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Manometer Report II: Manometric Calibrations of Primary Reference Gases and Internal Manometric Volume Calibrations During 1972

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Manometer Report II:

Manometric Calibrations of Primary Reference Gases

and

Internal Manometric Volume Calibrations

During 1972

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I. Introduction

Measurements were made during the fall of 1972 to redetermine the volume ratios of the constant volume manometric system previously determined in 1959 and 1961, and to redetermine the mole fraction of CO_2 in several reference gases previously analyzed in 1969 and 1970.

The manometric system consists of six chambers with volumes which vary by approximately a factor of four from 4 cc to 5000 cc. The five associated volume ratios were determined by measurements made from 12 September 1972 to 13 October 1972 by expanding CO_2 between adjacent sample chambers within the manometric system. In one case (250 to 1000 cc) gas transfer was made because the chambers are not adjacent. Each ratio determination used a different size sample of CO_2. The five ratios were multiplied together to obtain the overall 5000 cc/4 cc volume ratio required for the manometric calibration of reference gases.

Seven calibrations of three reference gases were made from 19 October 1972 to 13 November 1972. Owing to experimental difficulties, this work resulted in a rather poor set of calibrations and is dealt with only briefly in this report.

A problem with jumping mercury, wherein the mercury surface in the manometric chamber tends to bulge and jump into premature contact with a pointer, was encountered in nearly all of the measurements made in 1972. This problem apparently caused a

systematic error in the reference gas calibrations and may have affected the volume ratio results. The occurrence and effects of the jumping mercury problem are discussed in this report and again in Manometer Report III.

II. Experimental Procedures

Procedures discussed in detail in Manometer Report III will be only briefly mentioned here. The following discussion will describe specific gas handling procedures, the volume ratio calibrations and the jumping mercury problem. A full description of the manometric system is found in Manometer Report III.

A. Reference Gas Calibrations

Seven calibrations of three reference gases consisting of CO_2 in nitrogen were made in 1972 following the procedures discussed in detail in Manometer Report III.

Table 1 lists the original experimental data in the same format as in Manometer Report III. The output of the computer program MANØ 1, used to calculate the mole fraction of CO_2 from the data listed in Table 1, is included as Appendix 2.

Difficulties with jumping mercury were encountered in most of the calibrations listed in Table 1. Remarks indicating the severity of the problem are included on the computer output of MANØ 1. On many of the approaches to the 4 cc pointer the mercury surface bulged and jumped into contact with the pointer from a comparatively great distance below the pointer. Often the manometric

system cabinet was then jarred to dislodge the mercury and the approach to the pointer was continued. Usually a satisfactory approach could then be made, but the procedure may have resulted in error. The height of mercury in the sample column after dislodging the mercury from contact was typically .050 mm lower than the height before the mercury jumped into contact. Sometimes the approach to the 4 cc pointer was such that the mercury in the sample column had already made contact with the pointer after the first measurement of the vacuum column. In this situation the sequence of mercury height readings was as follows: (1) that of sample column close to pointer, (2) vacuum column, (3) sample column in contact, and (4) vacuum column. The two vacuum column measurements were always 0.100 mm or less apart, with the exceptions of the second approach for 6078-2 and the first approach for 2399-1.

In an attempt to reduce vibrations, hypothesized to be the cause of the jumping mercury, the fans were often shut off during the approach to the 4 cc pointer. This resulted in a temperature drift during the measurement. Measurements were also made in the morning after the fans had been off all night. Temperature drift in these cases was low, but gradients within the cabinet may have been abnormally large. In three cases, runs 1 and 2 for cylinder number 2399 and run 2 for cylinder number 10069, the measurement in the 5000 cc chamber of total gas was made under these conditions. Thermometer number 6115, situated near the 5000 cc

chamber, read about 0.08°C lower than the reading for thermometer number 6112, used to define the temperature of the measurement. Thus, a temperature error as great as 0.1°C, causing the calculated mole fraction to be 0.1 ppm high, may have occurred. On the other hand, since thermometer number 6112 is located near the 4 cc chamber, the CO_2 measurements made at the 4 cc pointer with the fans turned off probably had nearly the normal accuracy of temperature measurements.

Readings of all seven of the thermometers in the cabinet were made during the total gas measurements and preserved in Laboratory records. These readings are not reproduced in this report. For the total gas measurements in the 5000 cc chamber with the fans turned on, the maximum difference between the corrected readings of thermometers 6112 and 6115 was .03°C.

B. Volume Ratio Calibrations

The basic procedure used for the volume ratio calibrations was to fill, with purified CO_2, one of the sample chambers in the manometer to the maximum pressure permitted by the geometry of the system. The CO_2 gas pressure and temperature were then determined with the sample mercury column brought to near contact with the appropriate pointer. The gas was then expanded into the next larger sample chamber and its temperature and pressure measured. The gas was then compressed and measurements of the smaller volume repeated. Measurements were repeated at both pointers with the same sample of gas several times. The volume ratio of the two

adjacent manometric chambers was then calculated from all the data. This procedure was carried out for the following five volume pairs within the manometric system as denoted by the nominal volumes: 16 cc/4 cc, 64 cc/16 cc, 250 cc/64 cc, 1000 cc/250 cc, and 5000 cc/1000 cc. The five volume ratios calculated from the data multiplied together yield the overall 5000 cc/4 cc volume ratio.

Table 2 presents the experimental data for the 1972 volume ratio determinations arranged in chronological order. Included as a check are measurements of the height of the pointer made just before each calibrating measurement. Sample 1a involved the gas of sample 1 after transfer out of the small manometer and back in a series of vacuum sublimations. Sample 2a was derived from sample 2 in the same manner. Sample 2b refers to a special experiment using the same gas as sample 2a.

1. Filling of the Manometric Chamber with Purified CO_2

The volume ratio calibrating measurements were made on samples of CO_2 expanded from a cylinder of commercial CO_2 gas (supplied by the Matheson Company). Up to 1% by volume of the cylinder gas was found to be non-condensable, i.e. gas that did not freeze at liquid nitrogen temperature. For all the calibrations, the first step in the procedure was to flow the cylinder gas into the manometer through two traps at dry ice temperature to remove water vapor. The manometric sample chamber was filled with enough CO_2 so that a maximum pressure would be obtained in the smaller of the two chambers being

calibrated. For the 1000 cc/250 cc and 5000 cc/1000 cc calibrations, additional CO_2 was slowly added to that used for the previous, next smaller, calibration.

The second step was to purify the gas by transferring it out of the manometer to the associated vacuum line and then back into the manometer in a series of vacuum sublimations at dry ice temperature to remove any residual water vapor. The transfers were opened to the vacuum pump to pump away any non-condensable gases present. Vacuum gauge readings made after these sublimations indicated that the samples were adequately dried and purified by this procedure. For the first 16 cc/4 cc volume ratio calibration with sample 1, three sublimations were made on the gas. Four more were made on sample 1a used for the second set of 16 cc/4 cc measurements. Sample 2, used for the 64 cc/16 cc calibrations, was purified with four vacuum sublimations. Four more sublimations were made on the gas before the second set of calibrations, identified by sample 2a. Sample 3, for the 250 cc/64 cc calibrations, was purified with five vacuum sublimations. A noticeable lengthening of transfer times was observed with this sample. Sample 4, for the 1000 cc/250 cc calibrations, was purified with five sublimations. Transfer times were quite long and an appreciable amount of CO_2 was lost due to incomplete transfers. Sample 5, for the 5000 cc/1000 cc calibrations, was purified with two complete sublimations assisted with the pump plus one nearly complete sublimation without pumping. Transfer

times were the order of one hour even with pumping assistance. For these large samples, the CO_2 tended to melt very slowly at dry ice temperature. To speed up the process, the trap was isolated and thawed midway through the sublimation and then refrozen to dry ice temperature. Tests indicated that even this abbreviated purification process removed most of the water vapor.

