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GRAPHITE BURN-OUT RESULTING FROM CARBON MONOXIDE FORMATION IN C PILE

BY

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TECHNICAL SECTION
ENGINEERING DEPARTMENT

FEBRUARY 1, 1954

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February 1, 1954

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GRAPHITE BURN-OUT RESULTING FROM CARBON MONOXIDE FORMATION IN C PILE

INTRODUCTION

With the introduction of carbon dioxide into the piles as a gas atmosphere, new problems arose which concerned the chemical reactions undergone by the pile graphite with the gas atmosphere. These problems have been outlined and discussed by Jones and Bupp(1), Wright and Woodley(2), and Knott(3). In the interest of obtaining a better understanding of the nature and extent of these graphite-gas reactions, mass spectrometer analyses of the pile gas from a selected sampling port at C Pile were initiated at the time of start-up of that unit and were continued until several steady state conditions had been observed. The results of these analyses are presented and discussed herein.

SUMMARY

Mass spectrometric analyses of C Pile atmosphere have been made during and following the start-up period. The data thus obtained reveal the gas composition during operation at several different power levels and graphite temperatures. The results have been correlated with leakage rates from the pile to calculate the rate of carbon monoxide formation and the net rate of graphite burn-out.

The data indicate that the rate of carbon monoxide formation does not increase with temperature and/or neutron flux over the temperature range 284°C-345°C and the power level range of 700-1000 MW in the C Pile. In this range the average carbon monoxide content of the pile atmosphere is 2.7%. The rate of loss of graphite from the unit by burn-out and escape of carbon monoxide is only 0.016% per year for the reaction $C + CO_2 = 2CO$ and is double this if the burn-out is due to the reaction of graphite with water vapor. The rate of loss is principally a function of the total leakage

rate, which averages 13.4% per day. It should be recognized that the data give no information on graphite that may be oxidized and subsequently redeposited elsewhere in the pile. Graphite weight loss experiments(5) indicate the graphite burn-out to be greater than this value by a factor of ten or more.

Conclusions to be drawn from the data are: (1) that it may be possible to operate the pile at graphite temperatures up to 500°C without incurring greater carbon monoxide loss, (2) that the low carbon loss could be further reduced if gas leakage from the pile were reduced.

DISCUSSION

One approach to aid in elucidating some of the problems associated with pile atmosphere is to observe changes in its composition over an extended period of time. However, in order to draw worthwhile conclusions from gas composition data, several other factors must be considered. For example, the quantity and quality of make-up gas added to the unit for some time prior to the analysis will have a marked influence on the gas composition, and, in turn, the amount of make-up gas added is dependent upon the leakage rate from the unit prior to and during the sampling period. The temperature, radiation flux, time since last shut-down, and gas flow rates all influence the reactions that may take place in the unit or in the gas circulating system as a whole. Therefore, an occasional gas sample from a reactor is of little value in itself.

In a unit with all the complexities of a Hanford pile, it is only feasible to obtain reliable information from gas analysis data by taking numerous samples and correlating the results obtained with all the known variables that influence the gas composition. The individual quantitative effects of these variables on the gas composition are not known so that in practice one must seek out periods during which the bulk of these variables remain at some steady state condition.

With the start-up of C Pile a program was established to daily analyze representative samples of the pile atmosphere and to correlate the data thus obtained with the various parameters already mentioned. C Pile was chosen because the graphite there would be exposed to the CO_2 atmosphere from the initial start-up and because it was believed that the gas leakage rate from a new unit would be small after the shakedown period. Furthermore, the power level at C Pile was expected to become higher than in the older Hanford units so that radiation induced effects would be accentuated. It must be emphasized that the quantitative data obtained by analysis of the C Pile gas samples and reported herein are subject to the many variables imposed by the non-homogeneous and complicated properties of the reactor and must be treated accordingly. However, with the amount of data at hand it is apparent that the results obtained show certain unequivocal trends that are in themselves significant and point the way to further experimentation. The gas composition observed at C Pile over an extended period of time, and the gas compositions observed at B, D, H, and F Piles were fewer samples were taken, are given in the Appendix to this report.

METHOD OF ANALYSIS

All samples at 100-C were taken at sample port No. 45, which is located near the bottom center of the back face of the pile and which supplied samples of gas that had passed through a central zone in the pile from front to rear. This region is between the thermocouples in rows 69 and 73. This particular section was selected because gases passing through it would have been subjected to about the maximum temperature and neutron flux within the unit. The samples taken from the other reactors were taken in similar positions in those units.

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The sampling bulbs were made of Pyrex U-tubes which were fitted with stopcocks on each leg and had a standard tapered joint for attachment to the mass spectrometer manifold. When a sample was taken, the pile gas was allowed to fill and flow through these tubes for about fifteen minutes to insure reasonably representative samples.

Samples of the pile atmosphere were taken from the sampling line and transported to the mass spectrometer laboratory at 100-B. Each sample was first analyzed "as is" to determine the CO_2 content; then the CO_2 was removed from a portion of the sample and the residual gas was analyzed to effect a precise and sensitive determination of the minor constituents. Carbon dioxide removal was accomplished while the U tube remained attached to the spectrometer manifold, by reducing the temperature of the gas to $-196^{\circ}C$ with liquid nitrogen to freeze out the bulk of the CO_2. The gas phase in the cold tube was then analyzed. In some of the later experiments the CO_2 was removed by passing the gas through "Ascarite" absorbent. Analyses of the residual gases were identical for either method of CO_2 removal. Typical mass spectra of a pile gas sample before and after CO_2 removal are shown in Figures 1 and 2. The approximate relative precision (std. deviation) for these analyses is as follows:

$CO_2 \pm 0.5\%$

$N_2 \pm 1.5\%$

$CO \pm 1.5\%$

$He \pm 0.5\%$

$H_2 \pm 0.5\%$

$O_2 \pm 0.5\%$

The detection limit for any mass is approximately 100 ppm; i.e., 0.01 mole %.

