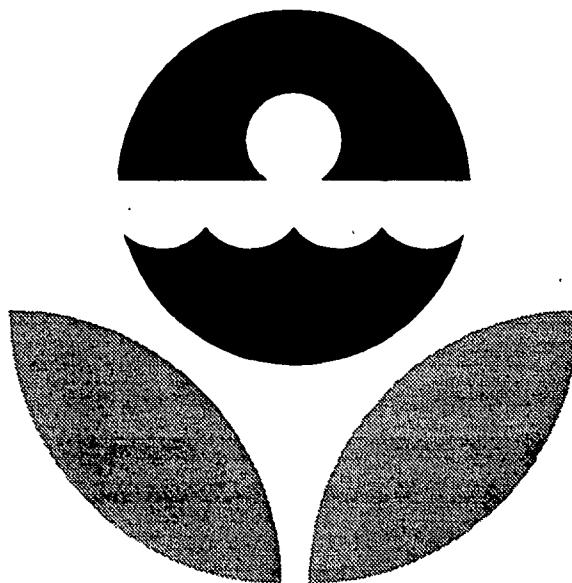




# **Radium in Water Performance Evaluation Study**

## **A Statistical Evaluation of the September 17, 1993 Data**

Radium in Water  
Performance Evaluation Study  
September 17, 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) Performance Evaluation Study for *Radium in Water*; **September 17, 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 Performance Evaluation Program, and can be found in the Environmental Radioactivity Performance Evaluation 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 George Dilbeck at 702/798-2104 or Patricia Honsa at 702/798-2141.

Sincerely,

A handwritten signature in cursive script that reads "George Dilbeck".

George Dilbeck  
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.

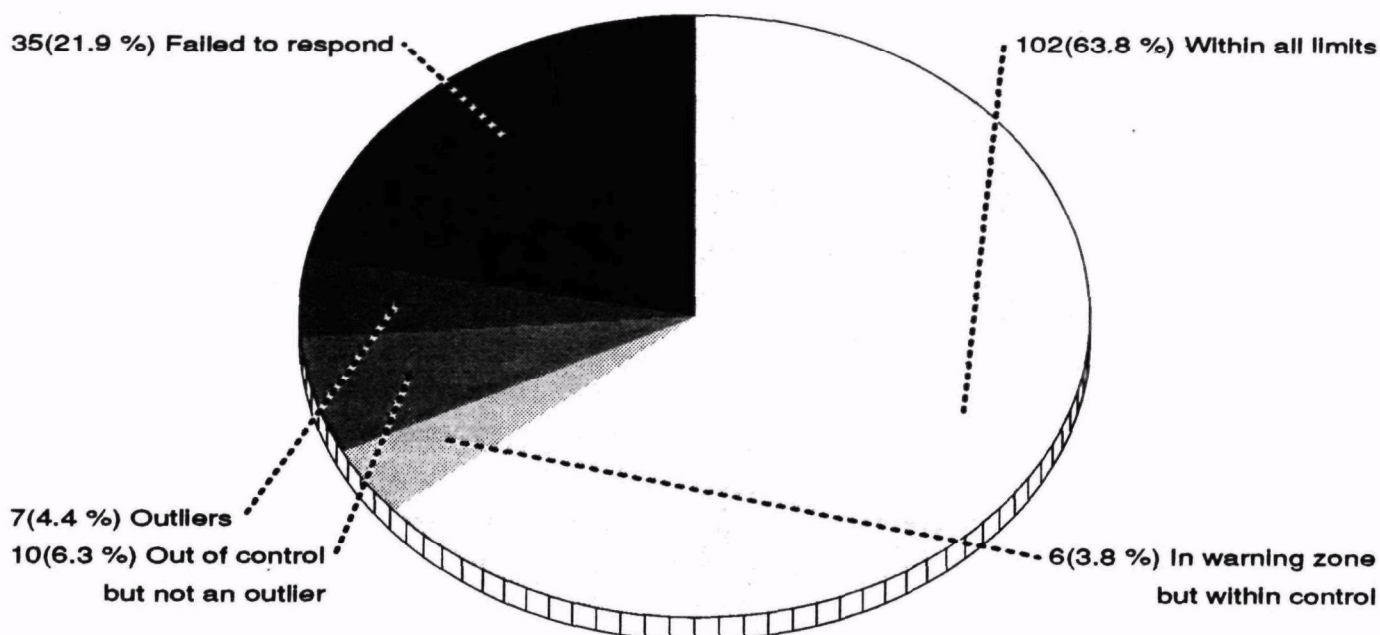
A complete explanation of the statistical calculations involved in the report may be found in the Environmental Radioactivity Performance Evaluation Studies Program information brochure [Draft Revision of EPA-600/4-81-004], available from George Dilbeck, EMSL-LV, 702/798-2104.