2. Bulging Mercury Problems

The approach to the pointer and the measurement of mercury heights followed basically the same procedure described in Manometer Report III. Of particular importance in the volume ratio determinations is that the pointer be reproducibly approached on adjacent calibrations. For example, the height of mercury at the 16 cc pointer should be the same for the 16 cc/4 cc calibration as for the 64 cc/16 cc calibration. If this is achieved the 16 cc measurement and similarly the other three intermediate measurements are simple mathematical transfers which do not affect the overall 5000 cc/4 cc volume ratio. As for the 4 cc and 5000 cc pointer, these should be approached in the same manner as they are for a reference gas calibration in order to give a valid result.

Due to the severity of the jumping mercury problem, reproducibility of pointer approach was difficult to achieve in 1972. As in the case of the reference gas calibrations discussed above, the mercury surface typically bulged toward the pointer and often then jumped into premature contact with the pointer. The bulging at a particular

pointer was always worse with the sample of higher pressure. Thus, at the 16 cc pointer, bulging and jumping of the mercury surface was worse for the 64 cc/16 cc calibration than for the 16 cc/4 cc calibration. This was true for all calibrations including the 5000 cc/1000 cc calibration where very close approach to the pointer is not necessary and was not even attempted. As with the reference gas calibrations, the air circulating fans in the manometric system cabinet were often turned off before final close approach to the pointer was attempted. This resulted in a relatively large drift in the cabinet temperature during the time measurements were made, and thus introduced a temperature error in the results. In the following, each of the volume ratio calibrations will be discussed with relation to the jumping mercury problem and temperature error.

a. 16 cc/4 cc Volume Ratio

Bulging or jumping difficulties were not as pronounced as for the larger chambers. It was, however, difficult for optical reasons to see the 16 cc pointer make contact with the mercury surface. Nevertheless, final readings at the 16 cc pointer were quite reproducible and close to measurements taken of the pointer. The first 16 cc measurement was 0.080 mm below the pointer and bulging, but the remaining four were within 0.030 mm. In several of the 4 cc pointer measurements, the two vacuum column measurements, before and after contact, were 0.200 mm apart instead of less than 0.100 mm as is desirable.

The fans were turned off during most of the approaches resulting in temperature drifts of about 0.05°C in the five minutes required to make the final measurements. Two of the measurements were made after the fans had been turned off overnight. There was no appreciable temperature drift during these measurements, although temperature gradients within the cabinet were probably greater than those for measurements made with the fans running.

b. 64 cc/16 cc Volume Ratio. Special Experiment Involving Approach to 16 cc Pointer

Bulging of the mercury surface and jumping of the mercury into contact with the pointer were severe problems, especially at the 16 cc pointer, which could not be approached as closely as in the 16 cc/4 cc calibrations. There were also large differences between the two vacuum column measurements which were averaged to obtain the final vacuum column height for each 16 cc pointer measurement. This difference, which averaged 0.260 mm, introduced considerable scatter and possibly caused systematic error as well.

The fans were turned off during the approaches to the 16 cc pointer, resulting in temperature drifts of .05°C to 0.10°C over five minutes. The 64 cc pointer approaches had negligible temperature drift as they were run either with the fans on or with them off overnight. The approach to the 16 cc pointer experiment using sample 2b discussed below was run with the fans on.

The final sample column heights for the 16 cc pointer averaged about 0.076 mm below the pointer in the 64 cc/16 cc calibration

as compared to only 0.032 mm below the pointer in the 16 cc/4 cc calibration. A transfer error was thus introduced into the overall volume ratio. To investigate this error, measurements of both sample and vacuum column heights were made on sample 2b with the sample mercury column at several distances from the 16 cc pointer, roughly .200 mm, 0.100 mm and 0.050 mm. Contact with the pointer was made at the closest distance. A second approach was also made, but the mercury was bulging excessively even at the 0.200 mm distance from the pointer. Unfortunately the pointer height was read only once during each of these approaches. The pointer measurements in Table 2 show that the 16 cc pointer reading can vary by as much as 0.060 mm. A more extensive experiment of this type would be helpful in further analyzing the approach effect.

c. 250 cc/64 cc Volume Ratio

Appreciable bulging of the mercury surface occurred during two of the six measurements at the 64 cc pointer with the result that the final mercury heights were .074 and .077 mm below the pointer. Results calculated from those measurements with bulging were nevertheless only one part in 5000 different from the nonbulging results. Sample column heights for the four nonbulging measurements averaged 0.010 mm above the 64 cc pointer, the same as that obtained in the 64 cc/16 cc calibrations.

The fans remained on throughout the 250 cc/64 cc calibrations with no appreciable temperature drift or gradients within the cabinet.

d. 1000 cc/250 cc Volume Ratio

Bulging and jumping of the mercury surface were again encountered, especially at the 250 cc pointer, but the final sample column heights were quite close to the pointer. The final reading of the mercury height averaged .020 mm lower than the height of the 250 cc pointer in the 1000 cc/250 cc volume ratio calibrations; in the 250 cc/64 cc calibrations, the final reading averaged .008 mm above the pointer. Readings of the 250 cc pointer height varied by as much as .040 mm.

All four of the 250 cc measurements were made before transferring the gas to the 1000 cc chamber. As a check on possible loss of CO_2 during the 250 cc to 1000 cc transfer, the gas sample should have been transferred back to the 250 cc volume and re-measured. This procedure, however, was not carried out.

With one air circulating fan operating in the cabinet, no appreciable temperature drift occurred during the measurements. However, a gradient of .04°C persisted between thermometer number 6112, located near the 250 cc volume, and thermometer number 6115, located near the 1000 cc volume.

e. 5000 cc/1000 cc Volume Ratio

Bulging and jumping problems were again encountered, especially during the 1000 cc chamber measurement. Approach to the pointer during the 1000 cc chamber measurement could be made to only about .190 mm before contact was made, whereas for the 1000 cc/250 cc calibrations, the average distance of the final sample column height below the 1000 cc pointer was only 0.040 mm. The

difference of 0.15 mm represents a volume of about .04 cc or about one part in 20,000 in the 1000 cc volume and is thus negligible.

The 5000 cc chamber measurements were made quite close to the pointer but only two were made. All the 1000 cc chamber measurements were made prior to expansion of the gas sample into the 5000 cc chamber. This was a wise procedure in this case as no possible transfer losses could be incurred.

The middle air circulating fan was on throughout the measurements. Negligible temperature drift was encountered. However, there was a .05°C difference between thermometer number 6112 and thermometer number 6115. The reading of thermometer number 6112 was adopted as the temperature of each run to be consistent with the other calculations.

C. Meniscus Corrections

Corrections were determined before and after the volume ratio calibrations to allow for the true meniscus effect caused by differing size tubes of mercury columns and the effect due to any non-level swing of the cathetometer. The procedure outlined in Manometer Report III was followed. For the corrections at the 250 cc pointer and the 1000 cc/5000 cc pointer, several cm pressure of dry nitrogen was introduced into the sample and vacuum columns in order to lower the sample columns below the pointer. Both columns were evacuated to less than one millitorr pressure for the corrections at the remaining pointers.

Table 3 summarizes the meniscus correction data. The average applied correction over the two sets of determinations for each pointer, as defined, is to be added to all the intervening mercury height differences between vacuum and sample columns.

III. Calculations and Results

A. Reference Gas Calibrations

The method of calculation of the results is the same as that discussed in detail in Manometer Report III and will not be discussed here. Table 4 summarizes the results of calibrations made in 1972; the printout from the computer program MANØ 1, included in Appendix 2, contains more detailed information on the calculations and results. The mole fraction of CO_2 was calculated using a volume ratio of 1320.6 obtained from the volume calibrations made in 1974. Entries listed under Individual Determinations are results calculated from all possible combinations of individual 4 cc and 5000 cc measurements. For runs 6078-1 and 2399-2, two measurements of the total gas in the 5000 cc chamber were made.

The 1972 data scatter more than either the 1969-1970 data, reported in Manometer Report I, or the 1974 data, reported in Manometer Report III. The standard deviation of an individual run is 0.17 ppm as compared to 0.08 ppm for the 1974 data. This increased scatter is ascribed to the severe jumping mercury problems and to the imprecision in temperature measurement due to the air circulating fans being shut off during measurements.

