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ACCURATE DETERMINATION OF IMPURITY CONCENTRATIONS IN PLUTONIUM METALS BY STATISTICAL EVALUATION OF ANALYTICAL DATA

by

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ABSTRACT

Analytical data from a plutonium-metal exchange program conducted by six ERDA laboratories are statistically evaluated. The objective is an accurate determination of five metal impurities (aluminum, chromium, iron, nickel, silicon) in each of three plutonium metals by using data from four analytical methods. The statistical evaluation yields the weighted mean and its standard deviation for each method, plutonium metal, and impurity, using a procedure that minimizes the effect of outliers by assigning zero weights to the most extreme values and variable weights to the remaining data. Where possible, weighted means from the various analytical methods are pooled.

I. INTRODUCTION

Well-characterized standard materials are invaluable for making accurate analytical measurements in any field, and in the nuclear field well-characterized plutonium metals have not been available. Data are presented here for three standard plutonium metals accurately characterized according to content of five impurities: aluminum, chromium, iron, nickel, and silicon.

Data from a plutonium-metal exchange program conducted by six ERDA laboratories have been analyzed, and three plutonium metals, identified as H, R, and P, have been carefully characterized. These well-characterized plutonium metals should be useful in resolving measurement differences among laboratories, improving current analytical methods, developing new measurement capabilities, and providing data with which to resolve shipper-receiver differences.

By using these standard plutonium metals, a laboratory can evaluate its analytical performance and take corrective action if its analytical results are in error. Also, work is under way using these three plutonium metals in evaluating several types of PuO_2 emission spectroscopy standards.

Data from the plutonium-metal exchange program, recorded quarterly from December 1971 to December 1974, will be considered here. Unfortunately, different reporting procedures were used during this period, and the same procedure was not used by all the laboratories at any given time. The effect of these differing procedures will be discussed later.

Four methods of analysis were used: emission spectroscopy; chemical method; spark source mass spectroscopy; and atomic absorption. Of the four, only emission spectroscopy can be used to determine all five impurity elements in all three plutonium metals. The chemical method determines only iron. Emission spectroscopy and the chemical method have been used in the exchange program longer than the other methods and so have contributed the largest number of values to this report.

Spark source mass spectroscopy has been used only at the Rocky Flats laboratory. For calibration purposes, spark source spectroscopy uses the iron value determined by atomic absorption for a given

sample and gives values for aluminum, chromium, nickel, and silicon.

Atomic absorption has been used in the exchange program for only a short time. The impurities determined by atomic absorption include aluminum, chromium, nickel, and iron. Rocky Flats has also reported a small number of values for silicon.

A secondary purpose of this report is to suggest a statistical treatment for future plutonium-metal exchange data that may lead to a consensus on impurity concentrations while a supply of a particular batch of plutonium metal still exists. These well-characterized metals could be considered "certified" plutonium metals. Additional determinations, such as those for carbon, gallium, plutonium, and uranium, could also be so treated.

II. STATISTICAL METHODOLOGY

For each impurity, plutonium metal, and analytical method, the data from the six participating laboratories are combined, and from 8 to 127 data values are given in the initial evaluation. P-metal iron data taken before December 1972 by emission spectroscopy at two of the laboratories showed a high bias and were deleted. The two laboratories had been using PuO_2 obtained from the direct ignition of plutonium metal. However, a study[1] made during 1972 showed that high iron values are obtained from P-metal when the particle size of the PuO_2 is not controlled. When the laboratories began to control PuO_2 particle size, the high bias for iron was no longer observed.

Because the data come from several laboratories, analytical methods, and reporting procedures, outliers are likely to be present. It is difficult to determine an underlying distribution for the data. Certainly the assumption of normality is not appropriate. How, then, does one best estimate the mean under these circumstances? An estimator that is not very sensitive to the underlying distribution is said to be "robust." We believe that the method described in this report is the best method of robust estimation[2] to date. It makes use of weighted means and prescribes how the weights are to be assigned. Standard deviations of the weighted means are also calculated, but their properties are not yet well known.

If x_i, $i = 1, \ldots, n$, denotes the i-th observation and w_i a weighting factor for the i-th observation, the weighted mean is defined as

$$\bar{X}_w = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i} .$$

Let $r_i = |x_i - \bar{X}_w|$ denote the absolute value of the i-th residual and define S to be the median residual. The weights themselves are defined iteratively as $w_i = 1/r_i \sin(r_i/cS)$, where c is an arbitrary scaling factor ($c = 1$ in this report). Ten iterations are made starting with unit weights. This method assigns zero weights to observations when $r_i > \pi S$, large weights to observations with small residuals, and small weights to observations with large residuals.

The standard deviation of the weighted mean, $S_{\bar{X}_w}$, is then calculated for each impurity in each plutonium metal and for each analytical procedure by

$$S_{\bar{X}_w} = \left[\frac{\sum_{i=1}^{n'} r_i^2 w_i}{(n'-1) \sum_{i=1}^{n'} w_i} \right]^{1/2}$$

where n' is the number of observations receiving nonzero weights.

The computer program, data, residuals, weights, and various means and standard deviations are given in Appendixes I and II.

III. RESULTS

The weighted mean and the standard deviation of the weighted mean for each impurity, plutonium metal, and analytical procedure are summarized in Table I.

A weighted mean and its standard deviation, both pooled from the analytical methods, are shown in Table II. These are computed as follows:

$$\bar{X}_w(\text{pooled}) = \frac{n_1' \bar{X}_{w_1} + n_2' \bar{X}_{w_2} + n_3' \bar{X}_{w_3}}{n_1' + n_2' + n_3'}$$

TABLE I

WEIGHTED MEAN AND ITS STANDARD DEVIATION FOR EACH IMPURITY FROM EACH ANALYTICAL METHOD
(micrograms per gram of plutonium metal)

Impurity	Plutonium Metal	Emission Spectroscopy	Spark Source Mass Spectroscopy	Atomic Absorption	Chemical Method
Aluminum	H	174.6 ± 2.9	177.5 ± 10.5	183.5 ± 2.5	-- --
	R	22.5 ± 0.5	16.2 ± 0.4	34.6 ± 2.4	-- --
	P	55.5 ± 1.3	53.7 ± 1.8	--	-- --
Chromium	H	196.7 ± 2.8	217.5 ± 3.7	171.5 ± 1.1	-- --
	R	45.0 ± 0.9	38.0 ± 1.5	48.9 ± 1.0	-- --
	P	48.6 ± 0.9	43.9 ± 2.7	--	-- --
Nickel	H	441.0 ± 5.2	449.1 ± 3.6	437.5 ± 3.1	-- --
	R	101.3 ± 1.2	94.2 ± 2.4	108.1 ± 1.6	-- --
	P	137.2 ± 1.5	135.4 ± 5.4	--	-- --
Silicon	H	180.8 ± 3.9	222.4 ± 20.2	129.7 ± 3.6	-- --
	R	34.6 ± 1.0	35.8 ± 1.1	32.6 ± 0.9	-- --
	P	24.4 ± 0.8	36.2 ± 2.2	--	-- --
Iron	H	962.8 ± 10.5	--	915.7 ± 11.4	947.0 ± 4.3
	R	111.4 ± 2.2	--	112.9 ± 2.1	114.4 ± 2.3
	P	318.1 ± 5.5	--	--	326.4 ± 2.1

TABLE II

WEIGHTED MEAN AND ITS STANDARD DEVIATION FOR EACH IMPURITY POOLED FROM SEVERAL ANALYTICAL METHODS[a]
(micrograms per gram of plutonium metal)

Impurity	Plutonium Metals		
	H	R	P
Aluminum	176.3 ± 4.2	22.5 ± 0.5[b]	55.3 ± 1.3
Chromium	196.7 ± 2.8[b]	46.1 ± 0.9[c]	48.2 ± 1.1
Nickel	440.9 ± 4.7	102.5 ± 1.4	137.0 ± 2.1
Silicon	185.8 ± 7.7[d]	34.5 ± 1.0	24.4 ± 0.8[b]
Iron	949.2 ± 8.8	112.7 ± 2.2	322.0 ± 4.2

[a]Data from all analytical methods are combined to compute the pooled weighted means and pooled standard deviations of the weighted means unless indicated by superscripts.

[b]Based on emission spectroscopy.

[c]Based on emission spectroscopy and atomic absorption.

[d]Based on emission spectroscopy and spark source mass spectroscopy.

and

$$S_{\overline{X}_w}\ (\text{pooled}) = \left[\frac{df_1\ S^2_{\overline{X}_{w_1}} + df_2\ S^2_{\overline{X}_{w_2}} + df_3\ S^2_{\overline{X}_{w_3}}}{df_1 + df_2 + df_3}\right]^{1/2}$$

where subscripts 1, 2, 3 refer to the various analytical methods, n_i' is the number of observations in the i-th mean with nonzero weight, and $df_i = n_i' - 1$.

In three instances, values come only from emission spectroscopy. This method has produced the largest amount of data, and the weighted mean of the emission spectroscopy results is between the weighted means reported from the other two analytical procedures. In two other cases the weighted means are pooled from two analytical procedures reporting values for an impurity. The weighted means not pooled in these cases are from analytical methods that have apparent biases for these impurity elements in these plutonium metals.

An approximate t-test, where

$$t = \frac{\overline{X}_{w_1} - \overline{X}_{w_2}}{\left(S^2_{\overline{X}_{w_1}} + S^2_{\overline{X}_{w_2}}\right)^{1/2}}$$

is used to check for significant differences at the 0.05 level among any two of the analytical methods. With judgment based on analytical experience, one can arrive at the same conclusion as the t-test in 80% of the cases. Because of the variety of reporting procedures and the rounding and averaging of results, the estimates of precision calculated for this report, while correct for the data as used, are not entirely satisfactory.

In 20% of the comparisons, the t-test gives a t-value marginally significant at the 0.05 level. The differences, while statistically significant, are not practically significant. In these few cases, analytical judgment indicates that the weighted means of the pertinent analytical methods can be pooled.