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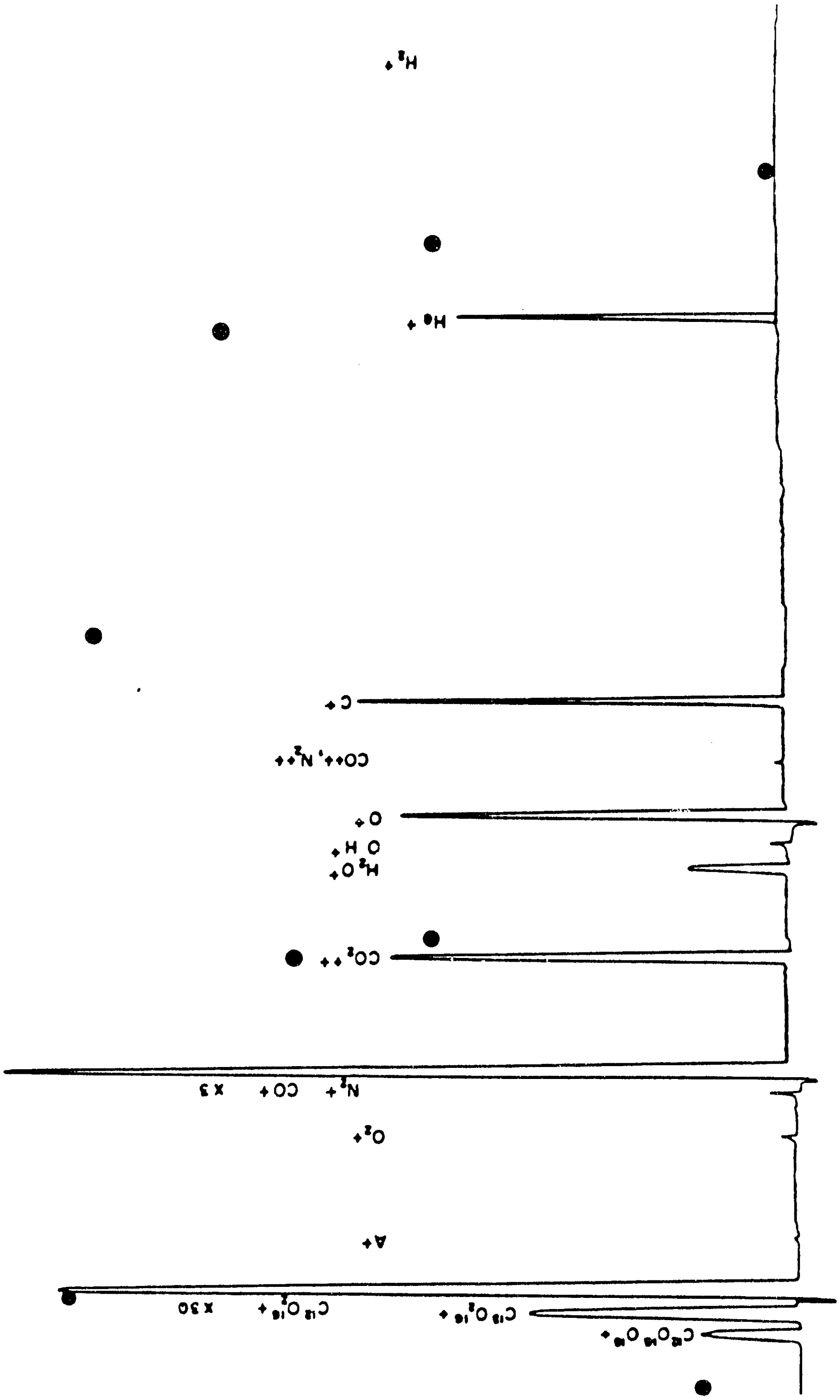