**Radium-226**

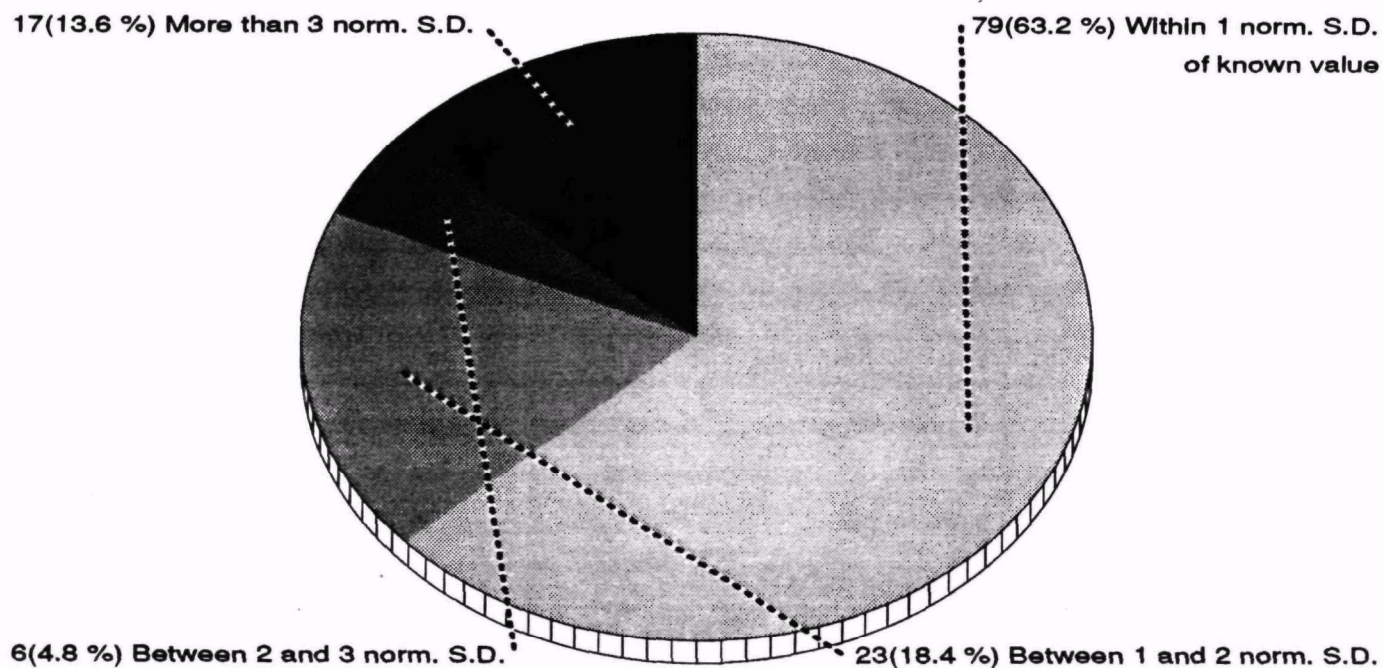
## Statistical Summary

160 Participants

The known value of this nuclide is **14.9 pCi/l** with an expected precision of **2.2**; the control limits are 11.1 to 18.7; the warning regions are 11.1 to 12.4 and 17.4 to 18.7



Statistic	Respondents	Non-outliers
Mean	15.04	<b>Grand Avg 14.73</b>
Std. Dev.	3.22	1.84
Variance	10.40	3.39
% Coef. of Var.	21.44	12.49
% deviation of mean from known value	0.96	-1.13
Norm. dev. of mean from known value	0.04	-0.09
Median	15.07	15.03
% deviation of median from known value	1.12	0.89
Norm. dev. of median from known value	0.05	0.07



**Radium-226**

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known) Tag	
A	15.7	15.4	15.6	0.15	0.081	15.57	0.66	0.52
AE	15.4	15.2	15.5	0.15	0.081	15.37	0.50	0.37
AF	15.2	15.3	15.2	0.06	0.027	15.23	0.39	0.26
AI								•
AJ	14.9	15.6	15.7	0.44	0.215	15.40	0.53	0.39
AK	13.6	13.8	14.4	0.42	0.215	13.93	-0.63	-0.76
AL	14.4	15.3	14.4	0.52	0.242	14.70	-0.03	-0.16
AP	14.8	15.1	15.5	0.35	0.188	15.13	0.32	0.18
AW	14.8	15.6	15.7	0.49	0.242	15.37	0.50	0.37
AZ	14.3	14.1	14.5	0.20	0.107	14.30	-0.34	-0.47
BA	14.8	15.7	14.7	0.55	0.268	15.07	0.26	0.13
BC	15.5	15.9	15.9	0.23	0.107	15.77	0.81	0.68
BG	15.5	16.9	16.4	0.71	0.376	16.27	1.21	1.08
BH	13.2	13.7	14.3	0.55	0.295	13.73	-0.79	-0.92
BK	13.7	14.5	14.6	0.49	0.242	14.27	-0.37	-0.50
BL								•
BM	13.3	14.9	14.3	0.81	0.430	14.17	-0.45	-0.58
BN	16.2	14.3	14.8	0.98	0.510	15.10	0.29	0.16
BO	15.4	15.4	14.9	0.29	0.134	15.23	0.39	0.26
C	15.4	14.2	12.0	1.72	0.913	13.87	-0.68	-0.81
CA	16.1	15.2	16.5	0.67	0.349	15.93	0.95	0.81
CE	14.1	13.9	14.8	0.47	0.242	14.27	-0.37	-0.50
CG	14.2	14.5	17.6	1.88	0.913	15.43	0.55	0.42
CJ	16.0	15.0	15.0	0.58	0.268	15.33	0.47	0.34
CK								•
CQ								•
CS	16.1	16.5	14.6	1.00	0.510	15.73	0.79	0.66
CX								•
DB	15.0	14.4	15.6	0.60	0.322	15.00	0.21	0.08
DE	14.1	14.2	14.2	0.06	0.027	14.17	-0.45	-0.58
DT	15.2	15.3	15.1	0.10	0.054	15.20	0.37	0.24
DZ	15.3	14.8	15.0	0.25	0.134	15.03	0.24	0.10
E	14.3	14.5	14.2	0.15	0.081	14.33	-0.31	-0.45
EB	15.0	15.2	14.7	0.25	0.134	14.97	0.18	0.05
EH								•
EO	14.8	15.5	15.3	0.36	0.188	15.20	0.37	0.24
EP	13.6	14.3	14.1	0.36	0.188	14.00	-0.58	-0.71
ER	15.6	15.8	15.6	0.12	0.054	15.67	0.74	0.60
FE	16.1	14.8	14.5	0.85	0.430	15.13	0.32	0.18
FN	15.8	15.0	15.5	0.40	0.215	15.43	0.55	0.42
FP	22.9	21.9	20.4	1.26	0.671	21.73	5.51	5.38 ×
FZ	9.7	8.9	12.0	1.61	0.832	10.20	-3.57	-3.70 ↓
GG								•
GN	2.8	3.1	2.9	0.15	0.081	2.93	-9.29	-9.42 ×
GO	14.3	14.3	15.0	0.40	0.188	14.53	-0.16	-0.29

