.9	1.11	0.866	7.10	-3.13	-3.12	↓

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Radium-226

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known)		Tag
TN	15.9	20.7	23.7	3.93	4.946	20.10	11.88	11.89	×
TQ	7.0	8.6	8.0	0.81	0.630	7.87	-2.24	-2.23	
TS									•
TU	10.9	10.9	10.1	0.46	0.315	10.63	0.95	0.96	
TV									•
TW									•
U	9.4	8.9	9.6	0.36	0.276	9.30	-0.59	-0.58	
UB									•
UC									•
UE	8.6	9.5	6.8	1.37	1.120	8.30	-1.74	-1.73	
UI	10.0	9.4	9.2	0.42	0.315	9.53	-0.32	-0.31	
UL	8.1	8.9	8.5	0.40	0.315	8.50	-1.51	-1.50	
UN	11.4	10.4	10.9	0.50	0.394	10.90	1.26	1.27	
W	7.7	9.7	8.9	1.01	0.788	8.77	-1.20	-1.19	
X	11.6	11.2	10.8	0.40	0.315	11.20	1.60	1.62	
Y	9.7	10.1	9.9	0.20	0.158	9.90	0.10	0.12	
Z	10.1	10.1	10.0	0.06	0.039	10.07	0.30	0.31	

Data sorted by Laboratory Average

Average	Tag	Lab	Average	Tag	Lab	Average	Tag	Lab
2.43	×	JY	8.97		BO	9.60		BN
4.90	×	SM	9.03		QZ	9.60		AZ
6.07	↓	LS	9.03		P	9.67		KL
6.70	↓	ID	9.03		HY	9.67		BK
7.10	↓	TL	9.10		AL	9.70		T
7.30		SI	9.13		RZ	9.70		NT
7.67		CJ	9.20		FE	9.73		ST
7.87		TQ	9.27		SC	9.73		MY
7.93		AW	9.27		J	9.73		AK
8.00		DE	9.30		U	9.77		AI
8.03		K	9.30		R	9.77		JX
8.20		RV	9.30		CA	9.80		S
8.20		KZ	9.33		EO	9.80		JG
8.23		OY	9.37		PV	9.80		CK
8.23		CE	9.37		KH	9.90		Y
8.30		UE	9.37		HK	9.93		HE
8.47		HL	9.40		DZ	9.93		BA
8.50		UL	9.47		RW	10.00		CG
8.50		SS	9.47		BL	10.03		N
8.53		BH	9.50		A	10.07		Z
8.73		DB	9.53		UI	10.07		NO
8.73		AF	9.53		SZ	10.07		ER
8.77		W	9.60		SD	10.13		PX
8.80		OB	9.60		NH	10.20		NG
8.83		FN	9.60		LT	10.20		ME

• ≡ No data submitted

TAG SYMBOLS

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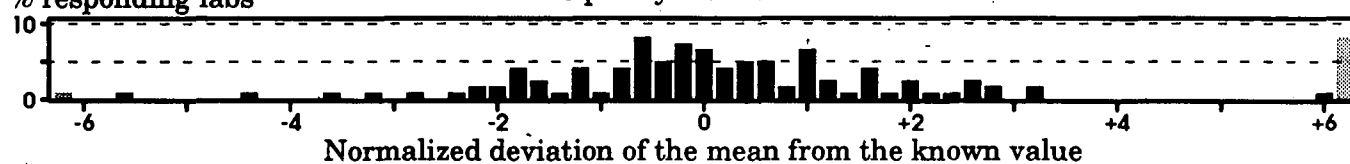
↓ ≡ Below control limit

Radium-226**Data sorted by Laboratory Average**

Average	Tag	Lab	Average	Tag	Lab	Average	Tag	Lab
10.27		BM	10.77		MS	12.10		TI
10.30		OX	10.90		UN	12.10		RF
10.33		OF	10.90		BG	12.23		RM
10.33		EB	11.03		E	12.30		L
10.37		CS	11.10		PB	12.57	↑	HP
10.40		QB	11.20		X	12.63	↑	JE
10.50		LZ	11.20		AP	15.07	×	GN
10.57		RN	11.23		AJ	15.10	×	TG
10.60		TA	11.27		BC	15.73	×	SW
10.60		GO	11.33		JS	18.33	×	FZ
10.63		TU	11.53		SF	18.70	×	RD
10.63		PP	11.53		I	20.10	×	TN
10.67		M	11.60		RL	21.30	×	FP
10.70		DT	11.77		LB	21.77	×	JN
10.70		AE	11.90		C	28.00	×	QX
10.73		PG	12.03		Q	28.13	×	GQ
						98.93	×	OS