The results for cylinder 6078 are very close to those obtained in 1974, but the results for cylinders 2399 and 10069 are both considerably higher. Only the measurements on 6078 were free from severe bulging problems and relatively free from temperature instabilities caused by the fans being turned off. The high results for cylinders 2399 and 10069 relative to 1974 are hard to explain in terms of the jumping mercury problem, since a low result is predicted when bulging or premature contact with the 4 cc pointer occurs. Bulging or premature contact at the 5000 cc pointer cannot produce a significant compensating error because of the very large volume of the chamber relative to the cross sectional area of the sample column. The low prediction is also supported by the observation that the mercury level, when dislodged from premature contact with the pointer, fell to a level lower than that immediately prior to bulging and contact. Inspection of the results for cylinder 2399 reveals no systematic effect in approaches to the pointer with bad bulging as compared to those with little bulging. The computer printout in the appendix may be consulted for details of the bulging situation and the temperature instability for each measurement.

The infrared analyzer index values for the reference gases analyzed in 1972 are listed in Table 9 of Reference Gas Report 26, reproduced in the appendix to Manometer Report III. The 1972 reference gas calibrations have not been used as primary data in the calibration of the infrared analyzer owing to the poor

experimental conditions, as outlined above.

B. Volume Ratio Calibrations

1. Calculations - Intermediate Results

The equation of state used to calculate results from the measured pressure, temperature, and volume is of the implicit form:

$$PV = nRT\left(1 + \frac{n}{V}B(T) + \ldots\right) \tag{1}$$

where P,V,T and n are the pressure, volume, absolute temperature, and moles of gas, R is the gas constant and B(T) is the temperature dependent second virial coefficient in the expansion of the compressibility factor PV in powers of the density 1/V. Higher order terms in 1/V are neglected.

The specific molar volume in cc/mole for a particular sample of gas, V/n, is thus:

$$\frac{V}{n} = \frac{2B}{\sqrt{1 + 4\frac{PB}{RT}} - 1} \tag{2}$$

where we choose the positive root of the equation in n^2 and where, specifically,

P = the pressure of the measurement, in dynes/cm^2

T = the temperature of the measurement, in °K

B = the second virial coefficient for CO_2 at the temperature of the measurement, in cm^3/mole

R = the gas constant, taken as 8.31436×10^7 ergs/mol - °K

The pressure P is calculated from the mercury height difference for a measurement by the equation:

$$P = \Delta h \cdot \rho_{Hg}(T) \cdot g \qquad (3)$$

where

Δh = the observed mercury height difference after the meniscus correction is applied, in cm

$\rho_{Hg}(T)$ = the density of mercury in the manometer at the observed temperature, in g/cc (g/ml ÷ 1.000027)

g = the acceleration of gravity at 32°52' N taken to be 979.558 cm^2/sec^2

A Wang programmable calculator program was used to calculate V/n for each measurement. Table 5 lists the input data to the program. Listed on the right side of the table are individual V/n values and values averaged over all the measurements for a particular sample of gas at a given pointer. The standard deviations of a single measurement are listed for each chamber. These vary from about one part in 2000 for the smaller chambers to about one part in 20,000 for the larger chambers. The rather high imprecision for the 5000 cc chamber (sigma of one part in 3500) is probably because only two measurements were made. No averages are calculated for sample 2b as that was a special set of measurements with the sample mercury column set at varying distances from the 16 cc pointer.

2. Volume Ratios

Division of the average V/n of the larger volume by that of the smaller volume yields the average volume ratio for a particular gas sample, listed in Table 6. The listed values of σ_R are obtained by combining the standard deviations for the average V/n's according to the following equation:

$$\sigma_R = R \sqrt{\left(\frac{\sigma}{V/n}\right)_L^2 + \left(\frac{\sigma}{V/n}\right)_S^2} \qquad (4)$$

where

σ_R = sigma of volume ratio

R = volume ratio

σ = sigma of V/n

V/n = average V/n for the smaller (S) or larger (L) volume for a gas sample.

For the 16 cc/4 cc and 64 cc/16 cc volume ratios, the volume ratios obtained for the two gas samples were averaged together with each ratio being weighted by the number of possible combinations of V/n's. For gas sample number 1, three measurements at each pointer were made, allowing nine possible combinations. For sample 1a, two measurements at each pointer were made allowing four possible combinations. Thus, the volume ratio for sample 1 received a weight of nine and that for sample 1a a weight of four. The variances (squares of the sigmas) were weighted by eight and three respectively

in order to obtain the sigma of the average ratio. This procedure yields the same average volume ratio and sigma as an alternate method of calculation in which each possible combination of V/n's is obtained and then all thirteen volume ratios averaged together and the simple sigma calculated. The results for gas sample 2 and 2a were combined in a similar manner. For the 250 cc/64 cc volume ratio, the result using all the data is listed along with the result using only the four preferred 64 cc V/n's.

The overall 5000 cc/4 cc volume ratio is obtained by multiplying together the five intermediate volume ratios. The overall sigma is obtained by combining the individual sigmas in the following equation:

$$(\sigma/R)\ \text{overall} = \sqrt{\sum_{i=1}^{5} (\sigma_i/R_i)^2} \qquad (5)$$

where R_i denotes the ith volume ratio and σ_i the sigma of the ith volume ratio.

3. Approach to 16 cc Pointer Experiment

The experimental data in this study of the approach to the 16 cc pointer were analyzed by calculating an apparent 64 cc/16 cc volume ratio for each measurement of sample 2b at varying distances below the 16 cc pointer. As a basis, the average V/n of the 64 cc measurements for both samples 2a and 2b was used (136183. with a σ of 29) since those data involved the same gas sample. To obtain

a best estimate for the height of the 16 cc pointer itself, all eleven of the measurements made were averaged together. The average pointer height thus obtained was 309.515 mm (σ of 0.020). The estimated distance of the mercury from the 16 cc pointer was then obtained by subtracting each mercury height from this average pointer height.

Figure 1 is a plot of the apparent volume ratio versus the distance of the sample mercury column from the 16 cc pointer. The data for the first approach, plotted as circles, fit well to a straight line obtained by least squares. The two points obtained for the second approach fall well off this line, however. The mercury surface was bulging toward the pointer in the second approach, even at a distance of 0.200 mm.

The straight line obtained from the first approach predicts a 64 cc/16 cc volume ratio of 3.9615 for the case of a distance from the pointer of .032 mm. The latter is the distance of the sample mercury column from the 16 cc pointer for the 16 cc/4 cc volume ratio calibration. This value is .073% or one part in 1370 higher than the value computed from samples 2 and 2a, suggestive that the results for these samples were influenced by bulging mercury.

IV. Discussion of Errors and Conclusions. Volume Ratio Calibrations

As discussed earlier the jumping mercury problem affected the 1972 volume ratio calibrations in several ways. Firstly, the

imprecision of the mercury height measurement was greater than otherwise because mercury heights in the sample column were harder to read and differences between vacuum column heights before and after contact with the pointer were greater. The additional imprecision from this source is estimated to be about one part in 4000 for the high pressure measurements most affected by the bulging and jumping of the mercury surface. Secondly, shutting off the air circulating fans in the manometric system cabinet caused excessive temperature drift and temperature gradients within the cabinet. The additional imprecision of the temperature measurements amounted to about .05°C or only about one part in 6000. These two effects may have caused both random and systematic errors, although the latter are not easily estimated. Thirdly, accuracy of the overall 5000 cc/4 cc volume ratio depends upon good reproducibility in approaching the pointer defining the intermediate volumes. As discussed above, this was not always the case. The most serious reproducibility error was probably at the 16 cc chamber pointer. A special experiment discussed above indicates a likely error of 1 part in 1370 in the direction of an under estimate of the 64 cc/16 cc ratio. An independent estimate of the transfer error can be made by noting the distances to the 16 cc pointer of the sample column heights recorded for the 16 cc/4 cc and 64 cc/16 cc volume ratio determinations. The difference between these readings corresponds to about one part in 1600 of the 16 cc chamber

volume.