• ≡ 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
GQ	12.9	13.2	13.4	0.25	0.134	13.17	-1.23	-1.36	
HE	16.8	16.1	16.8	0.40	0.188	16.57	1.44	1.31	
HK	14.8	14.4	15.0	0.31	0.161	14.73	0.00	-0.13	
HL	14.2	13.1	13.8	0.56	0.295	13.70	-0.81	-0.94	
HP	15.9	16.5	18.7	1.47	0.752	17.03	1.81	1.68	
HU	7.4	7.3	7.2	0.10	0.054	7.30	-5.85	-5.98	×
I	14.6	13.6	15.3	0.85	0.456	14.50	-0.18	-0.31	
LA									•
ID	19.3	19.0	19.5	0.25	0.134	19.27	3.57	3.44	↑
J	14.8	15.7	15.0	0.47	0.242	15.17	0.34	0.21	
JE	20.2	6.4	20.0	7.91	6.153	15.53	0.63	0.50	
JG	17.1	18.4	15.1	1.66	0.886	16.87	1.68	1.55	
JN	16.5	16.6	13.3	1.88	0.886	15.47	0.58	0.45	
JS	14.0	14.0	15.0	0.58	0.268	14.33	-0.31	-0.45	
JX	14.6	15.8	15.1	0.60	0.322	15.17	0.34	0.21	
JY	16.9	17.7	12.0	3.09	2.010	15.53	0.63	0.50	
K	12.5	13.8	12.5	0.75	0.349	12.93	-1.42	-1.55	
KF									•
KH	14.6	13.6	13.4	0.64	0.322	13.87	-0.68	-0.81	
KL	15.5	17.8	16.0	1.21	0.618	16.43	1.34	1.21	
KZ	13.6	13.5	13.7	0.10	0.054	13.60	-0.89	-1.02	
L	10.1	11.1	10.2	0.55	0.268	10.47	-3.36	-3.49	↓
LA									•
LB	12.2	12.3	12.4	0.10	0.054	12.30	-1.91	-2.05	
LM	12.7	12.6	12.5	0.10	0.054	12.60	-1.68	-1.81	
LS									•
LT	13.0	12.5	14.2	0.87	0.456	13.23	-1.18	-1.31	
LZ	15.2	15.2	15.0	0.12	0.054	15.13	0.32	0.18	
MN									•
MS	17.3	17.3	16.9	0.23	0.107	17.17	1.92	1.78	
MY									•
N	15.1	16.2	15.4	0.57	0.295	15.57	0.66	0.52	
NG	13.5	13.7	13.5	0.12	0.054	13.57	-0.92	-1.05	
NH	12.6	13.7	15.9	1.68	0.886	14.07	-0.52	-0.66	
NO	14.9	15.1	15.7	0.42	0.215	15.23	0.39	0.26	
NT	14.8	15.4	15.9	0.55	0.295	15.37	0.50	0.37	
OB	18.6	16.6	18.6	1.15	0.537	17.93	2.52	2.39	
OF	12.7	16.5	16.7	2.25	1.141	15.30	0.45	0.31	
OK									•
OS									•
OX	15.3	15.2	14.9	0.21	0.107	15.13	0.32	0.18	
OY	14.9	15.5	15.0	0.32	0.161	15.13	0.32	0.18	
OZ									•
P	17.2	16.6	17.3	0.38	0.188	17.03	1.81	1.68	
PB	15.8	15.8	15.7	0.06	0.027	15.77	0.81	0.68	

• = No data submitted

**TAG SYMBOLS**

↑ = Above control limit

Ø = 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
PC	9.7	10.4	11.1	0.70	0.376	10.40	-3.41	-3.54	↓
PG	16.7	17.1	16.7	0.23	0.107	16.83	1.65	1.52	
PP									•
PT	18.2	15.2	14.4	2.00	1.039	15.93	0.95	0.81	
PV	19.3	18.5	17.9	0.70	0.376	18.57	3.02	2.89	
PW	11.4	17.8	14.1	3.21	2.368	14.43	-0.24	-0.37	
PX	14.8	14.6	14.9	0.15	0.081	14.77	0.03	-0.10	
PY									•
Q	16.4	15.9	18.4	1.32	0.671	16.90	1.71	1.57	
QB	14.9	15.3	14.9	0.23	0.107	15.03	0.24	0.10	
QJ									•
QU	9.3	10.4	9.9	0.55	0.295	9.87	-3.83	-3.96	↓
QX	23.6	25.8	26.7	1.59	0.832	25.37	8.37	8.24	×
QY									•
QZ	14.3	13.3	13.8	0.50	0.268	13.80	-0.73	-0.87	
R	14.2	14.4	13.0	0.76	0.376	13.87	-0.68	-0.81	
RA	16.7	16.5	15.1	0.87	0.430	16.10	1.08	0.94	
RC	14.3	15.7	14.5	0.76	0.376	14.83	0.08	-0.05	
RD	10.0	9.4	8.8	0.60	0.322	9.40	-4.20	-4.33	↓
RF	18.6	18.3	21.1	1.54	0.752	19.33	3.62	3.49	↑
RL									•
RM	15.5	15.7	14.3	0.76	0.376	15.17	0.34	0.21	
RN	18.0	17.7	18.7	0.51	0.268	18.13	2.68	2.55	
RV	26.5	25.6	29.9	2.27	1.294	27.33	9.92	9.79	×
RW	13.0	13.9	15.3	1.16	0.618	14.07	-0.52	-0.66	
RX									•
RZ	14.2	14.5	14.7	0.25	0.134	14.47	-0.21	-0.34	
S	16.0	16.0	16.3	0.17	0.081	16.10	1.08	0.94	
SA									•
SC	14.6	15.5	16.8	1.11	0.591	15.63	0.71	0.58	
SD	14.5	13.4	14.5	0.64	0.295	14.13	-0.47	-0.60	
SF	14.8	14.0	16.0	1.01	0.537	14.93	0.16	0.03	
SI	14.3	11.3	11.8	1.61	0.805	12.47	-1.78	-1.92	
SM	13.3	12.3	13.0	0.51	0.268	12.87	-1.47	-1.60	
SS	14.3	13.9	12.6	0.89	0.456	13.60	-0.89	-1.02	
ST	15.1	15.1	15.1	0.01	0.000	15.10	0.29	0.16	
SW	13.8	11.4	13.0	1.22	0.644	12.73	-1.57	-1.71	
SX									•
SZ	14.8	14.5	15.5	0.51	0.268	14.93	0.16	0.03	
T	15.2	15.0	15.2	0.12	0.054	15.13	0.32	0.18	
TA	11.2	9.6	10.5	0.80	0.430	10.43	-3.38	-3.52	↓
TD	13.4	14.1	14.4	0.51	0.268	13.97	-0.60	-0.73	
TG	14.0	13.8	15.0	0.64	0.322	14.27	-0.37	-0.50	
TH	30.4	26.1	29.7	2.31	1.294	28.73	11.02	10.89	×
TI	19.5	18.6	20.5	0.95	0.510	19.53	3.78	3.65	↑