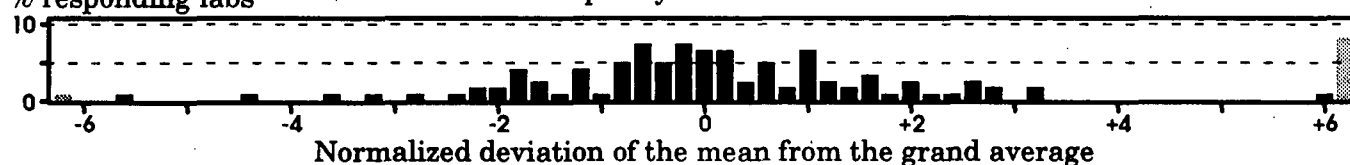
% responding labs

Frequency distribution



% responding labs

Frequency distribution



• = No data submitted

TAG SYMBOLS

↑ = Above control limit

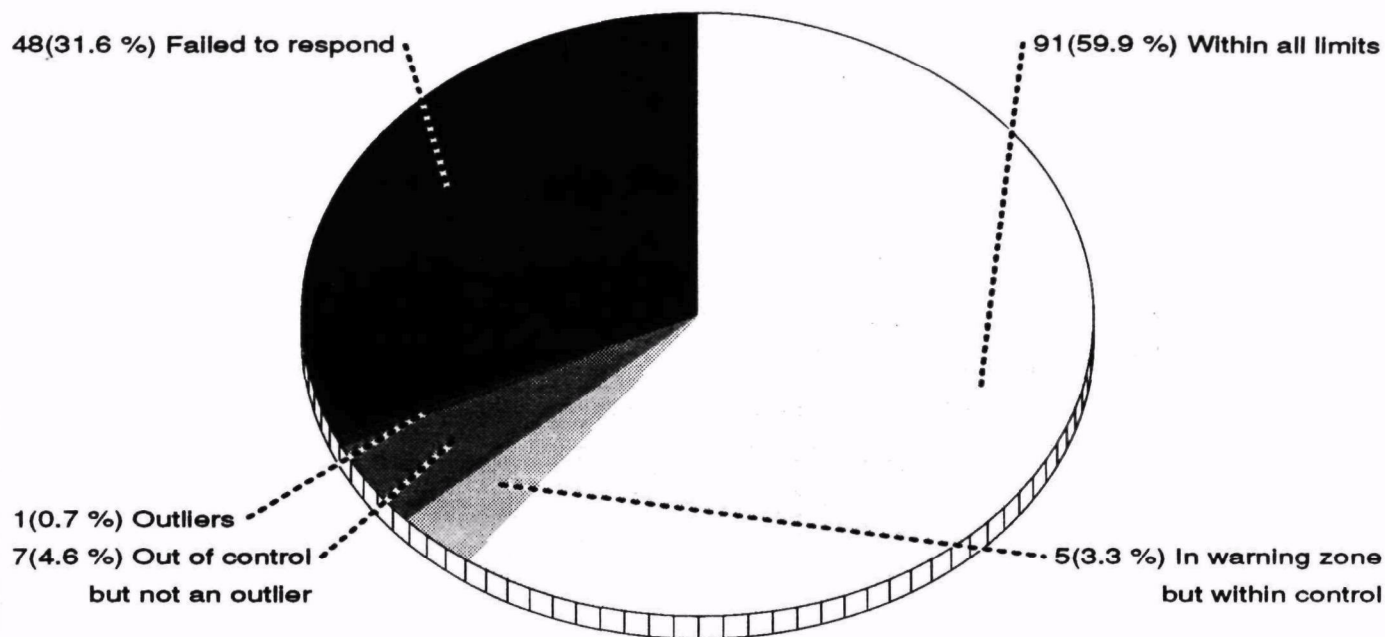
∅ = Insufficient data

× = Determined to be an outlier

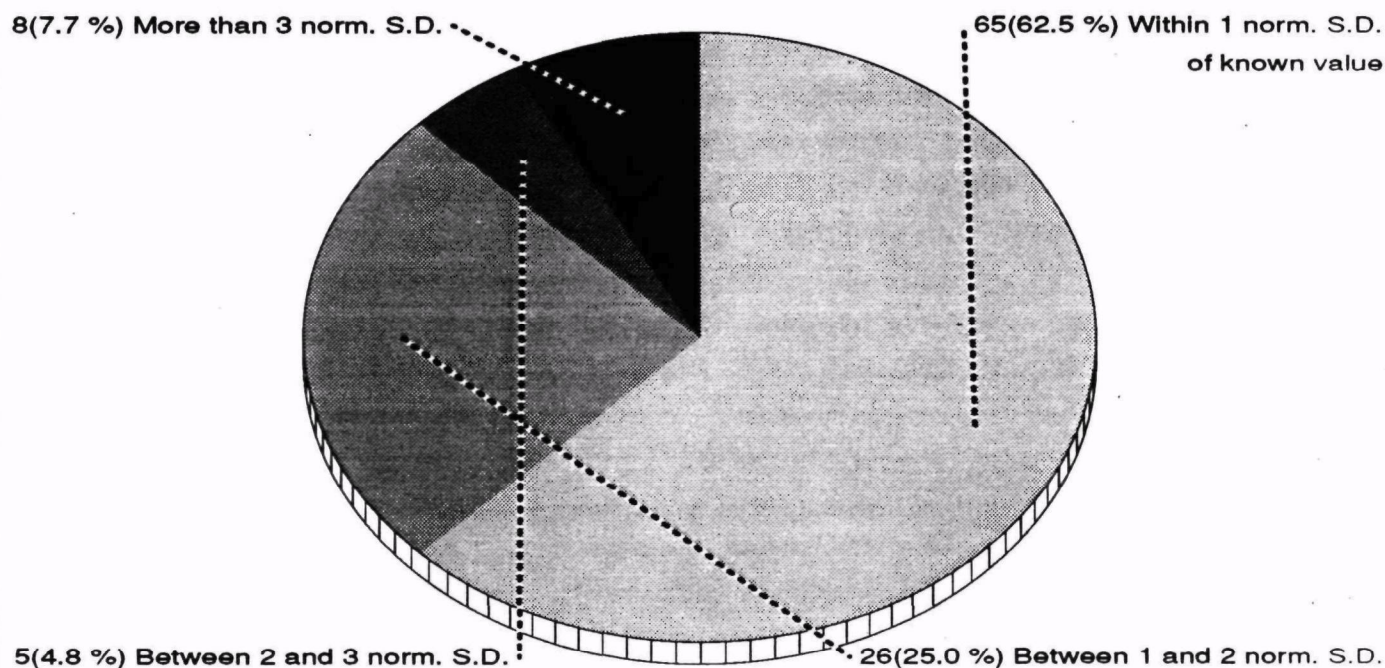
↓ = Below control limit

Radium-228**Statistical Summary****152 Participants**

The known value of this nuclide is **18.5 pCi/l** with an expected precision of **4.6**; the control limits are 10.5 to 26.5; the warning regions are 10.5 to 13.2 and 23.8 to 26.5



Statistic	Respondents	Non-outliers
Mean	17.69	Grand Avg 17.81
Std. Dev.	3.74	3.54
Variance	13.98	12.50
% Coef. of Var.	21.13	19.85
% deviation of mean from known value	-4.38	-3.72
Norm. dev. of mean from known value	-0.22	-0.19
Median	18.13	18.43
% deviation of median from known value	-1.98	-0.36
Norm. dev. of median from known value	-0.10	-0.02