FIGURE I
MASS SPECTRUM OF PILE GAS

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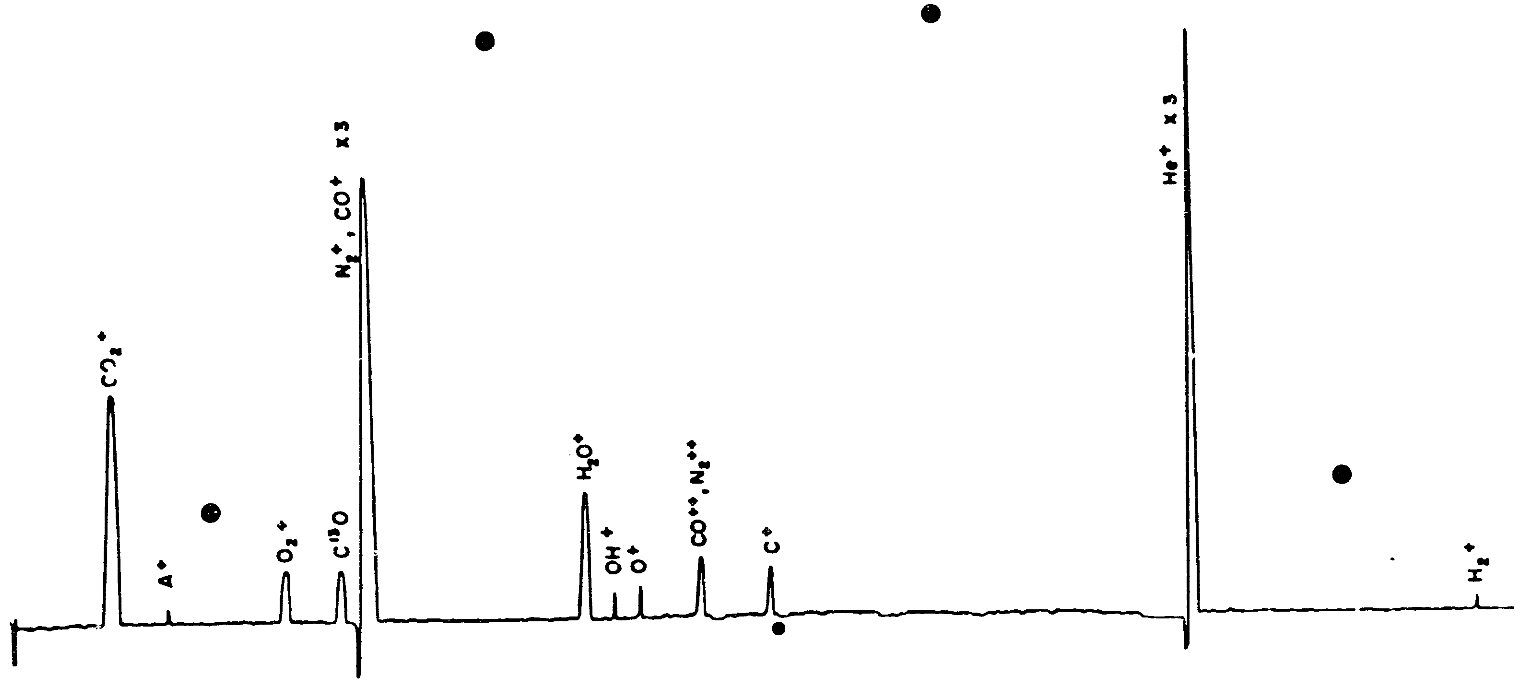

FIGURE 2
MASS SPECTRUM OF PILE GAS - CO_2 REMOVED

[redacted]

Rate of Carbon Monoxide Formation

During the period that these studies were made, there were two intervals in which the carbon monoxide concentration increased measurably from a low value to a higher steady state condition. These periods occurred when the unit had been purged with carbon dioxide after a shutdown. The pertinent data for these two periods are tabulated in Table I. In the first case, the pile operated at a power level of 500-600 MW and an average temperature of 282°C in the zone sampled. In the second case, the power level averaged 727 MW and 285°C. The first period listed is complicated by the presence of oxygen which gives rise to a high CO formation rate. The last five values in the second period are not complicated to any extent by this effect and show the increase of CO due to the reaction of the atmosphere with the pile graphite.

TABLE I
CARBON MONOXIDE GROWTH PERIODS

	Mole %			
Date	CO	N_2	O_2	Average volume loss from unit per day during this period
11/23/52	0.29	12.69	5.10	16%
24	0.64	4.10	0.60	
25	1.56	3.61	0.16	
26	1.31	2.60	0.01	
27	1.63	2.43	0.03	
28	1.73	2.37	0.05	
29	1.12	1.09	0.02	
30	1.71	2.03	0.01	
12/16/52	0.92	7.95	1.54	14%
17	1.09	5.95	0.28	
18	1.50	6.53	<.01	
19	1.57	5.91	<.01	
24	2.21	5.25	0.06	
26	2.64	4.63	0.01	
29	3.00	3.75	<.01	

[redacted]

If the logarithm of the carbon monoxide values for these five days is plotted vs. time, as in Figure 3, a straight line relationship is observed. This does not establish the order of the reaction for the CO formation, but if we make the assumption that the reaction is of the first order, a rate constant of 0.0631 day^{-1} is observed. This indicates that under the pile operating conditions at that time, the carbon monoxide concentration was increasing at the rate of 6.3% day to the steady state condition. This is a reasonably typical value for any such period since the pile variables at the time were representative of the normal conditions in the unit.

Amount of Carbon Monoxide at Steady State Conditions

Table II lists the six periods in which a steady state condition existed in the reactor unit during the period of study; the gas composition, power level, and temperature are average values for these respective periods. These steady state periods represent power levels ranging from 700 to 1000 MW and temperatures from 284°C to 353°C but show no significant change in CO content. Over this temperature and flux range the CO content seems to be a function of the CO_2 concentration. This was also observed during the time that helium was added to the unit to allow increased power level with decreased temperature; the mole % CO decreased, but the ratio CO/CO_2 remained constant and was independent of power level. This constancy of CO content with temperature and flux is in disagreement with the common belief that the CO will increase rapidly with an increase of temperature. The data presented herein indicate that it may be possible to go to the temperature which thermodynamically would predict a rapid CO increase before an excessive burn-out rate is encountered. Below 700 MW the CO content decreases with decreasing temperature or flux. This is shown in Figures 4 and 5 where the CO content is plotted vs. power level and temperature, respectively.