• = No data submitted

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↓ = 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
TK									•
TL	7.7	10.5	8.5	1.44	0.752	8.90	-4.59	-4.72	↓
TN	12.3	11.9	12.8	0.45	0.242	12.33	-1.89	-2.02	
TP									•
TQ	16.1	14.0	15.0	1.05	0.564	15.03	0.24	0.10	
TR									•
TS									•
TU	14.4	14.5	14.4	0.06	0.027	14.43	-0.24	-0.37	
TV									•
TW									•
U	14.1	12.9	13.3	0.61	0.322	13.43	-1.02	-1.15	
UB									•
UC									•
UE	13.4	12.7	14.6	0.96	0.510	13.57	-0.92	-1.05	
UI	14.2	15.4	15.6	0.76	0.376	15.07	0.26	0.13	
UL	11.7	11.4	11.6	0.15	0.081	11.57	-2.49	-2.62	
UN	29.7	28.8	27.5	1.11	0.591	28.67	10.97	10.84	×
UP	15.5	16.4	16.7	0.62	0.322	16.20	1.16	1.02	
UQ	13.0	15.0	14.0	1.00	0.537	14.00	-0.58	-0.71	
US									•
UW	15.8	14.4	14.3	0.84	0.403	14.83	0.08	-0.05	
VA									•
W	15.2	15.8	15.4	0.31	0.161	15.47	0.58	0.45	
X	18.7	16.2	15.9	1.54	0.752	16.93	1.73	1.60	
Y									•

**Data sorted by Laboratory Average**

Average	Tag	Lab	Average	Tag	Lab	Average	Tag	Lab
2.93	×	GN	13.17		GQ	14.07		RW
7.30	×	HU	13.23		LT	14.07		NH
8.90	↓	TL	13.43		U	14.13		SD
9.40	↓	RD	13.57		UE	14.17		DE
9.87	↓	QU	13.57		NG	14.17		BM
10.20	↓	FZ	13.60		SS	14.27		TG
10.40	↓	PC	13.60		KZ	14.27		CE
10.43	↓	TA	13.70		HL	14.27		BK
10.47	↓	L	13.73		BH	14.30		AZ
11.57		UL	13.80		QZ	14.33		JS
12.30		LB	13.87		R	14.33		E
12.33		TN	13.87		C	14.43		TU
12.47		SI	13.87		KH	14.43		PW
12.60		LM	13.93		AK	14.47		RZ
12.73		SW	13.97		TD	14.50		I
12.87		SM	14.00		UQ	14.53		GO
12.93		K	14.00		EP	14.70		AL

• = No data submitted

**TAG SYMBOLS**

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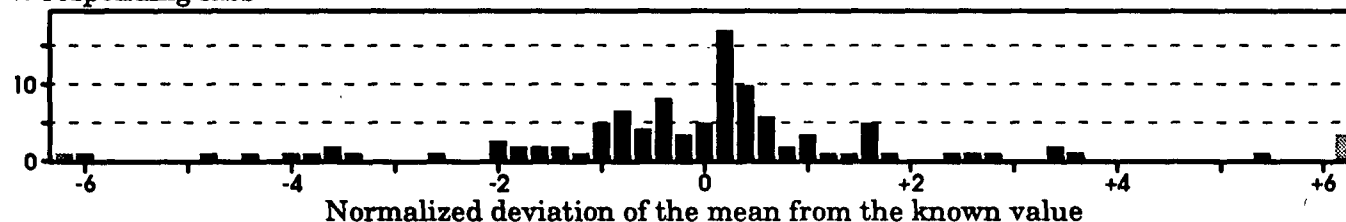
## Radium-226

## Data sorted by Laboratory Average

Average	Tag	Lab	Average	Tag	Lab	Average	Tag	Lab
14.73		HK	15.20		EO	15.93		CA
14.77		PX	15.20		DT	16.10		S
14.83		UW	15.23		NO	16.10		RA
14.83		RC	15.23		BO	16.20		UP
14.93		SZ	15.23		AF	16.27		BG
14.93		SF	15.30		OF	16.43		KL
14.97		EB	15.33		CJ	16.57		HE
15.00		DB	15.37		NT	16.83		PG
15.03		QB	15.37		AE	16.87		JG
15.03		TQ	15.37		AW	16.90		Q
15.03		DZ	15.40		AJ	16.93		X
15.07		UI	15.43		FN	17.03		P
15.07		BA	15.43		CG	17.03		HP
15.10		ST	15.47		W	17.17		MS
15.10		BN	15.47		JN	17.93		OB
15.13		T	15.53		JY	18.13		RN
15.13		OY	15.53		JE	18.57		PV
15.13		OX	15.57		N	19.27	↑	ID
15.13		LZ	15.57		A	19.33	↑	RF
15.13		FE	15.63		SC	19.53	↑	TI
15.13		AP	15.67		ER	21.73	×	FP
15.17		RM	15.73		CS	25.37	×	QX
15.17		JX	15.77		PB	27.33	×	RV
15.17		J	15.77		BC	28.67	×	UN
			15.93		PT	28.73	×	TH