IV. SUMMARY AND RECOMMENDATIONS

Differences between the weighted means for some impurities (Table I) may indicate that biases exist. If there are such biases, they are not consistent among the several impurities; i.e., one analytical procedure does not always yield higher results than another. Because the methods are supposed to measure the same quantity and because there seems to be no consistent bias between methods, the weighted means are pooled from the methods, except for those cases noted.

The values given in Tables I and II should be used with judgment. Where there are apparent differences among weighted means, further experimental work is recommended. To resolve these differences, individual laboratories should use the values of Table II in a conscientious effort to examine their analytical methods, especially where large discrepancies occur between their measurements and the ones reported here. In this way, and with consistent reporting practices, the accumulation of future data will be helpful in determining impurity concentrations in plutonium metals even more accurately than shown here.

ACKNOWLEDGMENTS

We gratefully acknowledge the efforts and cooperation of the many people at the participating laboratories who contributed the data discussed in this report. The participating laboratories are: Atlantic Richfield Hanford Company, Hanford, WA; Savannah River Plant, Aiken, SC; Rocky Flats, Golden, CO; Mound Laboratories, Miamisburg, OH; Argonne National Laboratory, Chicago, IL; and Los Alamos Scientific Laboratory, Los Alamos, NM.

REFERENCES

1. C. J. Martell, "The Effect of Particle Size on the Carrier-Distillation Analysis of PuO_2," Los Alamos Scientific Laboratory report LA-5454 (February 1974).

2. D. F. Andrews, "A Robust Method for Multiple Linear Regression," Technometrics **16**, 523-531 (November 1974).

APPENDIX I

COMPUTER PROGRAM USED FOR STATISTICAL EVALUATION OF THE ANALYTICAL DATA

```
      PROGRAM MAIN (INP,OUT)
      DIMENSION X(250), W(250), R(250), T(500), D(250), Y(250)
      DIMENSION TITLE(5)
C
C     READ TITLE,DATA
      J=0
      DO 120 MM=1,40
      READ 130, (TITLE(K),K=1,5)
      J=J+1
      PRINT 140, J
      PRINT 150, (TITLE(K),K=1,5)
      NCT=0
      READ 160, N
      READ 170, (X(I),I=1,N)
C
C     CALCULATE MEANS, STANDARD DEVIATIONS, AND RESIDUALS OF ORIGINAL DATA
      SUMX=0.0
      SUSX=0.0
      XA=0.0
      XAT=0.0
      XN=N
      DO 10 I=1,N
      SUMX=SUMX+X(I)
   10 CONTINUE
      DO 20 I=1,N
      R(I)=ABS(X(I)-SUMX/N)
   20 SUSX=SUSX+R(I)**2
      SUSX=SQRT(SUSX/(N-1.))
      XAB=SUSX/SQRT(XN)
      CALL SORT1 (N,0,R,T)
      NM=MOD(N,2)
      NX=N/2
      NY=NX+1
      STD=(R(NX)+R(NY))/2.
      IF (NM.EQ.1) STD=R(NY)
      XMM=SUMX/N
      PRINT 180, XMM,XAB
C
C     CALCULATE WEIGHTS USING ANDREWS  METHOD
      DO 90 M=4,4
      C=(.25*FLOAT(M)+0.0)*STD
      DO 80 ICNT=1,10
      DO 50 I=1,N
      IF (ICNT.EQ.1) GO TO 40
      IF (ABS(R(I)/C).GT.3.1415926) GO TO 30
      W(I)=SIN(R(I)/C)/R(I)
      GO TO 50
   30 W(I)=0.0
      IF (ICNT.EQ.10) NCT=NCT+1
      XNCT=NCT
```

```
      GO TO 50
   40 W(I)=1.0
   50 CONTINUE
C
C     CALCULATE WEIGHTED MEANS, STANDARD DEVIATIONS, AND RESIDUALS OF
C     WEIGHTED DATA
      SUM1=0.0
      SUM2=0.0
      DO 60 I=1,N
      SUM1=SUM1+W(I)*X(I)
   60 SUM2=SUM2+W(I)
      XBAR=SUM1/SUM2
      SUMR=0.0
      DO 70 I=1,N
      R(I)=X(I)-XBAR
   70 SUMR=SUMR+R(I)*R(I)*W(I)
      SUMR=SQRT(SUMR/((N-NCT-1)*(SUM2)))
   80 CONTINUE
   90 CONTINUE
C
C     CALCULATE MEANS, STANDARD DEVIATIONS OF DATA RECEIVING NON-ZERO
C     WEIGHTS
      DO 100 I=1,N
      Y(I)=X(I)
      IF (W(I).EQ.0.) Y(I)=0.
      XA=XA+Y(I)
  100 CONTINUE
      XAM=XA/(N-NCT)
      DO 110 I=1,N
      D(I)=Y(I)-XAM
      IF (W(I).EQ.0.) D(I)=0.
      XAT=XAT+D(I)**2
  110 CONTINUE
      XAT=SQRT(XAT/(N-NCT-1.))
      XAS=XAT/SQRT(XN-XNCT)
      IF (ICNT.EQ.10) PRINT 190, XAM,XAS
      IF (ICNT.EQ.10) PRINT 200, XBAR,SUMR
      IF (ICNT.EQ.10) PRINT 210
      IF (ICNT.EQ.10) PRINT 220, (K,X(K),R(K),W(K),K=1,N)
      PRINT 230
      PRINT 240
      PRINT 250
      PRINT 260
      PRINT 270
  120 CONTINUE
C
  130 FORMAT (5A10)
  140 FORMAT (1H1,///,55X,I3)
  150 FORMAT (//,35X,5A10)
  160 FORMAT (1I3)
  170 FORMAT (14F5.0)
  180 FORMAT (///* MEAN AND ST DEV OF MEAN (N  VALUES)
     1 *,2F15.4)
  190 FORMAT (* MEAN AND ST DEV OF MEAN (N' VALUES)                    *,
     12F15.4)
  200 FORMAT (* WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)*,
     12F15.4)
  210 FORMAT (//*    I    X(I)    R(I)    W(I)         I    X(I)    R(I)
```

```
     1    W(I)          I    X(I)    R(I)    W(I)          I    X(I)    R(
     2I)    W(I)*,/)
  220 FORMAT (I5,F8.0,F8.0,F8.3,3(I10,F8.0,F8.0,F3.3))
  230 FORMAT (///39X,*X(I) IS THE I-TH OBSERVATION*)
  240 FORMAT (39X,*R(I) IS THE I-TH RESIDUAL FROM THE WEIGHTED MEAN*)
  250 FORMAT (39X,*W(I) IS THE WEIGHT GIVEN THE I-TH OBSERVATION*)
  260 FORMAT (39X,*N IS THE NUMBER OF ORIGINAL OBSERVATIONS*)
  270 FORMAT (39X,*N' IS THE NUMBER OF OBSERVATIONS WITH NONZERO WEIGHTS
     1 *)
      END
```

APPENDIX II

DATA, RESIDUALS, WEIGHTS, AND VARIOUS MEANS AND STANDARD DEVIATIONS FOR EACH IMPURITY, PLUTONIUM METAL, AND ANALYTICAL PROCEDURE

Analytical Method	Impurity	Page
Emission Spectroscopy		
Metal H	Al	9
	Cr	10
	Fe	11
	Ni	12
	Si	13
Metal P	Al	14
	Cr	15
	Fe	16
	Ni	17
	Si	18
Metal R	Al	19
	Cr	20
	Fe	21
	Ni	22
	Si	23
Chemical Method		
Metal H	Fe	24
Metal P	Fe	25
Metal R	Fe	26
Spark Source Mass Spectroscopy		
Metal H	Al	27
	Cr	28
	Ni	29
	Si	30
Metal P	Al	31
	Cr	32
	Ni	33
	Si	34
Metal R	Al	35
	Cr	36
	Ni	37
	Si	38
Atomic Absorption		
Metal H	Al	39
	Cr	40
	Fe	41
	Ni	42
	Si	43
Metal R	Al	44
	Cr	45
	Fe	46
	Ni	47
	Si	48

ALUMINUM METAL M EMISSION

MEAN AND ST DEV OF MEAN (N VALUES)	173.8760	4.0787
MEAN AND ST DEV OF MEAN (N' VALUES)	172.2308	3.8833
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	174.6091	2.8806

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	93	-82	.004	2	141	-34	.027	3	116	-59	.015	4	125	-50	.020
5	117	-58	.016	6	179	4	.034	7	241	66	.011	8	266	91	0.000
9	155	-20	.032	10	111	-64	.013	11	221	46	.022	12	257	82	.003
13	91	-84	.003	14	130	-45	.022	15	218	43	.023	16	163	-12	.034
17	95	-80	.005	18	99	-76	.007	19	153	-12	.034	20	173	-2	.035
21	166	-9	.034	22	102	-73	.008	23	155	-20	.032	24	137	-38	.026
25	180	5	.034	26	169	-6	.034	27	96	-79	.005	28	105	-70	.010
29	220	45	.022	30	223	48	.021	31	160	-15	.033	32	153	-22	.031
33	155	-20	.032	34	113	-62	.014	35	221	46	.022	36	257	82	.003
37	150	-25	.031	38	196	21	.032	39	193	18	.032	40	214	39	.025
41	190	15	.033	42	186	11	.034	43	191	16	.033	44	140	-35	.027
45	275	100	0.000	46	155	-20	.032	47	137	-38	.026	48	200	25	.030
49	256	81	.004	50	210	35	.027	51	185	10	.034	52	163	-12	.034
53	147	-28	.030	54	184	9	.034	55	246	71	.009	56	150	-25	.031
57	126	-49	.020	58	208	33	.027	59	263	88	.001	60	184	9	.034
61	166	-9	.034	62	112	-63	.013	63	171	-4	.035	64	131	-44	.023
65	171	-4	.035	66	200	25	.030	67	214	39	.025	68	220	45	.022
69	190	15	.033	70	144	-31	.029	71	107	-68	.011	72	104	-71	.009
73	128	-47	.021	74	148	-27	.030	75	181	6	.034	76	167	-8	.034
77	215	40	.024	78	200	25	.030	79	125	-50	.020	80	115	-60	.015
81	210	35	.027	82	216	41	.024	83	197	22	.031	84	198	23	.031
85	174	-1	.035	86	167	-8	.034	87	146	-29	.029	88	148	-27	.030
89	168	-7	.034	90	231	56	.016	91	178	3	.035	92	195	20	.032
93	145	-30	.029	94	212	37	.026	95	181	6	.034	96	200	25	.030
97	118	-57	.016	98	106	-69	.010	99	79	-96	0.000	100	105	-70	.010
101	168	-7	.034	102	162	-13	.034	103	212	37	.026	104	188	13	.033
105	186	11	.034	106	224	49	.020	107	240	65	.012	108	268	93	0.000
109	185	10	.034	110	200	25	.030	111	175	0	.035	112	185	10	.034
113	245	70	.009	114	200	25	.030	115	210	35	.027	116	225	50	.020
117	170	-5	.034	118	190	15	.033	119	168	-7	.034	120	195	20	.032
121	145	-30	.029												