More work needs to be done to resolve the discrepancy between the overall volume ratio obtained from the expansions presented in this report and that obtained by calibrating the volumes of the 4 cc and 5000 cc chambers with reference to separate vessels, as reported in Manometer Report IV. All the intermediate volume ratios should be redetermined under non-jumping conditions, if this is possible. If bulging cannot be overcome, good results may still be obtained if experiments to determine the approach to the pointer are carried out at all pointers as was done at the 16 cc pointer. After the experience of 1972, it is recommended that even if the mercury level bulges and jumps, the air circulating fans should be left on to eliminate temperature as a source of error.

Concurrent with new determinations of volume ratio by expansion, the intermediate 16 cc, 64 cc and 250 cc chambers should be calibrated with reference to separate vessels calibrated by weighing water or mercury. The two methods taken together should then resolve the source of the discrepancy.

TABLE 1. MANOMETRIC REFERENCE GAS CALIBRATIONS - EXPERIMENTAL DATA

CYLINDER NO. -RUN NO.	REF. GAS TYPE	DATE	VOLUME CC	VAC.COL. HEIGHT,MM	SAMPLE COL. HEIGHT,MM	TEMP. DEG.C	MENIS. CORR.,MM
6078 - 1	CO2 IN N2	19 OCT 72	5000	779.309	173.358	19.17	0.018
		19 OCT 72	5000	779.349	173.340	19.20	0.018
		20 OCT 72	4	619.690	370.652	19.45	-0.392
		20 OCT 72	4	619.609	370.648	19.53	-0.392
2399 - 1	CO2 IN N2	31 OCT 72	5000	805.611	173.230	19.74	0.018
		31 OCT 72	4	641.364	370.633	19.39	-0.392
		1 NOV 72	4	641.700	370.636	19.49	-0.392
6078 - 2	CO2 IN N2	1 NOV 72	5000	789.278	173.298	19.42	0.018
		2 NOV 72	4	623.334	370.639	19.35	-0.392
		3 NOV 72	4	624.043	370.672	19.80	-0.392
10069 - 1	CO2 IN N2	2 NOV 72	5000	803.699	173.270	19.16	0.018
		6 NOV 72	4	667.633	370.648	19.96	-0.392
		6 NOV 72	4	667.629	370.638	20.01	-0.392
2399 - 2	CO2 IN N2	3 NOV 72	5000	794.616	173.270	19.37	0.018
		6 NOV 72	5000	796.107	173.248	20.04	0.018
		8 NOV 72	4	637.156	370.658	19.70	-0.392
		8 NOV 72	4	637.490	370.620	19.86	-0.392
10069 - 2	CO2 IN N2	8 NOV 72	5000	805.530	173.312	19.75	0.018
		9 NOV 72	4	667.890	370.647	19.73	-0.392
		9 NOV 72	4	667.847	370.632	19.78	-0.392

TABLE 1. MANOMETRIC REFERENCE GAS CALIBRATIONS - EXPERIMENTAL DATA

CYLINDER NO. -RUN NO.	REF. GAS TYPE	DATE	VOLUME CC	VAC.COL. HEIGHT, MM	SAMPLE COL. HEIGHT, MM	TEMP. DEG.C	MENIS. CORR., MM
2399 - 3	CO2 IN N2	10 NOV 72	5000	797.927	173.277	19.08	0.018
		13 NOV 72	4	639.276	370.654	20.07	-0.392
		13 NOV 72	4	639.323	370.646	20.17	-0.392

Table 2. Manometric Volume Ratio Determinations - Experimental Data

CO_2 Sample No.	Notes	Date	Nominal Volume of Chamber cc.	Vacuum Column Height mm.	Sample Column Height mm.	Pointer Height mm.	Temperature °C
1		12 Sep 72	16	413.857	309.408	309.488	18.68
		12 Sep 72	4	809.238	370.610	370.610	18.64
		12 Sep 72	16	413.896	309.459	309.460	18.66
		13 Sep 72	4	811.118	370.614	370.630	19.59
		13 Sep 72	16	414.008	309.439	309.460	18.86
		13 Sep 72	4	809.324	370.581	370.600	18.73
1a	1	13 Sep 72	16	413.801	309.481	309.512	18.08
	1	13 Sep 72	4	808.702	370.604	370.620	18.32
	1	13 Sep 72	16	413.782	309.441	309.470	18.24
	1	14 Sep 72	4	810.606	370.645	370.642	19.35
2		19 Sep 72	64	362.234	228.005	228.032	18.79
	2	19 Sep 72	16	838.316	309.428	309.498	18.42
		19 Sep 72	64	361.913	228.007	227.990	18.08
	2	19 Sep 72	16	838.571	309.419	309.492	18.40
		19 Sep 72	64	361.933	228.003	227.980	18.11
	2	19 Sep 72	16	838.342	309.422	309.490	18.27
		20 Sep 72	16	840.252	309.489	309.550	19.18
2a	1	21 Sep 72	64	362.111	228.062	228.030	18.44
	1,2	21 Sep 72	16	837.393	309.390	309.510	17.90
	1	21 Sep 72	64	362.011	227.996	- - - -	18.48
	1	21 Sep 72	16	837.974	309.436	309.500	18.26
2b	1,3	28 Sep 72	16	839.240	309.318	309.530	19.22
	1,3	28 Sep 72	16	840.023	309.434	309.518	19.21
	1,2,3	28 Sep 72	16	840.308	309.480	309.534	19.20
	1,3	29 Sep 72	64	362.278	228.016	228.032	18.94
	1,2,3	29 Sep 72	16	838.291	309.320	309.510	18.96
	1,2,3	29 Sep 72	16	840.270	309.429	309.532	18.97
	1,3	29 Sep 72	64	362.605	228.042	228.010	19.48

Table 2. Manometric Volume Ratio Determinations - Experimental Data

CO_2 Sample No.	Notes	Date	Nominal Volume of Chamber cc.	Vacuum Column Height mm.	Sample Column Height mm.	Pointer Height mm.	Temperature °C
3	2	4 Oct 72	64	784.889	227.976	228.050	19.25
		4 Oct 72	64	785.057	228.038	228.010	19.08
		5 Oct 72	250	286.951	177.990	177.940	18.51
		5 Oct 72	250	286.866	177.929	177.938	18.53
	2	5 Oct 72	64	783.473	227.953	228.030	18.60
		5 Oct 72	64	783.876	228.042	228.022	18.59
		5 Oct 72	250	286.995	177.900	177.900	18.86
		5 Oct 72	250	286.994	177.889	177.900	18.83
		6 Oct 72	64	784.484	228.013	228.018	18.89
		6 Oct 72	64	784.476	228.017	228.020	18.88
4		10 Oct 72	250	736.200	177.886	177.880	19.40
		10 Oct 72	250	736.207	177.873	177.908	19.41
		10 Oct 72	250	736.089	177.845	177.900	19.37
		10 Oct 72	250	736.078	177.874	177.880	19.37
		10 Oct 72	1000	350.758	173.370	173.430	19.32
		11 Oct 72	1000	350.468	173.388	173.450	18.77
		11 Oct 72	1000	350.644	173.424	173.422	18.94
5		13 Oct 72	1000	782.638	173.248	173.450	19.56
		13 Oct 72	1000	782.634	173.333	- - - -	19.50
		13 Oct 72	1000	782.456	173.270	173.440	19.47
		13 Oct 72	5000	297.938	173.404	173.430	19.40
		13 Oct 72	5000	297.952	173.390	173.412	19.35

Notes: 1. Previous sample transferred out of manometer then back into manometer.
2. Mercury column bulging and jumping toward pointer badly.
3. Special experiment varying distance of sample mercury column from 16 cc pointer (using sample 2a)