% responding labs

Frequency distribution



• ≡ No data submitted

TAG SYMBOLS

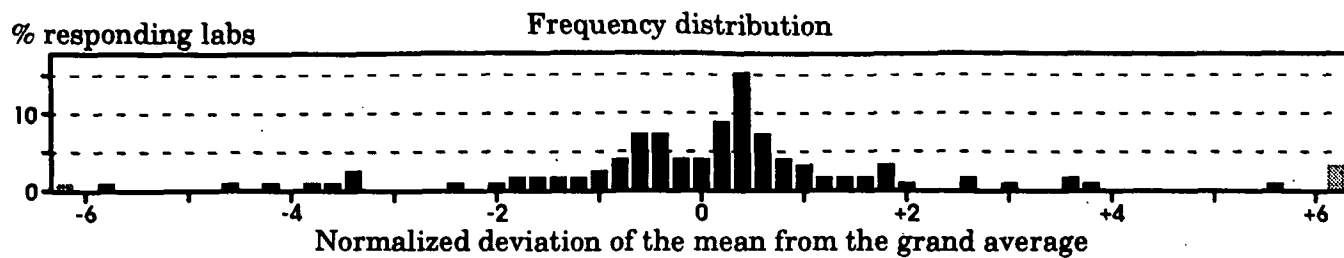
↑ ≡ Above control limit

∅ ≡ Insufficient data

× ≡ Determined to be an outlier

↓ ≡ Below control limit

**Radium-226**

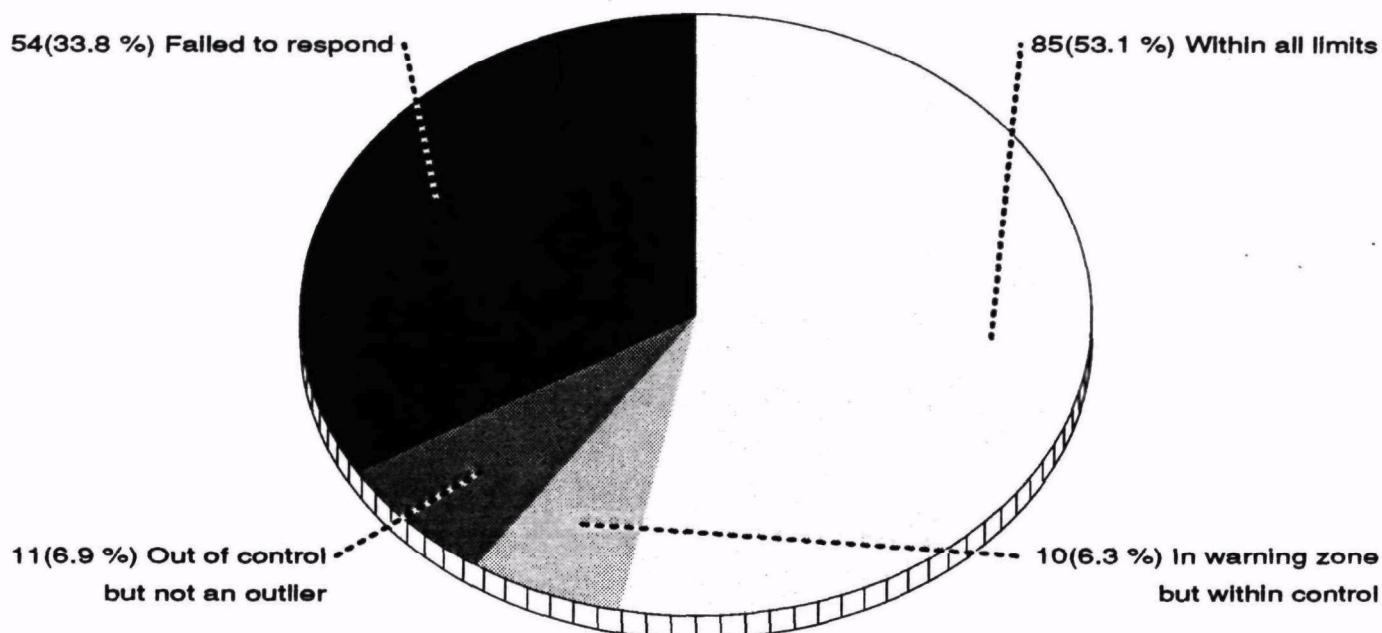




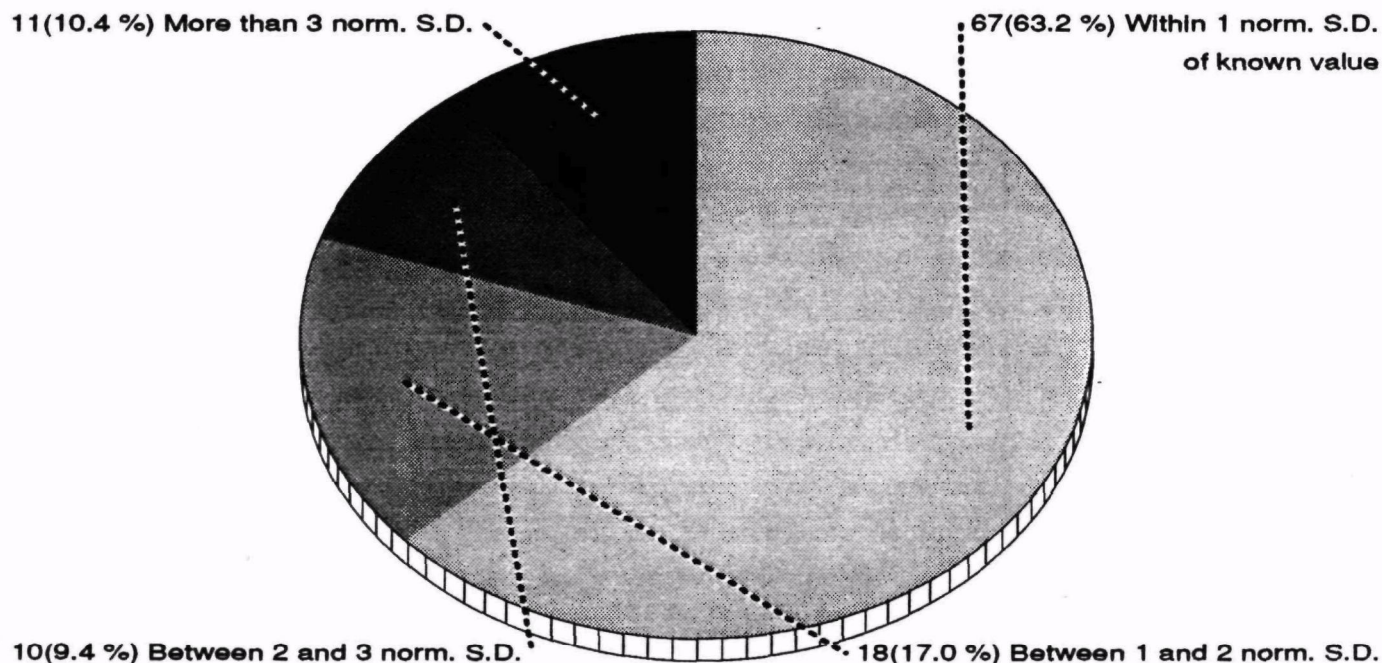
**Radium-228**
**Statistical Summary**

160 Participants

The known value of this nuclide is 20.4 pCi/l with an expected precision of 5.1; the control limits are 11.6 to 29.2; the warning regions are 11.6 to 14.5 and 26.3 to 29.2



Statistic	Respondents	Non-outliers
Mean	19.57	<b>Grand Avg 19.57</b>
Std. Dev.	5.09	5.09
Variance	25.95	25.95
% Coef. of Var.	26.04	26.04
% deviation of mean from known value	-4.09	-4.09
Norm. dev. of mean from known value	-0.16	-0.16
Median	20.08	20.08
% deviation of median from known value	-1.55	-1.55
Norm. dev. of median from known value	-0.06	-0.06



**Radium-228**

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known)		Tag
A	35.3	31.6	25.2	5.11	1.323	30.70	3.78	3.50	↑
AE	20.5	20.7	22.8	1.27	0.266	21.33	0.60	0.32	
AF	19.2	19.6	22.2	1.63	0.347	20.33	0.26	-0.02	
AI	17.2	18.2	22.6	2.87	0.625	19.33	-0.08	-0.36	
AJ	19.3	21.2	18.2	1.52	0.347	19.57	0.00	-0.28	
AK	20.9	22.6	22.9	1.08	0.232	22.13	0.87	0.59	
AL	25.1	25.3	24.7	0.31	0.069	25.03	1.86	1.57	
AP	17.5	19.0	18.3	0.75	0.174	18.27	-0.44	-0.72	