X(I) IS THE I-TH OBSERVATION
R(I) IS THE I-TH RESIDUAL FROM THE WEIGHTED MEAN
W(I) IS THE WEIGHT GIVEN THE I-TH OBSERVATION
N IS THE NUMBER OF ORIGINAL OBSERVATIONS
N' IS THE NUMBER OF OBSERVATIONS WITH NONZERO WEIGHTS

CHROMIUM METAL H EMISSION

MEAN AND ST DEV OF MEAN (N VALUES)	185.6535	4.9622
MEAN AND ST DEV OF MEAN (N' VALUES)	194.7768	3.4180
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	196.7204	2.8095

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	89	-108	0.000	2	176	-21	.029	3	214	17	.029	4	267	70	.012
5	172	-25	.028	6	167	-30	.027	7	225	28	.027	8	219	22	.029
9	155	-42	.023	10	200	3	.031	11	260	63	.015	12	253	56	.018
13	81	-116	0.000	14	90	-107	0.000	15	190	-7	.031	16	236	39	.024
17	194	-3	.031	18	149	-48	.021	19	209	12	.030	20	218	21	.029
21	151	-46	.022	22	126	-71	.012	23	145	-52	.019	24	111	-86	.006
25	221	24	.028	26	236	39	.024	27	72	-125	0.000	28	76	-119	0.000
29	234	37	.025	30	209	12	.030	31	148	-49	.020	32	130	-67	.013
33	77	-120	0.000	34	155	-42	.023	35	198	1	.031	36	234	37	.025
37	247	50	.020	38	289	92	.003	39	225	28	.027	40	246	49	.020
41	180	-17	.030	42	218	21	.029	43	56	-141	0.000	44	203	6	.031
45	148	-49	.020	46	191	-6	.031	47	235	38	.024	48	93	-104	0.000
49	186	-11	.030	50	189	-8	.031	51	270	73	.010	52	225	28	.027
53	58	-139	0.000	54	203	6	.031	55	240	43	.022	56	242	45	.022
57	233	36	.025	58	169	-28	.027	59	167	-30	.027	60	175	-22	.029
61	218	21	.029	62	229	32	.026	63	183	-14	.030	64	202	5	.031
65	209	12	.030	66	183	-14	.030	67	196	-1	.031	68	157	-40	.024
69	141	-56	.018	70	139	-58	.017	71	78	-119	0.000	72	76	-121	0.000
73	162	-35	.025	74	154	-43	.023	75	160	-37	.025	76	140	-57	.017
77	232	35	.025	78	208	11	.030	79	146	-51	.020	80	150	-47	.021
81	220	23	.028	82	230	33	.026	83	214	17	.029	84	194	-3	.031
85	216	19	.029	86	186	-11	.030	87	151	-46	.022	88	154	-43	.023
89	177	-20	.029	90	191	-6	.031	91	212	15	.030	92	210	13	.030
93	188	-9	.031	94	195	-2	.031	95	208	11	.030	96	210	13	.030
97	74	-123	0.000	98	118	-79	.008	99	68	-129	0.000	100	102	-95	.002
101	142	-55	.018	102	155	-42	.023	103	178	-19	.029	104	170	-27	.028
105	224	27	.027	106	226	29	.027	107	198	1	.031	108	192	-5	.031
109	220	23	.028	110	215	18	.029	111	190	-7	.031	112	215	18	.029
113	230	33	.026	114	220	23	.028	115	235	38	.024	116	217	20	.029
117	210	13	.030	118	185	-12	.030	119	190	-7	.031	120	185	-12	.030
121	204	7	.031	122	191	-6	.031	123	198	1	.031	124	193	-4	.031
125	360	163	0.000	126	413	216	0.000	127	164	-33	.026				

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IRON METAL H EMISSION

MEAN AND ST DEV OF MEAN (N VALUES)	944.5982	16.8311
MEAN AND ST DEV OF MEAN (N' VALUES)	965.4466	12.1352
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	962.8054	10.4942

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	413	-550	0.000	2	815	-148	.007	3	797	-166	.006	4	795	-168	.006
5	1075	112	.008	6	1063	100	.008	7	880	-83	.009	8	877	-86	.008
9	669	-294	.001	10	1084	121	.008	11	1088	125	.007	12	863	-100	.008
13	438	-525	0.000	14	575	-388	0.000	15	1056	93	.008	16	1111	148	.007
17	1150	187	.005	18	1138	175	.006	19	869	-94	.008	20	988	25	.009
21	808	-155	.006	22	780	-183	.005	23	1538	575	0.000	24	1203	240	.003
25	1156	193	.005	26	1185	222	.004	27	1150	187	.005	28	1138	175	.006
29	1065	102	.008	30	969	6	.010	31	888	-75	.009	32	810	-153	.007
33	535	-428	0.000	34	515	-448	0.000	35	1176	213	.004	36	1338	375	0.000
37	1125	162	.006	38	1175	212	.004	39	1117	154	.006	40	997	34	.009
41	935	-28	.009	42	905	-58	.009	43	880	-83	.009	44	783	-180	.006
45	1150	187	.005	46	882	-81	.009	47	1165	202	.005	48	1023	60	.009
49	1010	47	.009	50	991	28	.009	51	1075	112	.008	52	1004	41	.009
53	880	-83	.009	54	1059	96	.008	55	1051	88	.008	56	817	-146	.007
57	840	-123	.007	58	816	-147	.007	59	912	-51	.009	60	1142	179	.006
61	848	-115	.008	62	960	-3	.010	63	887	-76	.009	64	994	31	.009
65	933	-30	.009	66	945	-18	.009	67	861	-102	.008	68	1013	50	.009
69	955	-8	.010	70	932	-31	.009	71	526	-437	0.000	72	476	-487	0.000
73	974	11	.010	74	909	-54	.009	75	920	-43	.009	76	876	-87	.008
77	1025	62	.009	78	888	-75	.009	79	1140	177	.006	80	920	-43	.009
81	1030	67	.009	82	1010	47	.009	83	910	-53	.009	84	1101	138	.007
85	845	-118	.008	86	1102	139	.007	87	868	-95	.008	88	820	-143	.007
89	1025	62	.009	90	691	-272	.002	91	848	-115	.008	92	868	-95	.008
93	942	-21	.009	94	1066	103	.008	95	1050	87	.008	96	1080	117	.008
97	995	32	.009	98	795	-168	.006	99	870	-93	.008	100	1035	72	.009
101	925	-38	.009	102	775	-188	.005	103	875	-88	.008	104	975	12	.010
105	945	-18	.009	106	1118	155	.006	107	1088	125	.007	108	773	-190	.005
109	938	-25	.009	110	913	-50	.009	111	930	-33	.009	112	875	-88	.008

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NICKEL METAL H EMISSION

MEAN AND ST DEV OF MEAN (N VALUES)	444.9339	8.9380
MEAN AND ST DEV OF MEAN (N' VALUES)	449.0727	6.9790
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	440.9885	5.1914

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	256	-185	0.000	2	639	198	0.000	3	422	-19	.018	4	486	45	.016
5	450	9	.018	6	587	146	.003	7	417	-24	.018	8	474	33	.017
9	390	-51	.016	10	585	144	.003	11	413	-28	.018	12	432	-9	.018
13	148	-293	0.000	14	623	182	0.000	15	425	-16	.018	16	431	-10	.018
17	186	-255	0.000	18	191	-250	0.000	19	590	149	.003	20	438	-3	.018
21	418	-23	.018	22	190	-251	0.000	23	613	172	0.000	24	429	-12	.018
25	475	34	.017	26	408	-33	.017	27	463	22	.018	28	422	-19	.018
29	475	34	.017	30	340	-101	.009	31	355	-86	.012	32	514	73	.013
33	463	22	.018	34	480	39	.017	35	360	-81	.012	36	340	-101	.009
37	594	153	.002	38	434	-7	.018	39	558	117	.007	40	450	9	.018
41	420	-21	.018	42	486	45	.016	43	379	-62	.015	44	410	-31	.017
45	528	87	.011	46	735	294	0.000	47	556	115	.007	48	395	-46	.016
49	528	87	.011	50	560	119	.007	51	530	89	.011	52	540	99	.010
53	394	-47	.016	54	528	87	.011	55	523	82	.012	56	485	44	.017
57	521	80	.012	58	384	-57	.015	59	388	-53	.016	60	478	37	.017
61	465	24	.018	62	546	105	.009	63	339	-102	.009	64	437	-4	.018
65	412	-29	.018	66	420	-21	.018	67	581	140	.004	68	399	-42	.017
69	440	-1	.018	70	462	21	.018	71	354	-87	.011	72	346	-95	.010
73	605	164	.001	74	499	58	.015	75	318	-123	.006	76	308	-133	.005
77	535	94	.010	78	470	29	.018	79	405	-36	.017	80	375	-66	.014
81	474	33	.017	82	446	-5	.018	83	536	95	.010	84	478	37	.017
85	618	177	0.000	86	549	108	.008	87	367	-74	.013	88	350	-91	.011
89	475	34	.017	90	432	-9	.018	91	388	-53	.016	92	378	-63	.015
93	374	-67	.014	94	406	-35	.017	95	397	-44	.017	96	418	-23	.018
97	542	101	.009	98	560	119	.007	99	538	97	.010	100	570	129	.005
101	324	-117	.007	102	240	-201	0.000	103	295	-146	.003	104	284	-157	.002
105	430	-11	.018	106	430	-11	.018	107	390	-51	.016	108	445	4	.018
109	440	-1	.018	110	450	9	.018	111	430	-11	.018	112	430	-11	.018
113	403	-38	.017	114	588	147	.003	115	428	-13	.018	116	435	-6	.018
117	446	5	.018	118	450	9	.018	119	440	-1	.018	120	420	-21	.018
121	495	54	.016												