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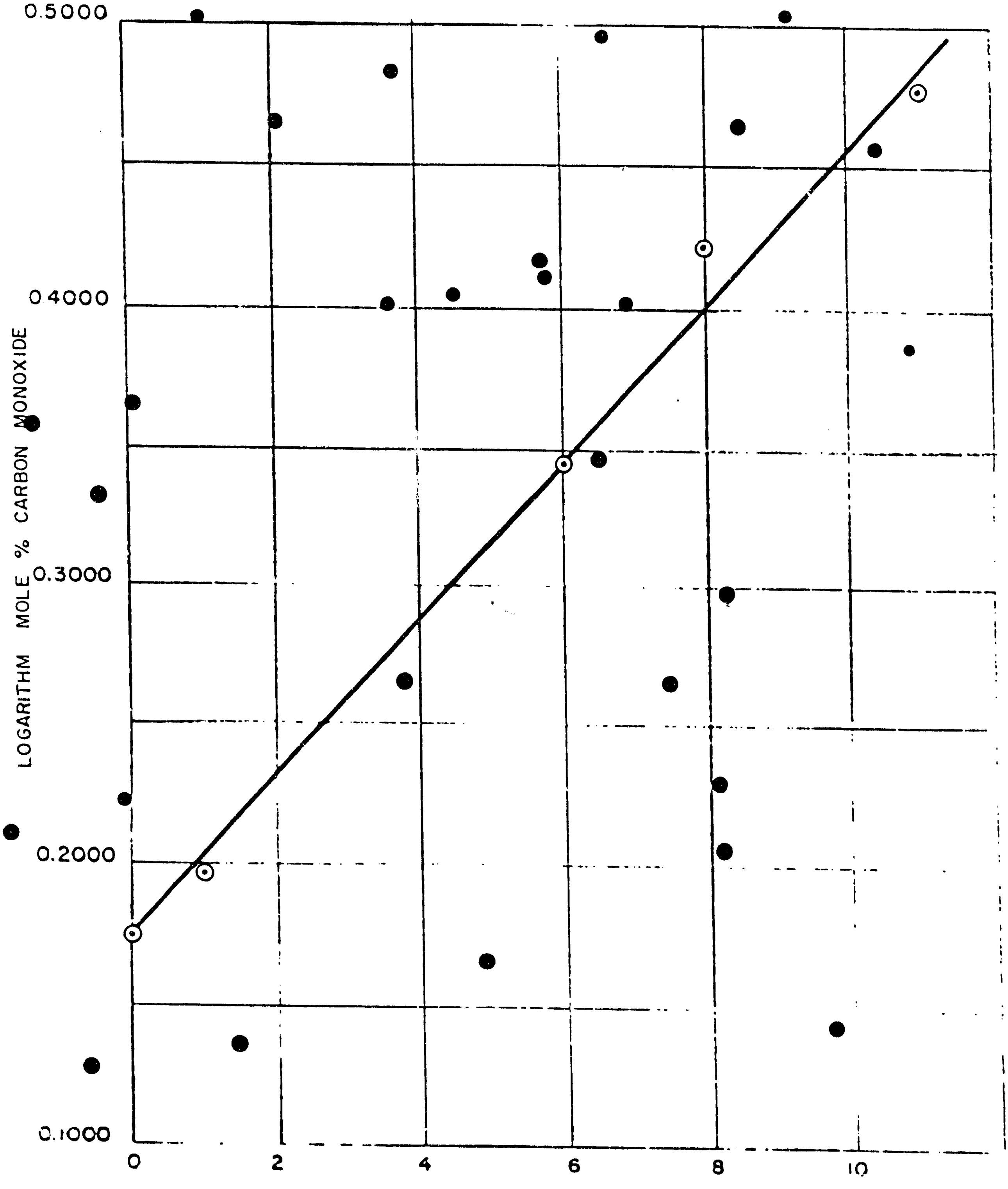

FIGURE 3
GROWTH OF CARBON MONOXIDE

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TABLE II

STEADY STATE PERIODS OBSERVED AT C PILE

Dates	Avg Power Level, MW	Avg Temp., °C	Avg Leakage Rate, % Added/Day			Mole %			
				CO_2	CO	N_2	He	H_2	CO/CO_2
12/29/52 to 1/23/53	709	284	11.7	93.33	2.78	1.46	none	0.01	0.029
2/13/53 to 2/27/53	759	300	10.0	94.92	2.50	2.50	none	0.04	0.026
3/18/53 to 3/30/53	798	312	11.9	94.93	2.78	2.26	none	<.01	0.029
5/22/53 to 6/5/53	941	353	14.1	94.61	2.70	1.45	none	0.14	0.029
7/27/53 to 8/3/53	897	327	16.9	85.10	2.51	0.57	11.66	0.10	0.029
8/13/53 to 8/31/53	994	308	15.9	69.30	1.93	0.58	25.58	0.09	0.028

Graphite Burn-Out Rate

The most probable reactions that may take place in a Hanford type reactor to form CO are as follows:

	K at 350° C
(1) $C + CO_2 \rightleftharpoons 2CO$	6.2×10^{-6}
(2) $C + H_2O \rightleftharpoons CO + H_2$	1.3×10^{-4}
(3) $CO_2 + H_2 \rightleftharpoons CO + H_2O$	4.8×10^{-2}
(4) $C + 1/2\ O_2 \rightleftharpoons CO$	----