Radium-228

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known) Tag	
A	18.9	18.9	19.0	0.06	0.013	18.93	0.42	0.16
AE	17.9	16.6	17.3	0.65	0.167	17.27	-0.21	-0.46
AF	19.7	19.9	21.8	1.16	0.270	20.47	1.00	0.74
AI	18.9	18.5	19.9	0.72	0.180	19.10	0.48	0.23
AJ	21.0	20.9	20.8	0.10	0.026	20.90	1.16	0.90
AK	19.6	19.5	20.6	0.61	0.141	19.90	0.79	0.53
AL	16.0	19.8	16.4	2.09	0.488	17.40	-0.16	-0.41
AP	11.7	9.2	10.5	1.25	0.321	10.47	-2.77	-3.02
AW	13.6	14.3	14.5	0.47	0.116	14.13	-1.39	-1.64
AZ	22.5	19.8	19.2	1.76	0.424	20.50	1.01	0.75
BA	17.1	18.3	18.1	0.64	0.154	17.83	0.01	-0.25
BC	19.1	19.9	20.3	0.61	0.154	19.77	0.74	0.48
BG								
BH	18.1	19.9	20.2	1.14	0.270	19.40	0.60	0.34
BK	19.5	18.4	18.3	0.67	0.154	18.73	0.35	0.09
BL								
BM	18.4	19.1	20.2	0.91	0.231	19.23	0.53	0.28
BN								
BO	17.3	17.4	16.8	0.32	0.077	17.17	-0.24	-0.50
C	21.5	21.8	21.3	0.25	0.064	21.53	1.40	1.14
CA	20.5	19.8	22.0	1.12	0.282	20.77	1.11	0.85
CE	20.1	19.4	19.6	0.36	0.090	19.70	0.71	0.45
CG	24.7	23.1	22.5	1.14	0.282	23.43	2.12	1.86
CJ	18.0	22.0	18.0	2.31	0.514	19.33	0.57	0.31
CK	15.6	17.5	19.2	1.80	0.462	17.43	-0.14	-0.40
CS	19.7	21.8	21.5	1.14	0.270	21.00	1.20	0.94
DB	13.1	13.7	12.5	0.60	0.154	13.10	-1.77	-2.03
DE	22.0	21.6	21.4	0.31	0.077	21.67	1.45	1.19
DT	18.3	18.9	18.3	0.35	0.077	18.50	0.26	0.00
DZ	17.3	17.1	16.9	0.20	0.051	17.10	-0.27	-0.53
E								
EB	15.4	15.4	15.5	0.06	0.013	15.43	-0.90	-1.15
EH								
EO	17.0	17.7	17.4	0.35	0.090	17.37	-0.17	-0.43
ER								
FE								
FN	13.0	13.3	12.8	0.25	0.064	13.03	-1.80	-2.06
FP	15.5	16.3	14.6	0.85	0.218	15.47	-0.88	-1.14
FZ	14.0	7.3	19.0	5.87	1.957	13.43	-1.65	-1.91
GG								
GN	7.0	7.1	7.2	0.10	0.026	7.10	-4.03	-4.29
GO								
GQ	14.7	15.0	15.1	0.21	0.051	14.93	-1.08	-1.34
HE	17.4	16.7	15.1	1.18	0.295	16.40	-0.53	-0.79
HK	18.2	18.8	18.3	0.32	0.077	18.43	0.23	-0.03

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Radium-228

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known) Tag	
HL	15.7	18.4	15.7	1.56	0.347	16.60	-0.46	-0.72
HP	17.8	19.0	20.0	1.10	0.282	18.93	0.42	0.16
HU								•
HY	16.9	15.8	17.1	0.70	0.167	16.60	-0.46	-0.72
I	16.7	17.3	14.3	1.59	0.385	16.10	-0.64	-0.90
IA								•
ID	10.5	10.5	10.0	0.29	0.064	10.33	-2.82	-3.08 ↓
J	20.3	21.1	20.8	0.40	0.103	20.73	1.10	0.84
JE	16.2	14.9	17.4	1.25	0.321	16.17	-0.62	-0.88
JG	23.1	17.8	20.0	2.66	0.681	20.30	0.94	0.68
JN								•
JS	21.0	22.0	21.0	0.58	0.128	21.33	1.33	1.07
JX	16.5	17.6	15.5	1.05	0.270	16.53	-0.48	-0.74
JY	5.0	4.7	5.1	0.21	0.051	4.93	-4.85	-5.11 ×
K	18.2	21.5	17.1	2.29	0.565	18.93	0.42	0.16
KF								•
KH	17.8	20.5	19.0	1.35	0.347	19.10	0.48	0.23
KL	21.5	21.3	19.3	1.22	0.282	20.70	1.09	0.83
KZ	17.7	17.7	17.7	0.00	0.000	17.70	-0.04	-0.30
L	20.6	20.7	20.0	0.38	0.090	20.43	0.99	0.73
LA								•
LB								•
LM								•
LS	16.0	22.0	19.0	3.00	0.770	19.00	0.45	0.19
LT	18.1	19.7	18.8	0.80	0.205	18.87	0.40	0.14
LZ								•
M	24.0	24.0	23.0	0.58	0.128	23.67	2.20	1.95
ME	13.4	14.1	15.0	0.80	0.205	14.17	-1.37	-1.63
MN								•
MO								•
MS	14.6	13.4	14.3	0.62	0.154	14.10	-1.40	-1.66
MY								•
N	20.2	20.2	18.6	0.92	0.205	19.67	0.70	0.44
NG	21.1	20.9	21.1	0.12	0.026	21.03	1.21	0.95
NH	16.0	12.3	18.4	3.07	0.783	15.57	-0.85	-1.10
NO	10.8	10.0	9.6	0.61	0.154	10.13	-2.89	-3.15 ↓
NT	20.6	21.4	21.0	0.40	0.103	21.00	1.20	0.94
OB								•
OF	16.2	17.2	14.0	1.64	0.411	15.80	-0.76	-1.02
OK								•
OS	28.2	21.6	23.8	3.36	0.847	24.53	2.53	2.27
OX	18.8	18.5	19.0	0.25	0.064	18.77	0.36	0.10
OY	9.2	10.4	10.0	0.61	0.154	9.87	-2.99	-3.25 ↓
P	13.8	10.9	16.1	2.61	0.668	13.60	-1.59	-1.85
PB	20.6	20.5	20.6	0.06	0.013	20.57	1.04	0.78