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SILICON METAL H EMISSION

MEAN AND ST DEV OF MEAN (N VALUES)	185.7236	5.5650
MEAN AND ST DEV OF MEAN (N' VALUES)	179.4407	5.0148
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	180.8253	3.9006

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	56	-125	.001	2	334	153	0.000	3	169	-12	.024	4	275	94	.008
5	107	-74	.013	6	268	87	.010	7	168	-13	.024	8	271	90	.009
9	92	-89	.009	10	193	12	.024	11	139	-42	.020	12	250	69	.014
13	88	-93	.008	14	168	-13	.024	15	137	-44	.020	16	217	36	.021
17	93	-88	.009	18	121	-60	.017	19	186	5	.024	20	120	-61	.016
21	220	39	.021	22	81	-100	.006	23	176	-5	.024	24	275	94	.008
25	141	-40	.021	26	213	32	.022	27	116	-65	.015	28	189	8	.024
29	217	36	.021	30	319	138	0.000	31	208	27	.023	32	99	-82	.011
33	178	-3	.025	34	213	32	.022	35	326	145	0.000	36	193	12	.024
37	146	-35	.022	38	153	-28	.023	39	229	48	.019	40	306	125	.001
41	209	28	.023	42	159	-22	.023	43	108	-73	.013	44	249	68	.015
45	204	23	.023	46	249	68	.015	47	196	15	.024	48	203	22	.023
49	185	4	.025	50	241	60	.017	51	311	130	0.000	52	185	4	.025
53	153	-28	.023	54	229	48	.019	55	223	42	.020	56	252	71	.014
57	190	9	.024	58	145	-36	.022	59	140	-41	.021	60	177	-4	.025
61	238	57	.017	62	201	20	.024	63	175	-6	.024	64	148	-33	.022
65	140	-41	.021	66	238	57	.017	67	182	1	.025	68	135	-46	.020
69	180	-1	.025	70	180	-1	.025	71	94	-87	.010	72	99	-82	.011
73	130	-51	.019	74	118	-63	.016	75	164	-17	.024	76	165	-16	.024
77	250	69	.014	78	232	51	.019	79	208	27	.023	80	212	31	.022
81	119	-62	.016	82	132	-49	.019	83	104	-77	.012	84	98	-83	.011
85	195	14	.024	86	116	-65	.015	87	223	42	.020	88	204	23	.023
89	238	57	.017	90	225	44	.020	91	212	31	.022	92	228	47	.019
93	86	-95	.008	94	76	-105	.005	95	94	-87	.010	96	92	-89	.009
97	192	11	.024	98	165	-16	.024	99	145	-36	.022	100	145	-36	.022
101	178	-3	.025	102	289	108	.004	103	380	199	0.000	104	307	126	.000
105	185	4	.025	106	185	4	.025	107	195	14	.024	108	175	-6	.024
109	270	89	.009	110	225	44	.020	111	220	39	.021	112	245	64	.016
113	220	39	.021	114	149	-32	.022	115	168	-13	.024	116	134	-47	.019
117	132	-49	.019	118	223	42	.020	119	161	-20	.024	120	210	29	.023
121	172	-9	.024	122	185	4	.025	123	200	19	.024				

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ALUMINUM METAL P EMISSION

MEAN AND ST DEV OF MEAN (N VALUES)	55.3069	1.7458
MEAN AND ST DEV OF MEAN (N' VALUES)	55.1563	1.5346
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	55.4685	1.2720

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	6	-49	0.000	2	65	10	.076	3	39	-16	.060	4	53	-2	.085
5	50	-5	.082	6	81	26	.032	7	39	-16	.060	8	45	-10	.075
9	59	4	.084	10	67	12	.072	11	44	-11	.072	12	35	-20	.048
13	5	-50	0.000	14	75	20	.051	15	39	-16	.060	16	52	-3	.084
17	50	-5	.082	18	94	39	0.000	19	35	-20	.048	20	52	-3	.084
21	72	17	.060	22	54	-1	.085	23	42	-13	.068	24	49	-6	.081
25	67	12	.072	26	82	27	.029	27	41	-14	.065	28	73	18	.057
29	50	-5	.082	30	54	-1	.085	31	74	19	.054	32	48	-7	.080
33	28	-27	.026	34	63	8	.080	35	59	4	.084	36	66	11	.074
37	46	-9	.076	38	68	13	.070	39	93	38	0.000	40	65	10	.076
41	51	-4	.083	42	58	3	.085	43	30	-25	.032	44	78	23	.042
45	36	-19	.051	46	83	28	.026	47	46	-9	.076	48	38	-17	.057
49	67	12	.072	50	34	-21	.045	51	61	6	.082	52	45	-10	.075
53	33	-22	.042	54	73	18	.057	55	45	-10	.075	56	49	-6	.081
57	50	-5	.082	58	67	12	.072	59	50	-5	.082	60	61	6	.082
61	69	14	.068	62	35	-20	.048	63	73	18	.057	64	83	28	.026
65	47	-8	.078	66	70	15	.065	67	59	4	.084	68	36	-19	.051
69	57	2	.085	70	38	-17	.057	71	78	23	.042	72	63	8	.080
73	33	-22	.042	74	70	15	.065	75	57	2	.085	76	69	14	.068
77	62	7	.081	78	62	7	.081	79	74	19	.054	80	44	-11	.072
81	59	4	.084	82	20	-35	.003	83	47	-8	.078	84	23	-32	.011
85	93	38	0.000	86	35	-20	.048	87	57	2	.085	88	45	-10	.075
89	85	30	.020	90	69	14	.068	91	50	-5	.082	92	44	-11	.072
93	66	11	.074	94	61	6	.082	95	70	15	.065	96	68	13	.070
97	58	3	.085	98	40	-15	.063	99	73	18	.057	100	46	-9	.076
101	64	9	.078												

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CHROMIUM METAL P EMISSION

MEAN AND ST DEV OF MEAN (N VALUES)	48.7526	2.1189
MEAN AND ST DEV OF MEAN (N' VALUES)	47.9655	1.0884
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	48.5506	.9064

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	20	-29	0.000	2	42	-7	.109	3	41	-8	.105	4	56	7	.105
5	100	51	0.000	6	56	7	.105	7	38	-11	.091	8	42	-7	.109
9	34	-15	.067	10	47	-2	.121	11	53	4	.115	12	10	-39	0.000
13	43	-6	.112	14	39	-10	.096	15	52	3	.118	16	200	151	0.000
17	52	3	.118	18	32	-17	.055	19	47	-2	.121	20	44	-5	.115
21	46	-3	.119	22	51	2	.119	23	38	-11	.091	24	58	9	.096
25	42	-7	.109	26	60	11	.086	27	44	-5	.115	28	41	-8	.105
29	54	5	.113	30	63	14	.068	31	21	-28	0.000	32	46	-3	.119
33	38	-11	.091	34	39	-10	.096	35	47	-2	.121	36	62	13	.074
37	76	27	0.000	38	45	-4	.118	39	55	6	.109	40	56	7	.105
41	32	-17	.055	42	54	5	.113	43	45	-4	.118	44	71	22	.018
45	49	0	.121	46	14	-35	0.000	47	35	-14	.074	48	28	-21	.029
49	66	17	.049	50	45	-4	.118	51	44	-5	.115	52	75	26	0.000
53	50	1	.121	54	20	-29	0.000	55	49	0	.121	56	33	-16	.061
57	59	10	.091	58	40	-9	.101	59	58	9	.096	60	60	11	.086
61	33	-16	.061	62	62	13	.074	63	64	15	.062	64	31	-18	.048
65	56	7	.105	66	48	-1	.121	67	61	12	.080	68	31	-18	.048
69	59	10	.091	70	45	-4	.118	71	64	15	.062	72	58	9	.096
73	41	-8	.105	74	61	12	.080	75	55	6	.109	76	31	-18	.048
77	55	6	.109	78	48	-1	.121	79	52	3	.118	80	20	-29	0.000
81	26	-23	.018	82	38	-11	.091	83	33	-16	.061	84	53	4	.115
85	62	13	.074	86	40	-9	.101	87	46	-3	.119	88	54	5	.113
89	54	5	.113	90	57	8	.101	91	55	6	.109	92	48	-1	.121
93	53	4	.115	94	54	5	.113	95	31	-18	.048	96	47	-2	.121
97	46	-3	.119												

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IRON METAL P EMISSION

MEAN AND ST DEV OF MEAN (N VALUES)	323.1791	7.7823
MEAN AND ST DEV OF MEAN (N' VALUES)	323.1791	7.7823
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	318.1077	5.4802