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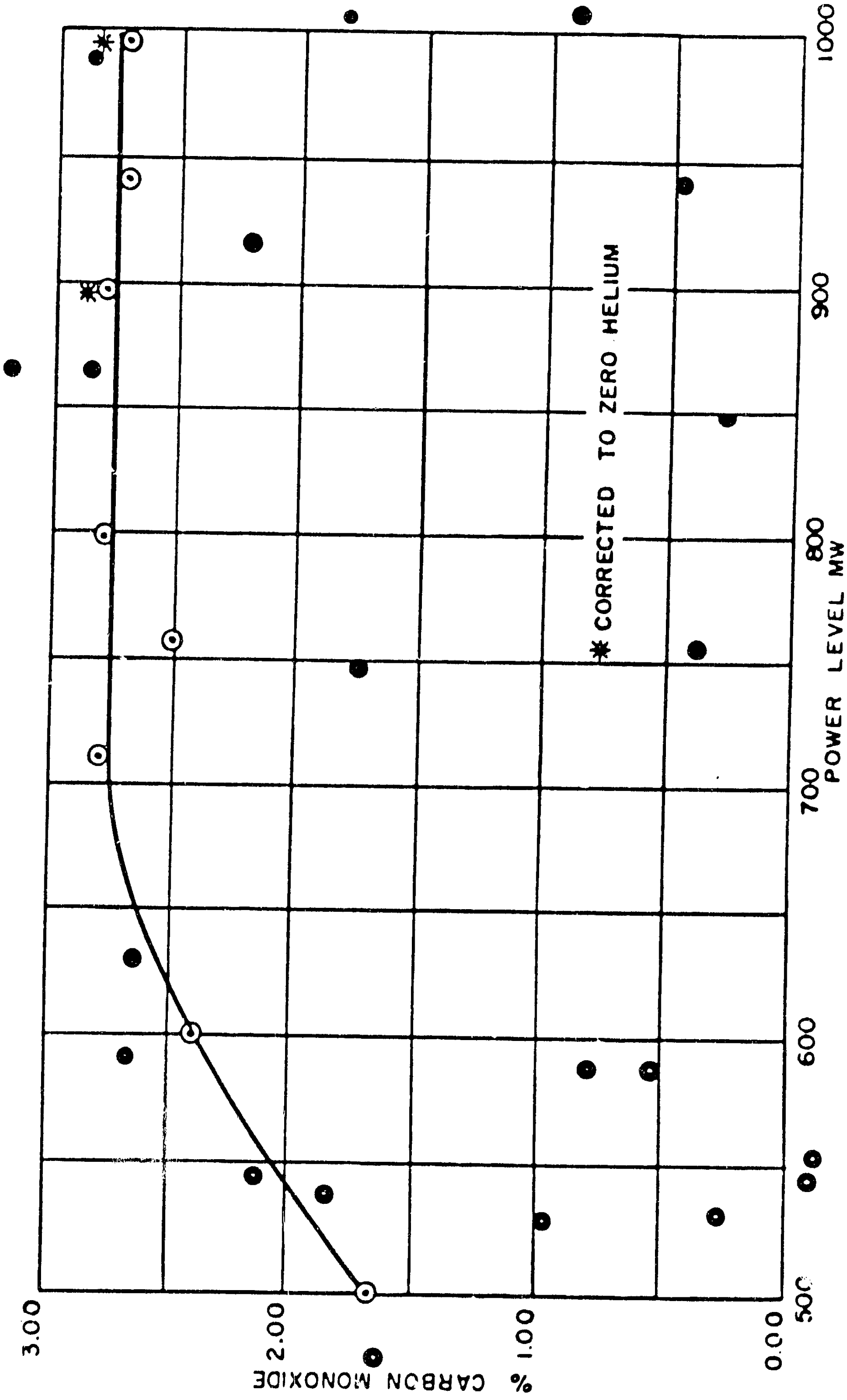

FIGURE 4
CARBON MONOXIDE CONTENT vs POWER LEVEL

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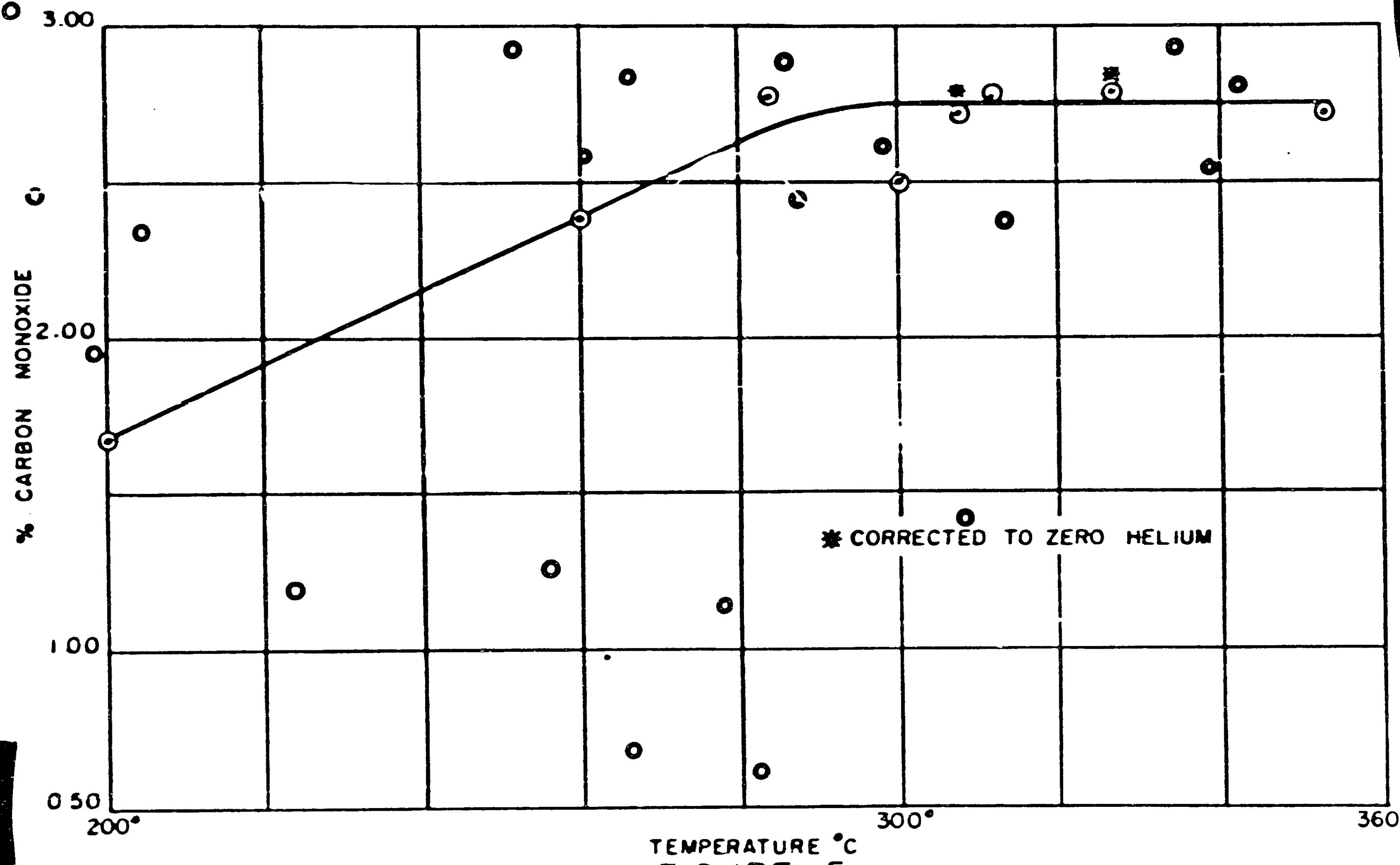