Table 3. Meniscus Corrections

Date	Approx. Dist. from Mercury to Pointer mm.	Pointer Reading mm.	Number of Det'ns	Average Sample Column Height mm.	Average Vac. Column Height mm.	Applied Correction mm.
4 cc Pointer in Small Manometer (Col. #4 [Sample] vs. Col. #2 [Vacuum])						
8 SEP 72	0.16	370.654	10	370.490	370.922	-0.432
21 NOV 72	0.11	370.670	10	370.563	370.916	-0.353
					Average	-0.392
16 cc Pointer in Small Manometer						
8 SEP 72	0.26	309.480	10	309.225	309.231	-0.006
22 NOV 72	0.17	309.506	10	309.336	309.374	-0.038
					Average	-0.022
64 cc Pointer in Small Manometer						
8 SEP 72	0.24	227.970	10	227.727	227.758	-0.031
22 NOV 72	0.32	227.996	10	227.673	227.693	-0.020
					Average	-0.026
250 cc Pointer in Small Manometer						
8 SEP 72	0.22	177.860	10	177.642	177.635	+0.007
22 NOV 72	0.30	177.908	10	177.604	177.619	-0.015
					Average	-0.004
Pointer in Large Manometer (Col. #5 [Sample] vs. Col. #8 [Vacuum])						
8 SEP 72	0.30	173.391	10	173.083	173.057	+0.026
22 NOV 72	0.41	173.427	10	173.014	173.004	+0.010
					Average	+0.018

Table 4. Summary of 1972 Manometric Reference Gas Calibrations

Cylinder No.	Run No.	Individual Det'ns ppm	Run Average ppm	Overall Average ppm	Number of Runs
6078	1	310.88	310.78	310.83	2
		310.88			
		310.69			
		310.69			
	2	310.71	310.88		
		311.04			
2399	1	324.66	324.80	324.62	3
		324.94			
	2	324.44	324.57		
		324.44			
		324.71			
		324.70			
	3	324.53	324.50		
		324.48			
10069	1	355.87	355.84	356.01	2
		355.81			
	2	356.23	356.18		
		356.13			

$$\sigma = \sqrt{\frac{\Sigma d_i^{\,2}}{N_a - N_f}} = 0.17$$

Where σ = standard deviation of an individual determination
d_i = deviation of individual run from the mean for that reference gas
N_i = total number of determinations (7)
N_f^a = total number of reference gases (3)

Table 5. Volume Ratio Determinations - Intermediate Results

CO_2 Sample No.	Nominal Volume of Chamber cc.	Corr. Hg Height Diff. cm.	Temp. °K	Second Virial Coeff. cc/mol.	Density of Hg g/cc	V/n cc/mol.	Average V/n
1	16	10.4427	291.84	-129.27	13.5491	174944.	
	4	43.8236	291.80	-129.31	13.5492	41582.4	
	16	10.4415	291.82	-129.29	13.5492	174951.	
	4	44.0112	292.75	-128.38	13.5468	41548.1	
	16	10.4547	292.02	-129.10	13.5486	174858	174918. σ = 52 (of 3)
	4	43.8351	291.89	-129.22	13.5490	41585.0	41571.8 σ = 20.6 (of 3)
1a	16	10.4298	291.24	-129.87	13.5506	174780.	
	4	43.7706	291.48	-129.63	13.5500	41584.3	
	16	10.4319	291.40	-129.71	13.5502	174846.	174813 σ = 47 (of 2)
	4	43.9569	292.51	-128.62	13.5474	41563.3	41573.8 σ = 14.8 (of 2)
2	64	13.4203	291.95	-129.16	13.5488	136154.	
	16	52.8866	291.58	-129.53	13.5498	34406.4	
	64	13.3880	291.24	-129.87	13.5506	136132.	
	16	52.9130	291.56	-129.55	13.5498	34386.8	
	64	13.3904	291.27	-129.84	13.5505	136123.	136136. σ = 16 (of 3)
	16	52.8898	291.43	-129.68	13.5501	34385.7	
	16	53.0741	292.34	-128.78	13.5479	34379.7	34389.6 σ = 11.6 (of 4)
2a	64	13.4023	291.60	-129.51	13.5497	136164.	
	16	52.7981	291.06	-130.04	13.5510	34399.1	
	64	13.3989	291.64	-129.47	13.5496	136219.	136192. σ = 39 (of 2)
	16	52.8516	291.42	-129.69	13.5502	34409.2	34404.2 σ = 7.1 (of 2)
2b	16	52.9900	292.38	-128.74	13.5478	34439.5	(Special experiment varying
	16	53.0567	292.37	-128.75	13.5478	34394.9	distance of mercury sample
	16	53.0806	292.36	-128.76	13.5478	34378.1	column from 16 cc pointer)
	64	13.4236	292.10	-129.02	13.5484	136195.	
	16	52.8949	292.12	-129.00	13.5484	34469.1	
	16	53.0819	292.13	-128.99	13.5484	34348.4	
	64	13.4537	292.64	-128.49	13.5471	136155.	

Table 5. Volume Ratio Determinations - Intermediate Results

CO_2 Sample No.	Nominal Volume of Chamber cc.	Corr. Hg Height Diff. cm.	Temp. °K	Second Virial Coeff. cc/mol.	Density of Hg g/cc	V/n cc/mol.	Average V/n
3	64	55.6887	292.41	-128.71	13.5477	32767.9	
	64	55.6993	292.24	-128.88	13.5481	32741.4*	
	250	10.8957	291.67	-129.44	13.5495	167562.	
	250	10.8933	291.69	-129.42	13.5495	167611.	
	64	55.5494	291.76	-129.35	13.5493	32772.6	
	64	55.5808	291.75	-129.36	13.5493	32752.8*	
	250	10.9091	292.02	-129.10	13.5486	167569	
	250	10.9101	291.99	-129.12	13.5487	167535.	167569. σ = 32 (of 4)
	64	55.6445	292.05	-129.07	13.5486	32751.0*	
	64	55.6433	292.04	-129.08	13.5486	32750.6*	32756.0 σ = 11.8 (of 6)
						(of 4 preferred)	32749.0 σ = 5.1
4	250	55.8310	292.56	-128.57	13.5473	32702.0	
	250	55.8330	292.57	-128.55	13.5473	32702.0	
	250	55.8240	292.53	-128.60	13.5474	32702.5	
	250	55.8200	292.53	-128.60	13.5474	32704.8	32702.8 σ = 1.2 (of 4)
	1000	17.7406	292.48	-128.64	13.5475	103163.	
	1000	17.7098	291.93	-129.18	13.5489	103137.	
	1000	17.7238	292.10	-129.02	13.5484	103120.	103140. σ = 22 (of 3)
5	1000	60.9408	292.72	-128.41	13.5469	29966.6	
	1000	60.9319	292.66	-128.47	13.5471	29964.4	
	1000	60.9204	292.63	-128.50	13.5471	29966.9	29966.0 σ = 1.4 (of 3)
	5000	12.4552	292.56	-128.57	13.5473	147038.	
	5000	12.4580	292.51	-128.62	13.5474	146979.	147008. σ = 42 (of 2)

*Preferred data

Table 6. Volume Ratio Determinations - Summary of Results

CO_2 Sample No.	Nominal Volumes V_2/V_1 cc	Ratio	σ_R	Average Ratio	Average σ_R	σ_R/R
1	16/4	4.2076	.0024			
1a	16/4	4.2049	.0019	4.2068	.0023	.00055
2	64/16	3.9586	.0014			
2a	64/16	3.9586	.0014	3.9586	.0014	.00035
3	250/64			5.1168[1]	.0013	.00025
	250/64			5.1157[2]	.0021	.00041
4	1000/250			3.1539	.0007	.00022
5	5000/1000			4.9058	.0014	.00028
Overall	5000/4			1318.41[1]	1.04	.00079
				1318.12[2]	1.12	.00085