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	317	-1	.022	2	325	7	.022	3	306	-12	.022	4	281	-37	.020
5	385	67	.015	6	393	75	.013	7	384	66	.015	8	350	32	.020
9	323	5	.022	10	303	-15	.021	11	425	107	.007	12	354	36	.020
13	324	6	.022	14	408	90	.010	15	175	-143	.000	16	308	-10	.022
17	336	18	.021	18	285	-33	.020	19	335	17	.021	20	326	8	.022
21	291	-27	.021	22	317	-1	.022	23	276	-42	.019	24	372	54	.017
25	377	59	.016	26	274	-44	.019	27	289	-29	.020	28	263	-55	.017
29	295	-23	.021	30	388	70	.014	31	227	-91	.010	32	328	10	.022
33	387	69	.014	34	219	-99	.008	35	387	69	.014	36	270	-48	.018
37	369	51	.018	38	263	-55	.017	39	302	-16	.021	40	456	138	.001
41	460	142	.000	42	353	35	.020	43	285	-33	.020	44	310	-8	.022
45	462	144	.000	46	300	-18	.021	47	383	65	.015	48	231	-87	.011
49	341	23	.021	50	414	96	.009	51	291	-27	.021	52	327	9	.022
53	375	57	.017	54	312	-6	.022	55	452	134	.002	56	236	-82	.012
57	266	-52	.017	58	234	-84	.011	59	328	10	.022	60	366	48	.018
61	191	-127	.003	62	245	-73	.014	63	258	-60	.016	64	341	23	.021
65	320	2	.022	66	270	-48	.018	67	309	-9	.022				

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NICKEL METAL P EMISSION

MEAN AND ST DEV OF MEAN (N VALUES)	130.2673	3.1946
MEAN AND ST DEV OF MEAN (N' VALUES)	137.4778	2.1224
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	137.1913	1.5273

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	63	-74	0.000	2	127	-10	.063	3	117	-20	.049	4	153	16	.056
5	100	-37	.016	6	171	34	.022	7	121	-16	.055	8	126	-11	.062
9	40	-97	0.000	10	142	-5	.067	11	132	-5	.066	12	139	2	.068
13	43	-94	0.000	14	153	16	.056	15	116	-21	.047	16	145	8	.065
17	175	38	.014	18	171	34	.022	19	124	-13	.059	20	146	9	.064
21	18	-119	0.000	22	139	-2	.068	23	123	-14	.058	24	149	12	.061
25	123	-14	.058	26	149	12	.061	27	127	-10	.063	28	157	20	.049
29	96	-41	.008	30	126	-11	.062	31	120	-17	.054	32	158	21	.047
33	63	-74	0.000	34	157	20	.049	35	114	-23	.043	36	143	6	.066
37	123	-14	.058	38	162	25	.040	39	203	66	0.000	40	142	5	.067
41	114	-23	.043	42	134	-3	.067	43	90	-47	0.000	44	144	7	.065
45	140	3	.067	46	177	40	.011	47	44	-93	0.000	48	135	-2	.068
49	127	-10	.063	50	156	19	.051	51	117	-20	.049	52	137	-0	.068
53	172	35	.020	54	50	-87	0.000	55	181	44	.004	56	126	-11	.062
57	130	-7	.065	58	140	3	.067	59	132	-5	.066	60	145	8	.065
61	148	11	.062	62	126	-11	.062	63	161	24	.042	64	100	-37	.016
65	139	2	.068	66	85	-52	0.000	67	142	5	.067	68	162	25	.040
69	95	-42	.007	70	149	12	.061	71	95	-42	.007	72	144	7	.065
73	170	33	.024	74	85	-52	0.000	75	140	3	.067	76	165	28	.034
77	143	6	.066	78	145	8	.065	79	127	-10	.063	80	162	25	.040
81	150	13	.060	82	120	-17	.054	83	138	1	.068	84	111	-26	.037
85	139	2	.068	86	122	-15	.056	87	120	-17	.054	88	154	17	.054
89	94	-43	.005	90	129	-8	.064	91	128	-9	.064	92	131	-6	.066
93	139	2	.068	94	125	-12	.060	95	181	44	.004	96	135	-2	.068
97	123	-14	.058	98	145	8	.065	99	155	18	.052	100	108	-29	.031
101	140	3	.067												

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SILICON METAL P EMISSION

MEAN AND ST DEV OF MEAN (N VALUES)	27.4756	1.4122
MEAN AND ST DEV OF MEAN (N' VALUES)	24.7763	.9622
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	24.4003	.7895

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	27	3	.131	2	15	-9	.101	3	27	3	.131	4	50	26	0.000
5	31	7	.117	6	23	-1	.133	7	22	-2	.131	8	35	11	.093
9	15	-9	.101	10	39	15	.064	11	24	-0	.134	12	20	-4	.126
13	24	-0	.134	14	5	-19	.027	15	30	6	.122	16	18	-6	.118
17	15	-9	.101	18	26	2	.133	19	20	-4	.126	20	31	7	.117
21	10	-14	.065	22	33	9	.106	23	16	-8	.107	24	20	-4	.126
25	12	-12	.080	26	35	11	.093	27	21	-3	.129	28	28	4	.129
29	11	-13	.073	30	29	5	.125	31	9	-15	.057	32	40	16	.056
33	22	-2	.131	34	23	-1	.133	35	20	-4	.126	36	26	2	.133
37	18	-6	.118	38	23	-1	.133	39	13	-11	.088	40	27	3	.131
41	17	-7	.113	42	27	3	.131	43	35	11	.093	44	37	13	.079
45	63	39	0.000	46	26	2	.133	47	38	14	.071	48	41	17	.048
49	26	2	.133	50	37	13	.079	51	66	42	0.000	52	30	6	.122
53	28	4	.129	54	22	-2	.131	55	17	-7	.113	56	31	7	.117
57	31	7	.117	58	27	3	.131	59	20	-4	.126	60	31	7	.117
61	28	4	.129	62	23	-1	.133	63	56	32	0.000	64	26	2	.133
65	15	-9	.101	66	59	35	0.000	67	18	-6	.118	68	31	7	.117
69	14	-10	.095	70	20	-4	.126	71	43	19	.033	72	26	2	.133
73	37	13	.079	74	18	-6	.118	75	24	-0	.134	76	76	52	0.000
77	25	1	.134	78	24	-0	.134	79	44	20	.025	80	20	-4	.126
81	17	-7	.113	82	26	2	.133								

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ALUMINUM METAL R EMISSION

MEAN AND ST DEV OF MEAN (N VALUES)	24.9878	.8254
MEAN AND ST DEV OF MEAN (N' VALUES)	23.1757	.6077
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	22.5234	.4886

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	32	9	.100	2	22	-1	.200	3	45	22	0.000	4	40	17	0.000
5	34	11	.065	6	27	4	.175	7	23	0	.200	8	38	15	.003
9	29	6	.149	10	27	4	.175	11	32	-9	.100	12	39	16	0.000
13	25	2	.192	14	24	1	.198	15	41	18	0.000	16	42	19	0.000
17	20	-3	.192	18	24	1	.198	19	26	3	.185	20	19	-4	.184
21	44	21	0.000	22	28	5	.163	23	28	5	.163	24	24	1	.198
25	44	21	0.000	26	23	0	.200	27	31	8	.117	28	21	-2	.197
29	20	-3	.192	30	26	3	.185	31	31	8	.117	32	27	4	.175
33	20	-3	.192	34	21	-2	.197	35	31	8	.117	36	21	-2	.197
37	30	7	.133	38	19	-4	.184	39	37	14	.016	40	25	2	.192
41	30	7	.133	42	25	2	.192	43	15	-8	.133	44	18	-5	.174
45	29	6	.149	46	39	16	0.000	47	20	-3	.192	48	21	-2	.197
49	28	5	.163	50	16	-7	.148	51	16	-7	.148	52	15	-8	.133
53	20	-3	.192	54	17	-6	.162	55	22	-1	.200	56	24	1	.198
57	19	-4	.184	58	14	-9	.116	59	18	-5	.174	60	16	-7	.148
61	19	-4	.184	62	21	-2	.197	63	23	0	.200	64	19	-4	.184
65	22	-1	.200	66	23	0	.200	67	25	2	.192	68	26	3	.185
69	17	-6	.162	70	21	-2	.197	71	20	-3	.192	72	18	-5	.174
73	20	-3	.192	74	22	-1	.200	75	24	1	.198	76	24	1	.198
77	24	1	.198	78	22	-1	.200	79	20	-3	.192	80	20	-3	.192
81	22	-1	.200	82	15	-8	.133								

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CHROMIUM METAL R EMISSION

MEAN AND ST DEV OF MEAN (N VALUES)	44.5057	1.2506
MEAN AND ST DEV OF MEAN (N' VALUES)	44.8415	1.0425
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	45.0045	.8806

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	55	10	.097	2	33	-12	.083	3	52	7	.115	4	28	-17	.045
5	63	18	.037	6	39	-6	.120	7	56	11	.090	8	28	-17	.045
9	15	-30	0.000	10	49	4	.127	11	30	-15	.061	12	54	9	.104
13	39	-6	.120	14	52	7	.115	15	34	-11	.090	16	61	16	.053
17	45	-0	.133	18	51	6	.120	19	40	-5	.124	20	57	12	.083
21	26	-19	.030	22	60	15	.061	23	39	-6	.120	24	50	5	.124
25	26	-19	.030	26	52	7	.115	27	38	-7	.115	28	51	6	.120
29	46	1	.133	30	52	7	.115	31	51	6	.120	32	46	1	.133
33	53	8	.110	34	41	-4	.127	35	34	-11	.090	36	74	29	0.000
37	44	-1	.133	38	13	-30	0.000	39	36	-9	.104	40	36	-9	.104
41	76	31	0.000	42	49	4	.127	43	30	-15	.061	44	31	-14	.068
45	40	-5	.124	46	39	-6	.120	47	58	13	.076	48	52	7	.115
49	39	-6	.120	50	38	-7	.115	51	38	-7	.115	52	38	-7	.115
53	66	21	.016	54	54	9	.104	55	36	-9	.104	56	45	-0	.133
57	59	14	.068	58	52	7	.115	59	56	11	.090	60	52	7	.115
61	46	1	.133	62	49	4	.127	63	36	-7	.115	64	42	-3	.130
65	36	-9	.104	66	45	-0	.133	67	34	-11	.090	68	35	-10	.097
69	44	-1	.133	70	48	3	.130	71	50	5	.124	72	53	8	.110
73	51	6	.120	74	59	14	.068	75	40	-5	.124	76	40	-5	.124
77	55	10	.097	78	55	10	.097	79	50	5	.124	80	48	3	.130
81	50	5	.124	82	47	2	.132	83	38	-7	.115	84	35	-10	.097
85	35	-10	.097	86	35	-10	.097	87	15	-30	0.000				