FIGURE 5
CARBON MONOXIDE CONTENT vs TEMP

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During periods of steady state the oxygen content is nil so that reaction (4) need not be considered as one of the primary sources of CO except in the case when oxygen may be present due to leakage, or as a reaction intermediate.

Reactions (1) and 2 represent a direct loss of graphite due to carbon monoxide formation. These reactions would not be expected to proceed significantly to the right at these temperatures as indicated by their respective thermodynamic equilibrium constants. Thus, if one or both of these reactions is the primary source of carbon monoxide, the thermodynamic equilibrium constants for these reactions are not valid under the complex conditions in the reactor. In the past this has been considered the case. Although reaction (3) does not represent a direct loss of graphite, it may, depending upon the source of hydrogen, indirectly be a step in a sequence of reactions that does result in graphite burn-out. The hydrogen may result from the decomposition of water by the radiation in the pile. If such is the case, each mole of water decomposed yields one-half mole of oxygen to react with graphite by reaction (4), so that for each mole of CO_2 reacting with hydrogen one mole of graphite may react with the oxygen to form carbon monoxide. Hydrogen may also result from a breakdown of the organic materials and moisture in the biological shield. This may or may not yield oxygen, and consequently, graphite burn-out. This is expected to be a rather minor source of hydrogen, however. Hydrogen could also arise as a result of reaction (2), but if the equilibrium constants are correct, this reaction would not take place to any appreciable extent. Another possibility of CO formation not listed is the direct rupture of CO_2 to CO and O_2 by pile radiation. This would also lead to graphite burn-out because of the oxygen released. Of the mechanisms suggested here, all except possibly the breakdown of the biological shield represent a graphite damage problem, involving one mole of carbon for either one or two moles of carbon monoxide produced, depending upon which mechanism is applicable.

[redacted]

The steady state hydrogen content of the C Pile gas ranged from 0.01 to 0.14% by volume, as shown in Table II, and the steady state water content is known to be approximately 0.1% by volume, based on dew point measurements. Taking average values for these constituents and calculating the equilibrium value for CO by reaction (3) at 350°C, the following results are obtained:

If, $CO_2 = 95\%$
$H_2 = 0.07\%$
$H_2O = 0.1\%$
$K_{350^\circ C} = 4.8 \times 10^{-2}$

Then,
$CO = 3.2\%$

This result is a rather good check of the experimental data.

Assuming that any of the mechanisms discussed above may apply to the data collected, the rate of burn-out of graphite by each mechanism has been calculated. The burn-out rate calculated on the basis of the five steady state periods shown in Table II is 0.016%/yr for either reaction (1), or reactions (3) plus (4), and 0.032%/yr for reaction (2). These values for the burn-out rate of graphite compare favorably with the values reported earlier (4) but will be low if CO polymerizes to lower oxides of carbon and deposits in the pile. Experimental results by Woodley(2, 5) show that the polymerization of carbon monoxide does take place under certain conditions; however, there are no data available as to the extent of the polymerization of CO in the process pile gas. The presently reported data thus give a measure of the graphite burn-out due to CO formation and should be corrected for any polymerization reactions when such data are available.

[redacted]

MISCELLANEOUS OBSERVATIONS

Abnormal Masses

The only abnormal masses or abnormally high peaks observed are those of m/e = 2, 15, and 30. Constituents of masses greater than m/e 46 have not been observed on any sample. The occasional peak at m/e 15, and the associated increase in m/e 2 peak, is probably due to methane or other hydrocarbons. These have appeared in only trace amounts. The peak at m/e = 30 has increased with time; it may be due to a growth of NO but the quantity of the constituent has not been sufficient to make positive identification. A more pronounced effect of minor constituents would undoubtedly be observed if the leakage rate of the unit were decreased so that true equilibrium conditions would be attained rather than conditions of steady state.

Data from Other Units

At D Pile a considerable number of samples were taken over a short period of time, and at B, DR, H, and F only a few analytical results are available. These data from the older units are difficult to interpret because operating conditions there are so varied that steady state conditions were not observed except for three periods at D Pile. The CO content is apparently less in these units than at C Pile. F Pile, which has not had helium additions during the periods reported, shows the same range of CO content that D Pile had prior to the helium addition. H Pile CO content is similar to that at DR on the basis of these data. The CO concentration at D Pile after helium was added is in the same range as that at H and DR. In general, the CO values in these piles (all but C Pile) range from 1 to 2%. The detailed data from these units are given in the Appendix.

Gas Leakage Rate

An inspection of the data reveals that the leakage rate of a new unit such as C Pile is excessive. A lower leakage rate would result in the following advantages.

1) Reduce graphite burn-out rate inasmuch as at steady state conditions the rate is only a function of the gas lost per unit time.
2) Decrease the nitrogen content of the atmosphere and thus yield a decrease in the in-hour loss.
3) Reduce the amount of CO_2 necessary to maintain constant pressure.
4) Allow more accurate evaluation of pile gas composition.