[1]Using preferred data for 250 cc/64 cc ratio

[2]Using all data for 250 cc/64 cc ratio

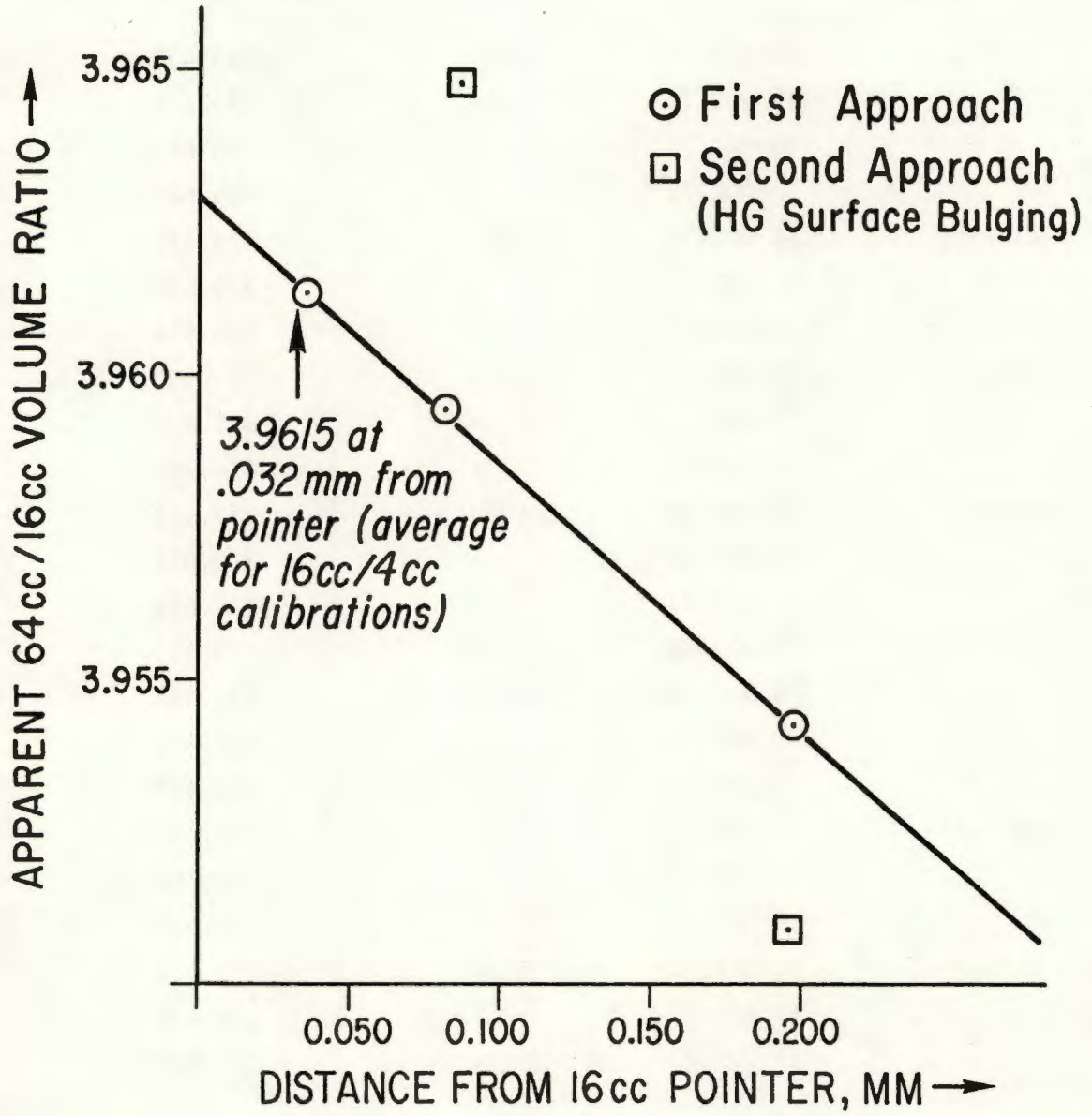

Figure 1. Approach to 16 cc Pointer Experiment

Appendix 1. Pointer Heights for Reference Gas Calibrations

Cylinder No. Run No.	Date	Volume, cc	Pointer Height, mm
6078-1	19 OCT 72	5000	173.430
	19 OCT 72	5000	173.432
	20 OCT 72	4	370.660
	20 OCT 72	4	370.680
2399-1	31 OCT 72	5000	173.422
	31 OCT 72	4	370.650
	1 NOV 72	4	370.654
6078-2	1 NOV 72	5000	173.400
	2 NOV 72	4	370.636
	3 NOV 72	4	370.708
10069-1	2 NOV 72	5000	173.458
	6 NOV 72	4	370.650
	6 NOV 72	4	370.652
2399-2	3 NOV 72	5000	173.410
	6 NOV 72	5000	173.444
	8 NOV 72	4	370.640
	8 NOV 72	4	370.642
10069-2	8 NOV 72	5000	173.440
	9 NOV 72	4	370.665
	9 NOV 72	4	370.645
2399-3	10 NOV 72	5000	173.422
	13 NOV 72	4	370.634
	13 NOV 72	4	370.658

Appendix 2. Printout from Computer Program MANO 1.

The following pages are copies of the printout from the computer program MANO 1 which calculates the manometric CO_2 concentrations from the experimental data. Some comments on the printout follow.

For the usual run with one total gas measurement in the large manometer and two CO_2 measurements in the small manometer, there are two pages of printout showing calculation of the CO_2 concentrations by combination of the large manometer measurement with each of the small manometer measurements plus another page summarizing both concentrations obtained for that run. For runs with more measurements, each possible combination of CO_2 and total gas measurement is calculated on a separate page of printout. The following experimental data appears on the printout: the observed mercury heights, the observed temperatures and the appropriate meniscus corrections. Also shown are the mercury densities, linearly interpolated from the table included in the program; the virial coefficients, interpolated from the tabular values using a quadratic Lagrangian interpolation; the calculated pressure in dynes per square centimeter; the values of the constants, acceleration due to gravity and gas constant; and the calibrated volumes of the 4 cc and 5000 cc sample chambers.

Appendix 2. Printout from Computer Program MANO 1. (continued)

The reference gas calibrations of 1972 are arranged in the appendix in order of reference gas cylinder number. Comments, identified by "Total Gas Measurement" or "CO_2 Measurement", appear on the printout. The comment referring to temperature instability occurs for almost all runs and means that the normal air circulation within the manometer system cabinet was not obtained because the fans were off during the measurement. Another comment referring to severe bulging and jumping problems at the 4 cc pointer occurs for all CO_2 measurements except those on reference gas 6078. A third comment, occurring three times, refers to premature contact of the 4 cc pointer with the mercury during the final measurement. The preferred sequence of measurements was not made in these cases. The fourth comment, occurring twice, refers to the mercury contacting the 5000 cc pointer during the measurement due to bulging problems. This last problem affects the results only slightly.

NO. OF TESTED CYLINDER = 2399, RUN NO. 1 CO2 IN N2

MENISCUS CORRECTION FOR CO2 VOLUME = -0.392 MM

MENISCUS CORRECTION FOR TOTAL GAS VOLUME = 0.018 MM

MERCURY COLUMN HEIGHTS FOR CO2 VOLUME WERE 641.364 MM AND 370.633 MM--TEMPERATURE WAS 19.39 DEG. C
MERCURY DENSITY WAS 13.5474 G/CC

MERCURY COLUMN HEIGHTS FOR TOTAL GAS VOLUME WERE 805.611 MM AND 173.230 MM--TEMPERATURE WAS 19.74 DEG. C
MERCURY DENSITY WAS 13.5465 G/CC

GAS DATA

CO2		TOTAL GAS	
VOLUME(CC)	3.7974	VOLUME(CC)	5014.9
TEMPERATURE(C)	19.39	TEMPERATURE(C)	19.74
PRESSURE(DYNE/SC)	.35875E+06	PRESSURE(DYNE/SC)	.83917E+06
VIRIAL(CC/MOLE)	128.6	VIRIAL(CC/MOLE)	-6.1

GAS CONSTANT = .83144E+08 ERG/MOLE-DEGREE
ACCELERATION OF GRAVITY = 979.558 CM/SEC**2

*** CO2 CONCENTRATION OF THIS GAS IS 324.66 PPM

CO2 MEASUREMENT -- MERCURY BULGING AND JUMPING TOWARD POINTER BADLY. MEASUREMENT MADE AFTER DISLODGING MERCURY FROM CONTACT WITH POINTER.
MERCURY PREMATURELY CONTACTED POINTER

TOTAL GAS MEASUREMENT -- TEMPERATURE INSTABILITY. FANS TURNED OFF FOR MEASUREMENT.