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IRON METAL R EMISSION

MEAN AND ST DEV OF MEAN (N VALUES)	115.3218	3.5962
MEAN AND ST DEV OF MEAN (N' VALUES)	110.7470	2.8078
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	111.3788	2.2247

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	60	-51	.009	2	100	-11	.049	3	107	-4	.051	4	206	95	0.000
5	68	-43	.018	6	51	-60	.000	7	102	-9	.050	8	124	13	.048
9	143	32	.032	10	93	-18	.044	11	80	-31	.032	12	124	13	.048
13	65	-46	.015	14	124	13	.048	15	114	3	.052	16	142	31	.033
17	104	-7	.051	18	85	-26	.037	19	150	39	.024	20	130	19	.044
21	70	-41	.020	22	134	23	.041	23	79	-32	.031	24	137	26	.038
25	165	54	.007	26	59	-52	.008	27	142	31	.033	28	92	-19	.043
29	129	18	.045	30	139	28	.036	31	96	-15	.046	32	100	-11	.049
33	125	14	.048	34	127	16	.046	35	271	160	0.000	36	101	-10	.049
37	114	3	.052	38	147	36	.027	39	118	7	.051	40	148	37	.026
41	97	-14	.047	42	103	-8	.050	43	74	-37	.025	44	71	-40	.021
45	90	-21	.042	46	90	-21	.042	47	88	-23	.040	48	104	-7	.051
49	122	11	.049	50	125	14	.048	51	125	14	.048	52	179	68	0.000
53	144	33	.030	54	108	-3	.051	55	107	-4	.051	56	90	-21	.042
57	113	2	.052	58	138	27	.037	59	113	2	.052	60	135	24	.040
61	140	29	.035	62	120	9	.050	63	100	-11	.049	64	99	-12	.048
65	90	-21	.042	66	96	-15	.046	67	100	-11	.049	68	130	19	.044
69	102	-9	.050	70	162	51	.010	71	145	34	.029	72	134	23	.041
73	185	74	0.000	74	112	1	.052	75	108	-3	.051	76	100	-11	.049
77	100	-11	.049	78	93	-18	.044	79	82	-29	.034	80	98	-13	.048
81	151	40	.022	82	125	14	.048	83	125	14	.048	84	90	-21	.042
85	128	17	.046	86	151	40	.022	87	86	-25	.038				

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NICKEL METAL R EMISSION

MEAN AND ST DEV OF MEAN (N VALUES)	97.5253	1.6758
MEAN AND ST DEV OF MEAN (N' VALUES)	99.1895	1.5206
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	101.3036	1.1630

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	61	-40	0.000	2	104	3	.086	3	96	-5	.084	4	98	-3	.086
5	54	-47	0.000	6	53	-48	0.000	7	98	-3	.086	8	93	-8	.079
9	106	5	.084	10	73	-28	.022	11	78	-23	.039	12	104	3	.086
13	86	-15	.063	14	100	-1	.087	15	128	27	.028	16	90	-11	.074
17	109	8	.080	18	84	-17	.058	19	117	16	.062	20	116	15	.065
21	78	-23	.039	22	114	13	.070	23	102	1	.087	24	112	11	.075
25	117	16	.062	26	68	-33	.007	27	112	11	.075	28	119	18	.056
29	111	10	.077	30	101	-0	.087	31	126	25	.034	32	109	8	.080
33	106	5	.084	34	84	-17	.058	35	105	4	.085	36	123	22	.044
37	109	8	.080	38	113	12	.073	39	103	2	.086	40	114	13	.070
41	98	-3	.086	42	110	9	.079	43	117	16	.062	44	93	-8	.079
45	102	1	.087	46	92	-9	.078	47	99	-2	.086	48	123	22	.044
49	90	-11	.074	50	92	-9	.078	51	98	-3	.086	52	107	6	.083
53	108	7	.082	54	105	4	.085	55	98	-3	.086	56	92	-9	.078
57	73	-28	.022	58	66	-35	.002	59	105	4	.085	60	98	-3	.086
61	85	-16	.061	62	88	-13	.069	63	115	14	.068	64	112	11	.075
65	99	-2	.086	66	93	-8	.079	67	85	-16	.061	68	72	-29	.019
69	86	-15	.063	70	114	13	.070	71	100	-1	.087	72	112	11	.075
73	110	9	.079	74	116	15	.065	75	114	13	.070	76	102	1	.087
77	100	-1	.087	78	86	-15	.063	79	88	-13	.069	80	88	-13	.069
81	85	-16	.061	82	70	-31	.013	83	64	-37	0.000	84	82	-19	.052
85	86	-15	.063	86	106	5	.084	87	105	4	.085	88	130	29	.021
89	112	11	.075	90	105	4	.085	91	78	-23	.039	92	71	-30	.016
93	66	-35	.002	94	88	-13	.069	95	82	-19	.052	96	108	7	.082
97	108	7	.082	98	104	3	.086	99	100	-1	.087				

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SILICON METAL R EMISSION

MEAN AND ST DEV OF MEAN (N VALUES)	35.8736	1.2605
MEAN AND ST DEV OF MEAN (N' VALUES)	34.7262	1.1138
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	34.6070	.9686

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	43	8	.097	2	26	-9	.096	3	38	3	.110	4	28	-7	.103
5	44	9	.093	6	28	-7	.103	7	40	5	.106	8	43	8	.097
9	39	4	.108	10	36	1	.112	11	38	3	.110	12	46	11	.084
13	28	-7	.103	14	68	33	0.000	15	28	-7	.103	16	33	-2	.112
17	53	18	.048	18	24	-11	.088	19	45	10	.089	20	30	-5	.108
21	26	-9	.096	22	49	14	.069	23	36	1	.112	24	35	0	.113
25	32	-3	.111	26	21	-14	.073	27	49	14	.069	28	40	5	.106
29	50	15	.064	30	36	1	.112	31	32	-3	.111	32	41	6	.103
33	20	-15	.068	34	55	20	.037	35	33	-2	.112	36	22	-13	.078
37	48	13	.075	38	20	-15	.068	39	26	-9	.096	40	44	9	.093
41	34	-1	.113	42	28	-7	.103	43	27	-8	.099	44	22	-13	.078
45	40	5	.106	46	37	2	.111	47	39	4	.108	48	36	1	.112
49	21	-14	.073	50	22	-13	.078	51	38	3	.110	52	37	2	.111
53	22	-13	.078	54	25	-10	.092	55	36	1	.112	56	26	-9	.096
57	33	-2	.112	58	43	8	.097	59	50	15	.064	60	44	9	.093
61	33	-2	.112	62	39	4	.108	63	22	-13	.078	64	21	-14	.073
65	25	-10	.092	66	24	-11	.088	67	72	37	0.000	68	50	15	.064
69	50	15	.064	70	64	29	0.000	71	48	13	.075	72	45	10	.089
73	40	5	.106	74	35	0	.113	75	48	13	.075	76	40	5	.106
77	36	1	.112	78	35	0	.113	79	18	-17	.058	80	20	-15	.068
81	18	-17	.058	82	12	-23	.025	83	38	3	.110	84	26	-9	.096
85	46	11	.084	86	26	-9	.096	87	57	22	.026				

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IRON METAL H CHEMICAL

MEAN AND ST DEV OF MEAN (N VALUES)	945.4118	8.8825
MEAN AND ST DEV OF MEAN (N' VALUES)	940.4659	5.6430
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	946.9627	4.3418

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	1125	178	0.000	2	898	-49	.019	3	989	42	.020	4	825	-122	.003
5	945	-2	.023	6	873	-74	.013	7	952	5	.023	8	820	-127	.002
9	1170	223	0.000	10	969	22	.022	11	990	43	.020	12	925	-22	.022
13	1175	228	0.000	14	991	44	.019	15	984	37	.020	16	928	-19	.022
17	926	-21	.022	18	1150	203	0.000	19	1007	60	.016	20	992	45	.019
21	913	-34	.021	22	917	-30	.021	23	950	3	.023	24	950	3	.023
25	988	41	.020	26	970	23	.022	27	925	-22	.022	28	968	21	.022
29	1098	151	0.000	30	1018	71	.014	31	968	21	.022	32	985	38	.020
33	971	24	.022	34	969	22	.022	35	1033	86	.011	36	930	-17	.023
37	962	15	.023	38	1020	73	.014	39	944	-3	.023	40	997	50	.018
41	953	6	.023	42	970	23	.022	43	893	-54	.018	44	910	-37	.020
45	883	-64	.016	46	905	-42	.020	47	1065	118	.003	48	933	-14	.023
49	896	-51	.018	50	968	21	.022	51	899	-48	.019	52	941	-6	.023
53	923	-24	.022	54	935	-12	.023	55	1010	63	.016	56	952	5	.023
57	786	-161	0.000	58	908	-39	.020	59	910	-37	.020	60	966	19	.022
61	982	35	.021	62	940	-7	.023	63	1004	57	.017	64	1001	54	.018
65	805	-142	0.000	66	826	-121	.003	67	942	-5	.023	68	862	-85	.011
69	934	-13	.023	70	927	-20	.022	71	968	21	.022	72	952	5	.023
73	1004	57	.017	74	1311	364	0.000	75	1158	211	0.000	76	1013	66	.015
77	883	-64	.016	78	862	-85	.011	79	881	-66	.015	80	882	-65	.015
81	910	-37	.020	82	920	-27	.022	83	890	-57	.017	84	880	-67	.015
85	791	-156	0.000	86	797	-150	0.000	87	1022	75	.013	88	850	-97	.008
89	983	36	.021	90	993	48	.019	91	931	-16	.023	92	955	8	.023
93	834	-113	.004	94	824	-123	.002	95	807	-140	0.000	96	740	-207	0.000
97	758	-189	0.000	98	965	18	.023	99	935	-12	.023	100	845	-102	.007
101	960	13	.023	102	987	40	.020								