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Radium-228

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known)		Tag
PC									•
PG									•
PP	13.1	16.4	16.6	1.97	0.449	15.37	-0.92	-1.18	
PT									•
PV	13.7	12.5	17.5	2.61	0.642	14.57	-1.22	-1.48	
PW									•
PX									•
PY									•
Q	15.4	13.0	12.7	1.48	0.347	13.70	-1.55	-1.81	
QB									•
QJ									•
QQ									•
QU									•
QX	27.9	27.3	26.7	0.60	0.154	27.30	3.57	3.31	↑
QZ	15.6	15.3	15.8	0.25	0.064	15.57	-0.85	-1.10	
R									•
RC									•
RD	22.8	20.4	19.3	1.79	0.449	20.83	1.14	0.88	
RF	21.5	18.7	19.5	1.44	0.360	19.90	0.79	0.53	
RL	15.3	15.3	14.9	0.23	0.051	15.17	-1.00	-1.26	
RM	17.2	18.8	15.0	1.91	0.488	17.00	-0.31	-0.56	
RN	14.3	15.1	15.4	0.57	0.141	14.93	-1.08	-1.34	
RV	14.2	14.5	14.4	0.15	0.039	14.37	-1.30	-1.56	
RW	11.8	12.2	11.6	0.31	0.077	11.87	-2.24	-2.50	
RZ	16.4	17.5	21.7	2.80	0.681	18.53	0.27	0.01	
S	18.7	14.1	12.6	3.18	0.783	15.13	-1.01	-1.27	
SA									•
SC	18.3	20.0	19.1	0.85	0.218	19.13	0.50	0.24	
SD	19.2	19.4	20.6	0.76	0.180	19.73	0.72	0.46	
SF	25.1	25.9	31.8	3.66	0.860	27.60	3.69	3.43	↑
SI	20.2	20.6	23.0	1.51	0.360	21.27	1.30	1.04	
SM	16.5	15.1	14.3	1.11	0.282	15.30	-0.95	-1.20	
SS	18.9	21.0	22.0	1.58	0.398	20.63	1.06	0.80	
ST	10.2	11.4	10.1	0.72	0.167	10.57	-2.73	-2.99	
SW	23.2	20.0	19.4	2.04	0.488	20.87	1.15	0.89	
SX	15.0	16.0	17.0	1.00	0.257	16.00	-0.68	-0.94	
SZ	21.7	20.4	21.2	0.66	0.167	21.10	1.24	0.98	
T	18.5	16.2	18.8	1.42	0.334	17.83	0.01	-0.25	
TA	19.7	21.7	19.2	1.32	0.321	20.20	0.90	0.64	
TD									•
TG									•
TH									•
TI	24.1	22.3	24.8	1.29	0.321	23.73	2.23	1.97	
TK									•
TL	16.0	19.0	16.4	1.63	0.385	17.13	-0.26	-0.51	