AW	18.8	20.1	20.0	0.72	0.151	19.63	0.02	-0.26	
AZ	17.2	19.3	18.1	1.05	0.243	18.20	-0.46	-0.75	
BA	11.2	10.9	10.3	0.46	0.104	10.80	-2.98	-3.26	↓
BC	18.1	19.5	18.5	0.72	0.162	18.70	-0.29	-0.58	
BG									•
BH	22.1	20.1	21.2	1.00	0.232	21.13	0.53	0.25	
BK	22.1	21.8	18.1	2.23	0.463	20.67	0.37	0.09	
BL									•
BM	20.1	19.4	20.4	0.51	0.116	19.97	0.14	-0.15	
BN									•
BO	21.4	21.5	20.0	0.84	0.174	20.97	0.48	0.19	
C	25.4	24.5	23.6	0.90	0.208	24.50	1.68	1.39	
CA	22.8	19.9	20.2	1.59	0.336	20.97	0.48	0.19	
CE	21.0	21.9	21.2	0.47	0.104	21.37	0.61	0.33	
CG	22.7	18.2	21.4	2.32	0.521	20.77	0.41	0.12	
CJ	20.0	22.0	20.0	1.15	0.232	20.67	0.37	0.09	
CK									•
CQ									•
CS	18.1	18.1	18.2	0.06	0.012	18.13	-0.49	-0.77	
CX									•
DB	16.5	15.8	16.5	0.40	0.081	16.27	-1.12	-1.40	
DE	21.9	21.9	22.0	0.06	0.012	21.93	0.80	0.52	
DT	17.4	20.8	20.0	1.78	0.394	19.40	-0.06	-0.34	
DZ	20.6	20.5	20.7	0.10	0.023	20.60	0.35	0.07	
E									•
EB	7.4	5.9	7.5	0.90	0.185	6.93	-4.29	-4.57	↓
EH									•
EO	20.5	20.9	20.0	0.45	0.104	20.47	0.31	0.02	
EP	18.2	18.6	19.0	0.40	0.093	18.60	-0.33	-0.61	
ER									•
FE									•
FN	20.3	21.2	21.4	0.59	0.127	20.97	0.48	0.19	
FP	11.6	10.8	12.3	0.75	0.174	11.57	-2.72	-3.00	
FZ	15.0	10.0	11.0	2.65	0.579	12.00	-2.57	-2.85	
GG									•
GN	4.7	5.2	5.5	0.40	0.093	5.13	-4.90	-5.18	↓
GO	14.6	14.0							∅