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IRON METAL P CHEMICAL

MEAN AND ST DEV OF MEAN (N VALUES)	341.5077	11.1315
MEAN AND ST DEV OF MEAN (N' VALUES)	328.3571	2.5729
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	326.3540	2.0635

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	300	-26	.037	2	340	14	.047	3	330	4	.051	4	293	-33	.030
5	725	399	0.000	6	342	16	.046	7	327	1	.051	8	323	-3	.051
9	55	-271	0.000	10	332	6	.051	11	308	-18	.044	12	320	-6	.050
13	312	-14	.047	14	363	37	.026	15	338	12	.048	16	303	-23	.040
17	384	58	.003	18	351	25	.039	19	329	3	.051	20	298	-28	.035
21	39	-287	0.000	22	328	2	.051	23	310	-16	.045	24	310	-16	.045
25	391	65	0.000	26	334	8	.050	27	326	-0	.051	28	315	-11	.048
29	494	168	0.000	30	345	19	.044	31	312	-14	.047	32	333	7	.050
33	506	180	0.000	34	339	13	.048	35	379	53	.008	36	315	-11	.048
37	322	-4	.051	38	300	-26	.037	39	504	178	0.000	40	331	5	.051
41	317	-9	.049	42	330	4	.051	43	536	210	0.000	44	347	21	.042
45	316	-10	.049	46	325	-1	.051	47	360	34	.029	48	343	17	.045
49	326	-0	.051	50	314	-12	.048	51	345	19	.044	52	322	-4	.051
53	319	-7	.050	54	330	4	.051	55	349	23	.040	56	339	13	.048
57	346	20	.043	58	312	-14	.047	59	330	4	.051	60	323	-3	.051
61	560	234	0.000	62	301	-25	.038	63	314	-12	.048	64	328	2	.051
65	360	34	.029												

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IRON METAL R CHEMICAL

MEAN AND ST DEV OF MEAN (N VALUES)	143.3553	9.4831
MEAN AND ST DEV OF MEAN (N' VALUES)	113.8030	2.5447
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	114.3650	2.3224

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	105	-9	.029	2	105	-9	.029	3	92	-22	.027	4	84	-30	.025
5	140	26	.026	6	120	6	.029	7	139	25	.027	8	140	26	.026
9	119	5	.029	10	271	157	0.000	11	101	-13	.028	12	100	-14	.028
13	55	-59	.017	14	58	-56	.018	15	148	34	.025	16	145	31	.025
17	120	6	.029	18	114	0	.029	19	129	15	.028	20	104	-10	.029
21	85	-29	.026	22	100	-14	.028	23	126	12	.029	24	136	22	.027
25	102	-12	.028	26	93	-21	.027	27	110	-4	.029	28	121	7	.029
29	328	214	0.000	30	291	177	0.000	31	112	-2	.029	32	111	-3	.029
33	105	-9	.029	34	103	-11	.029	35	113	-1	.029	36	130	16	.028
37	149	35	.024	38	121	7	.029	39	101	-13	.028	40	100	-14	.028
41	150	36	.024	42	153	39	.023	43	57	-57	.017	44	224	110	0.000
45	110	-4	.029	46	112	-2	.029	47	125	11	.029	48	130	16	.028
49	120	6	.029	50	120	6	.029	51	309	195	0.000	52	354	240	0.000
53	103	-11	.029	54	106	-8	.029	55	110	-4	.029	56	111	-3	.029
57	150	36	.024	58	132	18	.028	59	457	343	0.000	60	441	327	0.000
61	371	257	0.000	62	338	224	0.000	63	104	-10	.029	64	102	-12	.028
65	108	-6	.029	66	106	-8	.029	67	120	6	.029	68	115	1	.029
69	140	26	.026	70	120	6	.029	71	99	-15	.028	72	104	-10	.029
73	108	-6	.029	74	104	-10	.029	75	129	15	.028	76	127	13	.028

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ALUMINUM METAL H SPARK SOURCE

MEAN AND ST DEV OF MEAN (N VALUES)	189.0000	13.9044
MEAN AND ST DEV OF MEAN (N' VALUES)	189.0000	24.0832
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	177.5094	10.5257

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	103	-75	.012	2	146	-32	.024	3	156	-22	.026	4	260	82	.009
5	128	-50	.020	6	253	75	.011	7	290	112	.000	8	156	-22	.026
9	225	47	.020	10	160	-18	.027	11	173	-5	.028	12	211	33	.024
13	216	38	.023	14	145	-33	.024	15	213	35	.024				

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CHROMIUM METAL H SPARK SOURCE

MEAN AND ST DEV OF MEAN (N VALUES)	221.8125	8.1569
MEAN AND ST DEV OF MEAN (N' VALUES)	214.8667	4.5720
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	217.4941	3.6633

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	181	-36	.013	2	326	109	0.000	3	227	10	.067	4	238	21	.049
5	233	16	.058	6	213	-4	.072	7	205	-12	.063	8	240	23	.044
9	215	-2	.073	10	205	-12	.063	11	220	3	.073	12	213	-4	.072
13	220	3	.073	14	230	13	.063	15	188	-29	.028	16	195	-22	.044

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NICKEL METAL H SPARK SOURCE

MEAN AND ST DEV OF MEAN (N VALUES)	450.5000	11.5169
MEAN AND ST DEV OF MEAN (N' VALUES)	450.9167	4.2327
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	449.1192	3.5760

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	348	-101	0.000	2	461	12	.063	3	506	57	0.000	4	558	109	0.000
5	450	1	.071	6	430	-19	.051	7	478	29	.031	8	475	26	.037
9	445	-4	.070	10	455	6	.069	11	435	-14	.060	12	450	1	.071
13	449	-0	.071	14	445	-4	.070	15	385	-64	0.000	16	438	-11	.064

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SILICON METAL H SPARK SOURCE

MEAN AND ST DEV OF MEAN (N VALUES)	218.8125	22.8107
MEAN AND ST DEV OF MEAN (N' VALUES)	218.8125	26.3395
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	222.4366	20.1867

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	83	-139	.007	2	116	-106	.009	3	69	-153	.006	4	145	-77	.011
5	143	-79	.011	6	345	123	.008	7	355	133	.007	8	310	88	.011
9	325	103	.010	10	245	23	.013	11	170	-52	.012	12	261	39	.013
13	231	9	.013	14	225	3	.013	15	205	-17	.013	16	273	51	.012

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ALUMINUM METAL P SPARK SOURCE

MEAN AND ST DEV OF MEAN (N VALUES)	53.5556	1.9658
MEAN AND ST DEV OF MEAN (N' VALUES)	53.5556	2.6373
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	53.7043	1.8282

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	48	-6	.150	2	45	-9	.115	3	57	3	.170	4	62	8	.120
5	60	6	.144	6	53	-1	.180	7	56	2	.175	8	54	0	.180
9	47	-7	.139												

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CHROMIUM METAL P SPARK SOURCE

MEAN AND ST DEV OF MEAN (N VALUES)	46.8889	3.8996
MEAN AND ST DEV OF MEAN (N' VALUES)	43.8750	2.8058
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	43.8916	2.6937

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	55	11	.088	2	71	27	0.000	3	43	-1	.123	4	46	2	.122
5	50	6	.112	6	51	7	.108	7	37	-7	.109	8	34	-10	.095
9	35	-9	.100												

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NICKEL METAL P SPARK SOURCE

MEAN AND ST DEV OF MEAN (N VALUES)	139.1111	6.6174
MEAN AND ST DEV OF MEAN (N' VALUES)	139.1111	7.0188
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	135.3798	5.3912

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	155	20	.048	2	118	-17	.051	3	136	1	.063	4	176	41	.014
5	143	8	.061	6	155	20	.048	7	118	-17	.051	8	126	-9	.059
9	125	-10	.059												

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SILICON METAL P SPARK SOURCE

MEAN AND ST DEV OF MEAN (N VALUES)	32.5000	3.4641
MEAN AND ST DEV OF MEAN (N' VALUES)	35.1429	2.5859
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	36.2028	2.1890

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	14	-22	0.000	2	23	-13	.068	3	29	-7	.124	4	39	3	.149
5	37	1	.153	6	43	7	.127	7	39	3	.149	8	36	-0	.154

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ALUMINUM METAL R SPARK SOURCE

MEAN AND ST DEV OF MEAN (N VALUES)	17.1000	.6904
MEAN AND ST DEV OF MEAN (N' VALUES)	16.5556	.4747
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	16.2176	.3828

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	16	-0	.903	2	15	-1	.734	3	19	3	.207	4	15	-1	.734
5	18	2	.561	6	22	6	0.000	7	16	-0	.903	8	16	-0	.903
9	18	2	.561	10	16	-0	.903								

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CHROMIUM METAL R SPARK SOURCE

MEAN AND ST DEV OF MEAN (N VALUES)	38.7000	1.8918
MEAN AND ST DEV OF MEAN (N' VALUES)	38.7000	1.9941
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	38.0121	1.5307

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	32	-6	.162	2	30	-8	.122	3	34	-4	.194	4	38	-0	.222
5	38	-0	.222	6	43	5	.179	7	39	1	.220	8	38	-0	.222
9	46	8	.123	10	49	11	.059								

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NICKEL METAL R SPARK SOURCE

MEAN AND ST DEV OF MEAN (N VALUES)	94.8000	2.5768
MEAN AND ST DEV OF MEAN (N' VALUES)	94.8000	2.7142
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	94.1744	2.4290

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	105	11	.091	2	90	-4	.122	3	92	-2	.127	4	98	4	.123
5	106	12	.084	6	105	11	.091	7	93	-1	.128	8	85	-9	.101
9	86	-8	.106	10	88	-6	.115								

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SILICON METAL R SPARK SOURCE

MEAN AND ST DEV OF MEAN (N VALUES)	36.5000	2.7335
MEAN AND ST DEV OF MEAN (N' VALUES)	34.1111	1.4855
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	35.8063	1.0906

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	58	22	0.000	2	29	-7	.112	3	27	-9	.023	4	30	-6	.161
5	37	1	.325	6	39	3	.274	7	38	2	.305	8	37	1	.325
9	37	1	.325	10	33	-3	.287								