One factor of possible concern is that if the leakage occurs into a small or poorly ventilated space, the CO content of the air in that space may constitute a health hazard to personnel. Fifteen hundred to 2000 ppm of CO in air is dangerous if inhaled for a period of one hour, and 4000 ppm is fatal in less than one hour. This means that if the pile atmosphere leaked out and was diluted by no more than a factor of 10, it would constitute a serious health hazard.

CONCLUSIONS

The results of this study indicate that a temperature greater than that used previously may be used without an additional increase in the apparent burn-out rate being observed. The upper limit of temperature at which the CO may start to increase rapidly will probably be at a temperature of approximately 500°C as predicted by the thermodynamic equilibrium constant for the reaction $C + CO_2 \rightleftharpoons 2CO$. These data further show the desirability of decreasing the leakage rate from a pile. Further experiments are needed to ascertain the temperature and/or flux at which the burn-out rate increases excessively.

[redacted]

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APPENDIX

The data shown in this appendix include the date the sample was taken, the average power level of the unit for that day (previous 24 hours), the observed gas composition, and the per cent of the volume of the unit replaced that day. There are many days for which data are lacking. This is due to either poor sampling, a reactor shutdown, or other off-standard condition for that day.

An analysis of these raw data, coupled with the record of the operating conditions of the unit, enables one to pick out the steady state conditions listed in the text. The wide variation in the results shown, again emphasizes the complexity of the problem and stresses the need for a large amount of data.

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TABLE III

C PILE GAS COMPOSITION IN MOLE PERCENT

Date Sample Taken	Power Level MW	CO_2	CO	N_2	O_2	A	He	H_2	Volume of Make-up Gas add per day (% total)
11/13/52	0	65.6	.01	26.26	6.97	0.30	none	none	26.10
14	0	84.0	.01	11.99	3.10	0.15			9.49
17	0	80.73	.01	15.35		3.76			8.62
18	60	93.16	0.11	5.26	1.40	0.06			93.76
19	100	92.79	.01	5.65	1.49	0.07			13.77
20	100	93.10	0.03	5.37	1.44	0.07			15.38
21	100	89.10	0.23	8.46	2.11	0.10			22.60
23	400	81.76	0.29	12.69	5.10	0.16			20.34
24	500	94.63	0.64	4.10	0.60	0.05			10.56
25	500	94.62	1.56	3.61	0.16	0.05			17.72
26	500	96.05	1.31	2.60	0.01	0.03			22.88
27	500	95.88	1.63	2.43	0.03	0.03			14.50
28	500	95.90	1.73	2.37	0.05	0.03			14.09
29	600	97.78	1.12	1.09	0.02	0.02			8.97
30	600	96.26	1.71	2.03	0.01	0.02			18.80
12/6	655	69.91	2.21	19.52	5.80	0.24	2.32		10.14
9	685	94.03	2.67	0.92	0.01	0.02	2.35		4.44
10	685	94.10	2.06	1.73	< .01	0.02	2.09		10.64
11	715	94.33	1.96	1.89	0.01	0.02	1.79		19.36
12	715	92.60	2.81	2.41	< .01	0.03	2.15		12.96
16	556	89.19	0.92	7.95	1.54	0.10	0.27	0.04	29.20
17	705	92.42	1.09	5.95	0.28	0.07	0.16	0.02	8.16
18	715	91.62	1.50	6.53	< .01	0.08	0.23	0.04	9.40
19	724	92.93	1.57	5.91	< .01	0.09	0.16	0.04	16.10
24	725	92.35	2.21	5.25	0.06	0.08	0.02	0.03	15.76
26	735	92.44	2.64	4.63	0.01	0.08	0.05	0.17	10.24
29	735	92.90	3.00	3.75	0.01	0.07	0.02	0.25	10.24
30	710	93.83	2.29	3.73	<0.01	0.05	0.03	0.21	11.02
31	710	93.81	3.48	2.56	< .01	0.05	0.03	0.20	11.12

[redacted]

TABLE III (contd.)

Date Sample Taken	Power Level MW	CO_2	CO	N_2	O_2	A	He	H_2	Volume of Make-up Gas add per day (% total)
1/2/53	710	94.77	2.39	2.71	0.01	0.03	0.02	0.21	12.20
5	714	95.52	3.42	0.75	0.01	0.03	.01	0.29	12.00
7	725	96.0	2.55	1.35	.01	0.02	.01	0.22	9.32
12	715	96.49	2.43	.60	.01	0.11	.01	0.46	11.40
14	714	96.35	2.73	0.70	.01	.01	0.01	0.21	8.36
16	700	96.16	2.65	0.62	.01	.01	.01	0.56	11.80
20	693	96.37	2.43	0.91	0.02	.01	.01	0.27	13.20
21	690	96.43	3.21	0.11	.01	0.04	.01	0.24	12.58
2/4/53	694	90.69	1.40	7.60	0.21	0.10	0.01	0.02	13.48
6	735	91.74	1.41	6.79	.01	0.06	.01	.01	
9	755	94.95	1.16	3.77	.01	0.04	.01	0.07	12.00
11	760	96.04	1.23	2.62	.01	0.03	.01	0.07	14.12
13	760	96.01	2.47	1.50	.01	0.02	.01	0.01	6.72
16	750	95.66	2.49	1.78	.01	0.02	.01	0.12	10.76
18	746	96.63	2.24	1.08	0.03	0.02	.01	0.01	14.72
24	755	92.97	2.48	4.20	0.05	0.05	.01	0.30	9.42
25	760	93.73	2.68	3.56	.01	0.05	.01	0.10	4.78
27	770	94.52	2.64	2.90	.01	0.05	.01	0.11	7.60
3/2/53	777	96.29	1.56	2.00	0.02	0.02	.01	0.11	10.4
4	736	94.59	3.51	1.87	.01	0.02	--	.01	12.64
8		89.85	2.50	5.32	.01	0.06	2.11	0.16	18.5
9	592	91.66	2.23	6.00	.03	0.08			8.04
10		92.92	3.42	2.65	.01	0.04	0.97		8.08
11	745	92.40	2.30	5.23	.01	0.07			5.64
18	803	93.65	2.74	3.56	.01	0.04			5.6
20	798	93.97	2.89	3.10	.01	0.03			14.3
25	795	95.67	2.75	1.56	.01	0.01			14.6

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TABLE III (contd.)