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Radium-228

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known) Tag	
TN	14.7	16.8	19.8	2.56	0.655	17.10	-0.27	-0.53
TQ	17.7	21.5	17.6	2.22	0.501	18.93	0.42	0.16
TS								•
TU								•
TV								•
TW								•
U	16.3	17.4	16.9	0.55	0.141	16.87	-0.36	-0.62
UB								•
UC								•
UE	22.5	19.0	21.1	1.76	0.449	20.87	1.15	0.89
UI								•
UL								•
UN	14.2	17.5	16.7	1.72	0.424	16.13	-0.63	-0.89
W	15.8	16.7	15.4	0.67	0.167	15.97	-0.70	-0.95
X	16.6	18.2	18.2	0.92	0.205	17.67	-0.05	-0.31
Y								•
Z	18.7	18.5	18.7	0.12	0.026	18.63	0.31	0.05

Data sorted by Laboratory Average

Average	Tag	Lab	Average	Tag	Lab	Average	Tag	Lab
4.93	×	JY	15.47		FP	17.83		T
7.10	↓	GN	15.57		QZ	17.83		BA
9.87	↓	OY	15.57		NH	18.43		HK
10.13	↓	NO	15.80		OF	18.50		DT
10.33	↓	ID	15.97		W	18.53		RZ
10.47	↓	AP	16.00		SX	18.63		Z
10.57		ST	16.10		I	18.73		BK
11.87		RW	16.13		UN	18.77		OX
13.03		FN	16.17		JE	18.87		LT
13.10		DB	16.40		HE	18.93		HP
13.43		FZ	16.53		JX	18.93		A
13.60		P	16.60		HY	18.93		TQ
13.70		Q	16.60		HL	18.93		K
14.10		MS	16.87		U	19.00		LS
14.13		AW	17.00		RM	19.10		KH
14.17		ME	17.10		TN	19.10		AI
14.37		RV	17.10		DZ	19.13		SC
14.57		PV	17.13		TL	19.23		BM
14.93		RN	17.17		BO	19.33		CJ
14.93		GQ	17.27		AE	19.40		BH
15.13		S	17.37		EO	19.67		N
15.17		RL	17.40		AL	19.70		CE
15.30		SM	17.43		CK	19.73		SD
15.37		PP	17.67		X	19.77		BC
15.43		EB	17.70		KZ	19.90		RF

• ≡ No data submitted

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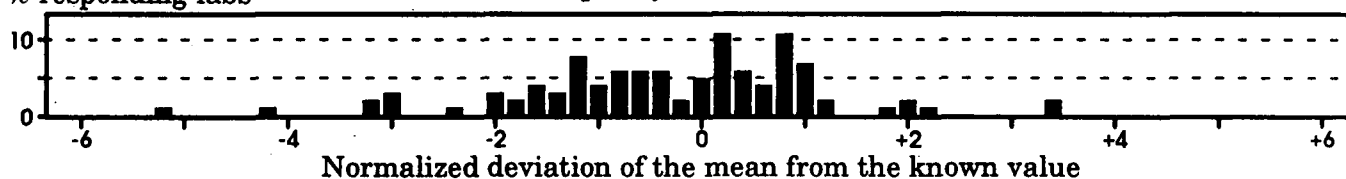
Radium-228

Data sorted by Laboratory Average

Average	Tag	Lab	Average	Tag	Lab	Average	Tag	Lab
19.90		AK	20.73		J	21.27		SI
20.20		TA	20.77		CA	21.33		JS
20.30		JG	20.83		RD	21.53		C
20.43		L	20.87		UE	21.67		DE
20.47		AF	20.87		SW	23.43		CG
20.50		AZ	20.90		AJ	23.67		M
20.57		PB	21.00		NT	23.73		TI
20.63		SS	21.00		CS	24.53		OS
20.70		KL	21.03		NG	27.30	↑	QX
			21.10		SZ	27.60	↑	SF

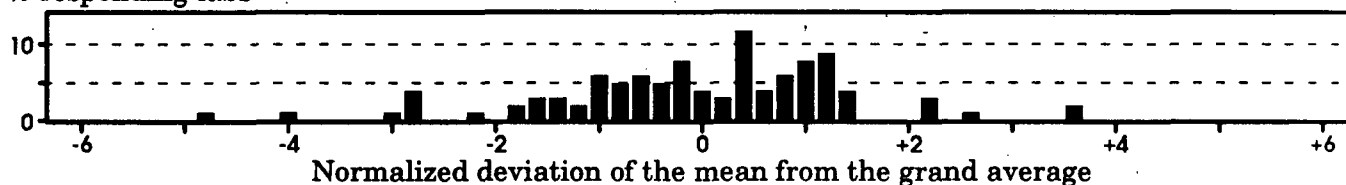
% responding labs

Frequency distribution



% responding labs

Frequency distribution



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