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ALUMINUM METAL H ATOMIC ABSORPTION

MEAN AND ST DEV OF MEAN (N VALUES)	189.1471	14.5586
MEAN AND ST DEV OF MEAN (N' VALUES)	184.0000	2.8527
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	183.7951	2.4743

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	553	369	0.000	2	451	267	0.000	3	174	-10	.058	4	168	-16	.053
5	132	-52	0.000	6	122	-62	0.000	7	169	-15	.054	8	178	-6	.061
9	220	36	.022	10	183	-1	.062	11	127	-57	0.000	12	126	-58	0.000
13	167	-17	.051	14	172	-12	.057	15	122	-62	0.000	16	118	-66	0.000
17	183	-1	.062	18	189	5	.061	19	131	-53	0.000	20	133	-51	0.000
21	194	10	.058	22	194	10	.058	23	198	14	.054	24	196	12	.056
25	197	13	.055	26	192	8	.059	27	186	2	.062	28	182	-2	.062
29	188	4	.061	30	185	1	.062	31	188	4	.061	32	194	10	.058
33	158	-26	.039	34	161	-23	.043								

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CHROMIUM METAL H ATOMIC ABSORPTION

MEAN AND ST DEV OF MEAN (N VALUES)	171.3824	4.3137
MEAN AND ST DEV OF MEAN (N VALUES)	172.4000	1.9647
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	171.4908	1.1288

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	174	3	.140	2	169	-2	.140	3	172	1	.143	4	173	2	.142
5	120	-51	0.000	6	117	-54	0.000	7	181	10	.103	8	178	7	.123
9	251	80	0.000	10	218	47	0.000	11	153	-18	.026	12	151	-20	.010
13	196	25	0.000	14	172	1	.143	15	142	-29	0.000	16	166	-5	.129
17	164	-7	.117	18	168	-3	.137	19	132	-39	0.000	20	144	-27	0.000
21	172	1	.143	22	171	-0	.143	23	166	-5	.129	24	169	-2	.140
25	171	-0	.143	26	170	-1	.142	27	173	2	.142	28	170	-1	.142
29	187	16	.052	30	187	16	.052	31	192	21	.010	32	191	20	.018
33	170	-1	.142	34	197	26	0.000								

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IRON METAL H ATOMIC ABSORPTION

MEAN AND ST DEV OF MEAN (N VALUES)	928.7778	13.9504
MEAN AND ST DEV OF MEAN (N' VALUES)	928.7778	16.1086
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	915.7068	11.3898

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	890	-26	.014	2	834	-82	.011	3	847	-69	.012	4	1044	128	.008
5	824	-92	.010	6	1120	204	.001	7	915	-1	.014	8	894	-22	.014
9	850	-66	.012	10	931	15	.014	11	840	-76	.012	12	882	-34	.014
13	1028	112	.009	14	1110	194	.002	15	794	-122	.008	16	827	-89	.011
17	895	-21	.014	18	935	19	.014	19	999	83	.011	20	910	-6	.014
21	1000	84	.011	22	858	-58	.013	23	991	75	.012	24	997	81	.011
25	1021	105	.009	26	1028	112	.009	27	1004	88	.011	28	908	-8	.014
29	1026	110	.009	30	909	-7	.014	31	899	-17	.014	32	825	-91	.011
33	853	-63	.012	34	897	-19	.014	35	909	-7	.014	36	942	26	.014

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NICKEL METAL H ATOMIC ABSORPTION

MEAN AND ST DEV OF MEAN (N VALUES)	431.8056	5.0307
MEAN AND ST DEV OF MEAN (N' VALUES)	437.6061	4.1531
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	437.4692	3.1393

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	408	-29	.034	2	373	-64	0.000	3	458	21	.043	4	496	59	.000
5	425	-12	.050	6	420	-17	.046	7	425	-12	.050	8	456	19	.045
9	414	-23	.041	10	414	-23	.041	11	412	-25	.038	12	412	-25	.038
13	427	-10	.051	14	450	13	.050	15	380	-57	.001	16	378	-59	0.000
17	424	-13	.049	18	440	3	.053	19	434	-3	.053	20	460	23	.041
21	461	24	.040	22	423	-14	.048	23	457	20	.044	24	445	8	.052
25	446	9	.052	26	404	-33	.029	27	442	5	.053	28	451	14	.049
29	461	24	.040	30	423	-14	.048	31	439	2	.053	32	353	-84	0.000
33	473	36	.027	34	445	8	.052	35	445	8	.052	36	471	34	.029

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SILICON METAL H ATOMIC ABSORPTION

MEAN AND ST DEV OF MEAN (N VALUES)	144.8333	10.1211
MEAN AND ST DEV OF MEAN (N' VALUES)	130.7000	3.9329
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	129.7360	3.6409

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	156	26	.037	2	150	20	.043	3	117	-13	.048	4	126	-4	.051
5	132	2	.052	6	122	-8	.050	7	125	-5	.051	8	127	-3	.052
9	127	-3	.052	10	125	-5	.051	11	224	94	0.000	12	207	77	0.000

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ALUMINUM METAL R ATOMIC ABSORPTION

MEAN AND ST DEV OF MEAN (N VALUES)	56.8125	15.8015
MEAN AND ST DEV OF MEAN (N' VALUES)	34.7333	2.4556
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	34.5727	2.4359

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	21	-14	.034	2	19	-16	.034	3	28	-7	.035	4	25	-10	.035
5	23	-12	.034	6	21	-14	.034	7	51	16	.033	8	52	17	.033
9	51	16	.033	10	53	18	.033	11	49	14	.034	12	51	16	.033
13	49	14	.034	14	53	18	.033	15	29	-6	.035	16	32	-3	.035
17	35	0	.035	18	31	-4	.035	19	28	-7	.035	20	23	-12	.034
21	24	-11	.035	22	22	-13	.034	23	21	-14	.034	24	23	-12	.034
25	45	10	.035	26	38	3	.035	27	21	-14	.034	28	17	-18	.033
29	453	418	0.000	30	323	288	0.000	31	56	21	.032	32	51	16	.033

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CHROMIUM METAL R ATOMIC ABSORPTION

MEAN AND ST DEV OF MEAN (N VALUES)	49.6765	1.2984
MEAN AND ST DEV OF MEAN (N' VALUES)	49.6765	1.3383
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	48.8868	1.0449

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	41	-8	.124	2	41	-8	.124	3	50	1	.171	4	54	5	.150
5	37	-12	.075	6	40	-9	.112	7	50	1	.171	8	51	2	.168
9	53	4	.158	10	53	4	.158	11	52	3	.164	12	50	1	.171
13	59	10	.098	14	59	10	.098	15	50	1	.171	16	42	-7	.134
17	51	2	.168	18	49	0	.172	19	56	7	.132	20	49	0	.172
21	50	1	.171	22	55	6	.142	23	63	14	.047	24	65	16	.023
25	46	-3	.165	26	43	-6	.144	27	42	-7	.134	28	41	-8	.124
29	61	12	.072	30	63	14	.047	31	48	-1	.171	32	46	-3	.165
33	39	-10	.100	34	40	-9	.112								

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IRON METAL R ATOMIC ABSORPTION

MEAN AND ST DEV OF MEAN (N VALUES)	123.5556	5.6042
MEAN AND ST DEV OF MEAN (N' VALUES)	114.0312	2.4763
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	112.8587	2.1336

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	106	-7	.062	2	98	-15	.055	3	122	9	.061	4	130	17	.052
5	136	23	.043	6	122	9	.061	7	92	-21	.047	8	100	-13	.057
9	111	-2	.064	10	111	-2	.064	11	118	5	.063	12	123	10	.060
13	111	-2	.064	14	126	13	.057	15	127	14	.056	16	115	2	.064
17	120	7	.062	18	115	2	.064	19	94	-19	.050	20	94	-19	.050
21	104	-9	.061	22	108	-5	.063	23	108	-5	.063	24	108	-5	.063
25	269	156	0.000	26	202	89	0.000	27	105	-8	.062	28	98	-15	.055
29	150	37	.018	30	143	30	.031	31	162	49	0.000	32	166	53	0.000
33	122	9	.061	34	121	8	.061	35	105	-8	.062	36	106	-7	.062

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NICKEL METAL R ATOMIC ABSORPTION

MEAN AND ST DEV OF MEAN (N VALUES)	106.0833	2.4137
MEAN AND ST DEV OF MEAN (N' VALUES)	104.8571	2.1393
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	108.0791	1.5994

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	80	-28	.011	2	80	-28	.011	3	110	2	.100	4	104	-4	.098
5	90	-18	.054	6	90	-18	.054	7	106	-2	.100	8	109	1	.101
9	117	9	.088	10	117	9	.088	11	117	9	.088	12	116	8	.090
13	115	7	.093	14	115	7	.093	15	116	8	.090	16	116	8	.090
17	121	13	.075	18	125	17	.059	19	114	6	.095	20	110	2	.100
21	104	-4	.098	22	116	8	.090	23	104	-4	.098	24	98	-10	.084
25	149	41	0.000	26	116	8	.090	27	82	-26	.019	28	82	-26	.019
29	103	-5	.096	30	102	-6	.095	31	112	4	.098	32	102	-6	.095
33	91	-17	.058	34	88	-20	.045	35	103	-5	.096	36	99	-9	.087

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SILICON METAL R ATOMIC ABSORPTION

MEAN AND ST DEV OF MEAN (N VALUES)	32.5000	1.2225
MEAN AND ST DEV OF MEAN (N' VALUES)	32.5000	1.2886
WEIGHTED MEAN AND STD DEV OF WEIGHTED MEAN (N' VALUES)	32.5833	.9216

I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)	I	X(I)	R(I)	W(I)
1	26	-7	.074	2	34	1	.379	3	38	5	.153	4	31	-2	.374
5	29	-4	.276	6	33	0	.398	7	33	0	.398	8	29	-4	.276
9	38	5	.153	10	34	1	.379								

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