Date Sample Taken	Power Level MW	CO_2	CO	N_2	O_2	A	He	H_2	Volume of Make-up Gas add per day (% total)
4/3/53	818	94.10	1.47	4.35	0.03	0.05			14.2
6	875	93.16	2.00	3.33	< .01	0.04	1.46		3.1
17	905	73.61	1.61	1.39	< .01	.01	22.92	<.01	104.4
20	806	89.42	1.54	4.83	0.06	.06	4.07	0.03	21.7
22	894	92.86	1.52	3.27	< .01	04	2.17	0.09	18.4
24	905	95.07	1.84	2.08	< .01	.02	0.85	0.08	21.0
27	905	94.42	2.27	2.10	< .01	0.04	2.01	0.51	5.7
29	404	93.99	2.27	2.62	0.48	0.04	0.51	0.08	
5/1/53	888	91.78	3.04	3.53	< .01	0.05	0.73	0.14	5.1
4	851	91.96	3.28	3.98	< .01	0.05	0.49	0.23	4.52
13	377	95.50	1.81	2.56	< .01	0.04	0.02	0.07	21.7
15	866	88.63	1.63	9.14	0.45	0.12	0.02	0.07	
18	648	92.05	1.74	6.04	< .01	0.07	0.02	0.08	25.7
20	757	89.11	1.30	8.70	0.74	0.11	<.01	0.04	7.6
22	920	91.68	2.11	6.04	0.01	0.08	0.01	0.07	15.2
25	930	94.37	2.59	2.89	0.01	0.04	<.01	0.10	13.3
29	936	94.29	3.16	2.29	< .01	0.03	<.01	0.22	16.4
6/1/53	954	95.21	3.06	1.51	< .01	0.02	0.01	0.20	14.1
3	968	97.03	2.41	0.42	0.01	0.01	<.01	0.12	10.3
5	970	95.13	2.86	0.12	< .01	0.01	1.77	0.12	18.1
8	960	92.12	3.25	0.17	< .01	0.01	4.30	0.16	13.8
10	960	94.39	2.36	0.93	< .01	0.01	2.25	0.10	20.7
24	860	96.05	2.32	1.05	0.03	0.01	0.49	0.09	25.9
29	776	94.25	0.97	4.51	< .01	0.05	0.18	0.05	14.4

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TABLE III (contd.)

Date Sample Taken	Power Level MW	CO_2	CO	N_2	O_2	A	He	H_2	Volume of Make-up Gas add per day (% total)
7/1/53	850	88.91	0.90	6.95	0.09	0.02	3.06	0.06	16.4
3	850	89.75	2.00	2.16	0.02	0.03	5.88	0.15	19.9
8	857	66.89	0.87	14.62	3.84	0.17	13.61	.01	15.3
10	862	94.21	2.32	0.48	0.04	0.01	0.30	0.13	14.7
13	822	97.61	1.32	0.30	0.02	.01	0.69	0.07	17.1
15	888	98.84	0.78	0.14	0.02	.01	0.18	0.03	17.9
17	890	98.71	0.91	0.16	0.02	.01	0.15	0.04	18.6
24	879	95.94	2.80	0.32	0.08	0.01	0.75	0.10	24.1
27	890	85.40	2.66	0.49	0.05	0.01	11.39	.01	16.8
29	890	84.24	2.47	0.62	0.04	.01	12.53	0.10	15.2
31	894	85.59	2.43	0.61	0.04	0.01	11.18	0.15	
8/3/53	885	85.21	2.49	0.56	0.03	0.01	11.55	0.16	
7	329	84.07	0.86	3.90	0.30	0.05	10.77	0.06	16.0
10	890	89.43	1.21	2.54	0.03	0.03	6.65	0.10	18.0
13	966	65.36	2.09	1.69	0.04	0.02	30.72	0.08	12.0
19	946	67.78	2.09	0.22	0.03	.01	29.74	0.14	16.8
25	993	70.54	7.91	0.28	0.03	.01	29.11	0.14	18.0
26	990	69.23	2.03	0.26	0.02	.01	28.41	0.08	19.2
28	999	70.30	1.54	0.63	.01	.01	27.48	0.05	15.2
31	1023	71.63	1.92	0.40	.01	.01	26.00	0.05	14.0
9/2/53	848	75.85	1.69	1.11	0.03	.01	21.27	0.05	
7	952	80.12	0.77	3.50	0.02	0.03	15.55	.01	
9	1000	81.19	0.79	2.38	0.02	0.03	15.55	0.04	
19	957	75.46	0.75	2.37	0.05	0.03	21.33	0.02	
20	1003	72.21	1.12	1.79	0.03	0.02	24.79	0.04	
23	367	83.73	0.84	5.25	0.02	0.07	10.08	0.01	
24	942	83.53	0.57	8.09	2.04	0.10	5.64	0.02	
28	1055	73.03	0.98	1.73	0.03	0.02	24.14	0.08	
29	1058	72.39	1.04	1.15	0.04	0.02	25.30	0.06	

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