• = No data submitted

**TAG SYMBOLS**

↑ = Above control limit

∅ = Insufficient data

× = Determined to be an outlier

↓ = Below control limit

**Radium-228**

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known) Tag	
GQ	26.7	27.5	28.2	0.75	0.174	27.47	2.68	2.40
HE	15.0	17.9	20.6	2.80	0.649	17.83	-0.59	-0.87
HK	19.3	18.4	17.8	0.75	0.174	18.50	-0.36	-0.65
HL	22.0	20.9	18.5	1.79	0.405	20.47	0.31	0.02
HP	18.7	19.0	20.0	0.68	0.151	19.23	-0.11	-0.40
HU								•
I	20.7	18.0	19.9	1.39	0.313	19.53	-0.01	-0.29
IA								•
ID	22.1	21.2	22.3	0.59	0.127	21.87	0.78	0.50
J	20.2	20.2	17.2	1.73	0.347	19.20	-0.12	-0.41
JE	8.9	8.4	8.4	0.29	0.058	8.57	-3.74	-4.02 ↓
JG	13.8	17.2	13.4	2.09	0.440	14.80	-1.62	-1.90
JN								•
JS	24.0	22.0	21.0	1.53	0.347	22.33	0.94	0.66
JX	18.0	15.8	17.0	1.10	0.255	16.93	-0.89	-1.18
JY	25.7	20.9	19.1	3.41	0.764	21.90	0.79	0.51
K	12.4	18.4	18.6	3.52	0.718	16.47	-1.05	-1.34
KF								•
KH	18.9	21.9	18.1	2.00	0.440	19.63	0.02	-0.26
KL	26.2	24.3	21.5	2.36	0.544	24.00	1.51	1.22
KZ	19.3	19.3	19.3	0.01	0.000	19.30	-0.09	-0.37
L	15.9	15.6	15.8	0.15	0.035	15.77	-1.29	-1.57
LA								•
LB								•
LM								•
LS								•
LT	23.5	19.2	22.9	2.33	0.498	21.87	0.78	0.50
LZ								•
MN								•
MS	22.8	19.2	21.0	1.80	0.417	21.00	0.49	0.20
MY								•
N	18.6	21.3	19.7	1.36	0.313	19.87	0.10	-0.18
NG	25.8	26.0	26.8	0.53	0.116	26.20	2.25	1.97
NH	21.5							Ø
NO	15.3	16.0	17.1	0.91	0.208	16.13	-1.17	-1.45
NT	22.7	22.8	22.9	0.10	0.023	22.80	1.10	0.82
OB								•
OF	18.3	20.1	19.2	0.90	0.208	19.20	-0.12	-0.41
OK								•
OS								•
OX	20.3	20.2	19.6	0.38	0.081	20.03	0.16	-0.12
OY	24.7	26.3	22.5	1.91	0.440	24.50	1.68	1.39
OZ								•
P	17.0	26.8	17.8	5.44	1.257	20.53	0.33	0.05
PB	19.3	19.7	18.3	0.72	0.162	19.10	-0.16	-0.44

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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	19.2	20.2	21.4	1.10	0.255	20.27	0.24	-0.05	
PG									•
PP									•
PT	15.6	22.2	16.1	3.67	0.764	17.97	-0.54	-0.83	
PV	14.9	13.5	14.2	0.70	0.162	14.20	-1.82	-2.11	
PW	9.2	8.2	11.8	1.86	0.417	9.73	-3.34	-3.62	↓
PX									•
PY									•
Q	24.8	19.5	21.1	2.72	0.614	21.80	0.76	0.48	
QB									•
QJ									•
QU	7.8	8.2	8.1	0.21	0.046	8.03	-3.92	-4.20	↓
QX									•
QY	21.2	22.4	21.8	0.60	0.139	21.80	0.76	0.48	
QZ	15.8	17.4	10.6	3.56	0.788	14.60	-1.69	-1.97	
R									•
RA									•
RC	24.1	22.7	22.8	0.78	0.162	23.20	1.23	0.95	
RD	24.2	20.3	18.3	3.00	0.683	20.93	0.46	0.18	
RF	19.7	22.6	21.4	1.46	0.336	21.23	0.57	0.28	
RL									•
RM	13.9	11.7	11.6	1.30	0.266	12.40	-2.43	-2.72	
RN	18.7	19.5	20.1	0.70	0.162	19.43	-0.05	-0.33	
RV	7.1	7.8	8.2	0.56	0.127	7.70	-4.03	-4.31	↓
RW	18.3	19.0	19.4	0.56	0.127	18.90	-0.23	-0.51	
RX									•
RZ	19.8	18.6	18.7	0.67	0.139	19.03	-0.18	-0.46	
S	17.7	17.8	17.8	0.06	0.012	17.77	-0.61	-0.89	
SA									•
SC	20.3	21.4	20.7	0.56	0.127	20.80	0.42	0.14	
SD	24.6	21.3	20.0	2.37	0.533	21.97	0.82	0.53	
SF	29.8	31.1	31.3	0.81	0.174	30.73	3.79	3.51	↑
SI	30.1	29.3	28.2	0.95	0.220	29.20	3.27	2.99	
SM	22.0	28.0	27.8	3.41	0.695	25.93	2.16	1.88	
SS	14.9	21.4	20.5	3.52	0.753	18.93	-0.21	-0.50	
ST	21.9	22.4	21.4	0.50	0.116	21.90	0.79	0.51	
SW	30.6	26.3	18.8	5.97	1.698	25.23	1.92	1.64	
SX									•
SZ	23.3	20.3	24.3	2.08	0.463	22.63	1.04	0.76	
T	20.2	20.0	20.4	0.20	0.046	20.20	0.22	-0.07	
TA	23.4	23.1	20.3	1.71	0.359	22.27	0.92	0.63	
TD	6.3	4.7	4.6	0.95	0.197	5.20	-4.88	-5.16	↓
TG	17.9	21.5	21.0	1.95	0.417	20.13	0.19	-0.09	
TH	25.5	27.4	28.1	1.35	0.301	27.00	2.52	2.24	
TI	23.2	20.9	26.4	2.76	0.637	23.50	1.34	1.05	