THIS MEASUREMENT WAS MADE ON 31 OCT 72

OBTAINED FROM CO2 MEASUREMENT NO. 1 AND TOTAL GAS MEASUREMENT NO. 1

NO. OF TESTED CYLINDER = 2399, RUN NO. 1 CO2 IN N2

MENISCUS CORRECTION FOR CO2 VOLUME = -0.392 MM

MENISCUS CORRECTION FOR TOTAL GAS VOLUME = 0.018 MM

MERCURY COLUMN HEIGHTS FOR CO2 VOLUME WERE 641.700 MM AND 370.636 MM--TEMPERATURE WAS 19.49 DEG. C
MERCURY DENSITY WAS 13.5471 G/CC

MERCURY COLUMN HEIGHTS FOR TOTAL GAS VOLUME WERE 805.611 MM AND 173.230 MM--TEMPERATURE WAS 19.74 DEG. C
MERCURY DENSITY WAS 13.5465 G/CC

GAS DATA

CO2		TOTAL GAS	
VOLUME(CC)	3.7974	VOLUME(CC)	5014.9
TEMPERATURE(C)	19.49	TEMPERATURE(C)	19.74
PRESSURE(DYNE/SC)	.35919E+06	PRESSURE(DYNE/SC)	.83917E+06
VIRIAL(CC/MOLE)	128.5	VIRIAL(CC/MOLE)	-6.1

GAS CONSTANT = .83144E+08 ERG/MOLE-DEGREE
ACCELERATION OF GRAVITY = 979.558 CM/SEC**2

*** CO2 CONCENTRATION OF THIS GAS IS 324.94 PPM

CO2 MEASUREMENT -- TEMPERATURE INSTABILITY. FANS TURNED OFF FOR MEASUREMENT.
MERCURY BULGING AND JUMPING TOWARD POINTER BADLY. MEASUREMENT MADE AFTER
DISLODGING MERCURY FROM CONTACT WITH POINTER.

TOTAL GAS MEASUREMENT -- TEMPERATURE INSTABILITY. FANS TURNED OFF FOR MEASUREMENT.

THIS MEASUREMENT WAS MADE ON 31 OCT 72 (TOTAL GAS) AND 1 NOV 72 (CO2)

OBTAINED FROM CO2 MEASUREMENT NO. 2 AND TOTAL GAS MEASUREMENT NO. 1

SUMMARY OF MANOMETRIC CO2 CONCENTRATIONS ON CYLINDER NO. 2399 RUN NO. 1

TOTAL GAS RUN NO.	CO2 RUN NO.	CONC.
1	1	324.66
1	2	324.94

NO. OF TESTED CYLINDER = 2399, RUN NO. 2 CO2 IN N2

MENISCUS CORRECTION FOR CO2 VOLUME = -0.392 MM

MENISCUS CORRECTION FOR TOTAL GAS VOLUME = 0.018 MM

MERCURY COLUMN HEIGHTS FOR CO2 VOLUME WERE 637.156 MM AND 370.658 MM--TEMPERATURE WAS 19.70 DEG. C
MERCURY DENSITY WAS 13.5466 G/CC

MERCURY COLUMN HEIGHTS FOR TOTAL GAS VOLUME WERE 794.616 MM AND 173.270 MM--TEMPERATURE WAS 19.37 DEG. C
MERCURY DENSITY WAS 13.5474 G/CC

GAS DATA

CO2		TOTAL GAS	
VOLUME(CC)	3.7974	VOLUME(CC)	5014.9
TEMPERATURE(C)	19.70	TEMPERATURE(C)	19.37
PRESSURE(DYNE/SC)	.35311E+06	PRESSURE(DYNE/SC)	.82458E+06
VIRIAL(CC/MOLE)	128.3	VIRIAL(CC/MOLE)	-6.2

GAS CONSTANT = .83144E+08 ERG/MOLE-DEGREE
ACCELERATION OF GRAVITY = 979.558 CM/SEC**2

*** CO2 CONCENTRATION OF THIS GAS IS 324.44 PPM

CO2 MEASUREMENT -- MERCURY BULGING AND JUMPING TOWARD POINTER BADLY. MEASUREMENT MADE AFTER DISLODGING MERCURY FROM CONTACT WITH POINTER.
TEMPERATURE INSTABILITY. FANS TURNED OFF FOR MEASUREMENT.

TOTAL GAS MEASUREMENT -- MERCURY CONTACTED POINTER DURING MEASUREMENT. TEMPERATURE INSTABILITY

THIS MEASUREMENT WAS MADE ON 3 NOV 72 (TOTAL GAS) AND 8 NOV 72 (CO2)

OBTAINED FROM CO2 MEASUREMENT NO. 1 AND TOTAL GAS MEASUREMENT NO. 1

NO. OF TESTED CYLINDER = 2399, RUN NO. 2 CO2 IN N2

MENISCUS CORRECTION FOR CO2 VOLUME = -0.392 MM

MENISCUS CORRECTION FOR TOTAL GAS VOLUME = 0.018 MM

MERCURY COLUMN HEIGHTS FOR CO2 VOLUME WERE 637.156 MM AND 370.658 MM--TEMPERATURE WAS 19.70 DEG. C
MERCURY DENSITY WAS 13.5466 G/CC

MERCURY COLUMN HEIGHTS FOR TOTAL GAS VOLUME WERE 796.107 MM AND 173.248 MM--TEMPERATURE WAS 20.04 DEG. C
MERCURY DENSITY WAS 13.5457 G/CC

GAS DATA

CO2		TOTAL GAS	
VOLUME(CC)	3.7974	VOLUME(CC)	5014.9
TEMPERATURE(C)	19.70	TEMPERATURE(C)	20.04
PRESSURE(DYNE/SC)	.35311E+06	PRESSURE(DYNE/SC)	.82649E+06
VIRIAL(CC/MOLE)	128.3	VIRIAL(CC/MOLE)	-6.1

GAS CONSTANT = .83144E+08 ERG/MOLE-DEGREE
ACCELERATION OF GRAVITY = 979.558 CM/SEC**2

*** CO2 CONCENTRATION OF THIS GAS IS 324.44 PPM

CO2 MEASUREMENT -- MERCURY BULGING AND JUMPING TOWARD POINTER BADLY. MEASUREMENT MADE AFTER DISLODGING MERCURY FROM CONTACT WITH POINTER.
TEMPERATURE INSTABILITY. FANS TURNED OFF FOR MEASUREMENT.

TOTAL GAS MEASUREMENT - TEMPERATURE INSTABILITY. FANS TURNED OFF FOR MEASUREMENT.

THIS MEASUREMENT WAS MADE ON 6 NOV 72 (TOTAL GAS) AND 8 NOV 72 (CO2)

OBTAINED FROM CO2 MEASUREMENT NO. 1 AND TOTAL GAS MEASUREMENT NO. 2

NO. OF TESTED CYLINDER = 2399, RUN NO. 2 CO2 IN N2

MENISCUS CORRECTION FOR CO2 VOLUME = -0.392 MM

MENISCUS CORRECTION FOR TOTAL GAS VOLUME = 0.018 MM

MERCURY COLUMN HEIGHTS FOR CO2 VOLUME WERE 637.490 MM AND 370.620 MM--TEMPERATURE WAS 19.86 DEG. C
MERCURY DENSITY WAS 13.5462 G/CC

MERCURY COLUMN HEIGHTS FOR TOTAL GAS VOLUME WERE 794.616 MM AND 173.270 MM--TEMPERATURE WAS 19.37 DEG. C
MERCURY DENSITY WAS 13.5474 G/CC

GAS DATA

CO2		TOTAL GAS	
VOLUME(CC)	3.7974	VOLUME(CC)	5014.9
TEMPERATURE(C)	19.86	TEMPERATURE(C)	19.37
PRESSURE(DYNE/SC)	.35360E+06	PRESSURE(DYNE/SC)	.82458E+06
VIRIAL(CC/MOLE)	128.1	VIRIAL(CC/MOLE)	-6.2

GAS CONSTANT = .83144E+08 ERG/MOLE-DEGREE
ACCELERATION OF GRAVITY = 979.558 CM/SEC**2

*** CO2 CONCENTRATION OF THIS GAS IS 324.71 PPM

CO2 MEASUREMENT -- MERCURY BULGING AND JUMPING TOWARD POINTER BADLY. MEASUREMENT MADE AFTER DISLODGING MERCURY FROM CONTACT WITH POINTER.
TEMPERATURE INSTABILITY. FANS TURNED OFF FOR MEASUREMENT.