• = No data submitted

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↓ = Below control limit

**Radium-228**

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known)		Tag
TK									•
TL	23.4	26.8	15.5	5.80	1.588	21.90	0.79	0.51	
TN	16.2	16.9	22.8	3.63	0.764	18.63	-0.32	-0.60	
TP									•
TQ	17.3	20.2	18.8	1.45	0.336	18.77	-0.27	-0.55	
TR									•
TS									•
TU									•
TV									•
TW									•
U	16.0	18.5	12.6	2.96	0.683	15.70	-1.31	-1.60	
UB									•
UC									•
UE	16.4	19.7	19.0	1.74	0.382	18.37	-0.41	-0.69	
UI	14.8	17.1	16.2	1.16	0.266	16.03	-1.20	-1.48	
UL									•
UN	23.1	24.0	32.3	5.07	1.125	26.47	2.34	2.06	
UP	31.0	36.0	38.0	3.61	0.811	35.00	5.24	4.96	↑
UQ	25.0	30.0	27.0	2.52	0.579	27.33	2.64	2.35	
US									•
UW	21.1	19.6	21.0	0.84	0.174	20.57	0.34	0.06	
VA									•
W	15.1	15.3	15.9	0.42	0.093	15.43	-1.40	-1.69	
X	13.0	9.9	16.5	3.30	0.764	13.13	-2.18	-2.47	
Y									•

**Data sorted by Laboratory Average**

Average	Tag	Lab	Average	Tag	Lab	Average	Tag	Lab
5.13	↓	GN	15.77		L	18.77		TQ
5.20	↓	TD	16.03		UI	18.90		RW
6.93	↓	EB	16.13		NO	18.93		SS
7.70	↓	RV	16.27		DB	19.03		RZ
8.03	↓	QU	16.47		K	19.10		PB
8.57	↓	JE	16.93		JX	19.20		OF
9.73	↓	PW	17.77		S	19.20		J
10.80	↓	BA	17.83		HE	19.23		HP
11.57		FP	17.97		PT	19.30		KZ
12.00		FZ	18.13		CS	19.33		AI
12.40		RM	18.20		AZ	19.40		DT
13.13		X	18.27		AP	19.43		RN
14.20		PV	18.37		UE	19.53		I
14.60		QZ	18.50		HK	19.57		AJ
14.80		JG	18.60		EP	19.63		KH
15.43		W	18.63		TN	19.63		AW
15.70		U	18.70		BC	19.87		N

• = No data submitted

**TAG SYMBOLS**

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↓ = Below control limit

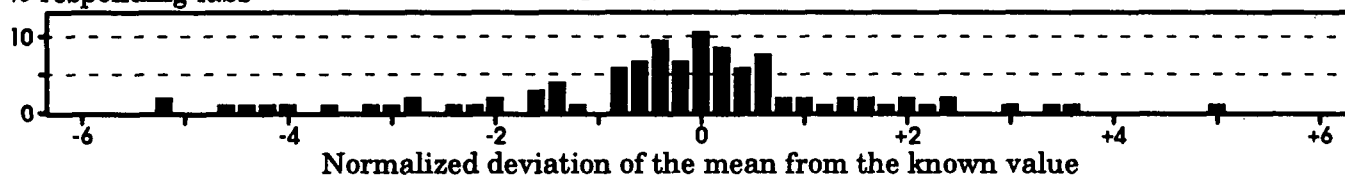
## Radium-228

## Data sorted by Laboratory Average

Average	Tag	Lab	Average	Tag	Lab	Average	Tag	Lab
19.97		BM	20.97		BO	22.63		SZ
20.03		OX	21.00		MS	22.80		NT
20.13		TG	21.13		BH	23.20		RC
20.20		T	21.23		RF	23.50		TI
20.27		PC	21.33		AE	24.00		KL
20.33		AF	21.37		CE	24.50		OY
20.47		HL	21.80		QY	24.50		C
20.47		EO	21.80		Q	25.03		AL
20.53		P	21.87		LT	25.23		SW
20.57		UW	21.87		ID	25.93		SM
20.60		DZ	21.90		TL	26.20		NG
20.67		CJ	21.90		ST	26.47		UN
20.67		BK	21.90		JY	27.00		TH
20.77		CG	21.93		DE	27.33		UQ
20.80		SC	21.97		SD	27.47		GQ
20.93		RD	22.13		AK	29.20		SI
20.97		FN	22.27		TA	30.70	↑↑	A
20.97		CA	22.33		JS	30.73	↑↑	SF
						35.00	↑↑	UP

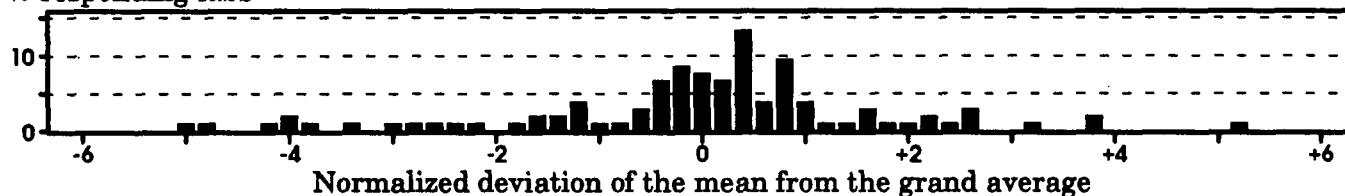
% responding labs

Frequency distribution



% responding labs

Frequency distribution



• ≡ No data submitted

∅ ≡ Insufficient data

## TAG SYMBOLS

× ≡ Determined to be an outlier

↑↑ ≡ Above control limit

↓↓ ≡ Below control limit