TOTAL GAS MEASUREMENT - MERCURY CONTACTED POINTER DURING MEASUREMENT. TEMPERATURE INSTABILITY

THIS MEASUREMENT WAS MADE ON 3 NOV 72 (TOTAL GAS) AND 8 NOV 72 (CO2)

OBTAINED FROM CO2 MEASUREMENT NO. 2 AND TOTAL GAS MEASUREMENT NO. 1

NO. OF TESTED CYLINDER = 2399, RUN NO. 2 CO2 IN N2

MENISCUS CORRECTION FOR CO2 VOLUME = -0.392 MM

MENISCUS CORRECTION FOR TOTAL GAS VOLUME = 0.018 MM

MERCURY COLUMN HEIGHTS FOR CO2 VOLUME WERE 637.490 MM AND 370.620 MM--TEMPERATURE WAS 19.86 DEG. C
MERCURY DENSITY WAS 13.5462 G/CC

MERCURY COLUMN HEIGHTS FOR TOTAL GAS VOLUME WERE 796.107 MM AND 173.248 MM--TEMPERATURE WAS 20.04 DEG. C
MERCURY DENSITY WAS 13.5457 G/CC

GAS DATA

CO2		TOTAL GAS	
VOLUME(CC)	3.7974	VOLUME(CC)	5014.9
TEMPERATURE(C)	19.86	TEMPERATURE(C)	20.04
PRESSURE(DYNE/SC)	.35360E+06	PRESSURE(DYNE/SC)	.82649E+06
VIRIAL(CC/MOLE)	128.1	VIRIAL(CC/MOLE)	-6.1

GAS CONSTANT = .83144E+08 ERG/MOLE-DEGREE
ACCELERATION OF GRAVITY = 979.558 CM/SEC**2

*** CO2 CONCENTRATION OF THIS GAS IS 324.70 PPM

CO2 MEASUREMENT -- MERCURY BULGING AND JUMPING TOWARD POINTER BADLY. MEASUREMENT MADE AFTER DISLODGING MERCURY FROM CONTACT WITH POINTER.
TEMPERATURE INSTABILITY. FANS TURNED OFF FOR MEASUREMENT.

TOTAL GAS MEASUREMENT -- TEMPERATURE INSTABILITY. FANS TURNED OFF FOR MEASUREMENT.

THIS MEASUREMENT WAS MADE ON 6 NOV 72 (TOTAL GAS) AND 8 NOV 72 (CO2)

OBTAINED FROM CO2 MEASUREMENT NO. 2 AND TOTAL GAS MEASUREMENT NO. 2

SUMMARY OF MANOMETRIC CO2 CONCENTRATIONS ON CYLINDER NO. 2399 RUN NO. 2

TOTAL GAS RUN NO.	CO2 RUN NO.	CONC.
1	1	324.44
2	1	324.44
1	2	324.71
2	2	324.70

NO. OF TESTED CYLINDER = 2399, RUN NO. 3 CO2 IN N2

MENISCUS CORRECTION FOR CO2 VOLUME = -0.392 MM

MENISCUS CORRECTION FOR TOTAL GAS VOLUME = 0.018 MM

MERCURY COLUMN HEIGHTS FOR CO2 VOLUME WERE 639.276 MM AND 370.654 MM--TEMPERATURE WAS 20.07 DEG. C
MERCURY DENSITY WAS 13.5457 G/CC

MERCURY COLUMN HEIGHTS FOR TOTAL GAS VOLUME WERE 797.927 MM AND 173.277 MM--TEMPERATURE WAS 19.08 DEG. C
MERCURY DENSITY WAS 13.5481 G/CC

GAS DATA

CO2		TOTAL GAS	
VOLUME(CC)	3.7974	VOLUME(CC)	5014.9
TEMPERATURE(C)	20.07	TEMPERATURE(C)	19.08
PRESSURE(DYNE/SC)	.35591E+06	PRESSURE(DYNE/SC)	.82901E+06
VIRIAL(CC/MOLE)	127.9	VIRIAL(CC/MOLE)	-6.3

GAS CONSTANT = .83144E+08 ERG/MOLE-DEGREE
ACCELERATION OF GRAVITY = 979.558 CM/SEC**2

*** CO2 CONCENTRATION OF THIS GAS IS 324.53 PPM

CO2 MEASUREMENT -- MERCURY BULGING AND JUMPING TOWARD POINTER BADLY. MEASUREMENT MADE AFTER DISLODGING MERCURY FROM CONTACT WITH POINTER.
TEMPERATURE INSTABILITY. FANS TURNED OFF FOR MEASUREMENT.

THIS MEASUREMENT WAS MADE ON 10 NOV 72 (TOTAL GAS) AND 13 NOV 72 (CO2)

OBTAINED FROM CO2 MEASUREMENT NO. 1 AND TOTAL GAS MEASUREMENT NO. 1

NO. OF TESTED CYLINDER = 2399, RUN NO. 3 CO2 IN N2

MENISCUS CORRECTION FOR CO2 VOLUME = -0.392 MM

MENISCUS CORRECTION FOR TOTAL GAS VOLUME = 0.018 MM

MERCURY COLUMN HEIGHTS FOR CO2 VOLUME WERE 639.323 MM AND 370.646 MM--TEMPERATURE WAS 20.17 DEG. C
MERCURY DENSITY WAS 13.5454 G/CC

MERCURY COLUMN HEIGHTS FOR TOTAL GAS VOLUME WERE 797.927 MM AND 173.277 MM--TEMPERATURE WAS 19.08 DEG. C
MERCURY DENSITY WAS 13.5481 G/CC

GAS DATA

CO2		TOTAL GAS	
VOLUME(CC)	3.7974	VOLUME(CC)	5014.9
TEMPERATURE(C)	20.17	TEMPERATURE(C)	19.08
PRESSURE(DYNE/SC)	.35597E+06	PRESSURE(DYNE/SC)	.82901E+06
VIRIAL(CC/MOLE)	127.8	VIRIAL(CC/MOLE)	-6.3

GAS CONSTANT = .83144E+08 ERG/MOLE-DEGREE
ACCELERATION OF GRAVITY = 979.558 CM/SEC**2

*** CO2 CONCENTRATION OF THIS GAS IS 324.48 PPM

CO2 MEASUREMENT -- MERCURY BULGING AND JUMPING TOWARD POINTER BADLY. MEASUREMENT MADE AFTER DISLODGING MERCURY FROM CONTACT WITH POINTER. MERCURY PREMATURELY CONTACTED POINTER. TEMPERATURE INSTABILITY. FANS TURNED OFF FOR MEASUREMENT.

THIS MEASUREMENT WAS MADE ON 10 NOV 72 (TOTAL GAS) AND 13 NOV 72 (CO2)

OBTAINED FROM CO2 MEASUREMENT NO. 2 AND TOTAL GAS MEASUREMENT NO. 1

SUMMARY OF MANOMETRIC CO2 CONCENTRATIONS ON CYLINDER NO. 2399 RUN NO. 3

TOTAL GAS RUN NO.	CO2 RUN NO.	CONC.
1	1	324.53
1	2	324.48

NO. OF TESTED CYLINDER = 6078, RUN NO. 1 CO2 IN N2

MENISCUS CORRECTION FOR CO2 VOLUME = -0.392 MM

MENISCUS CORRECTION FOR TOTAL GAS VOLUME = 0.018 MM

MERCURY COLUMN HEIGHTS FOR CO2 VOLUME WERE 619.690 MM AND 370.652 MM--TEMPERATURE WAS 19.45 DEG. C
MERCURY DENSITY WAS 13.5472 G/CC

MERCURY COLUMN HEIGHTS FOR TOTAL GAS VOLUME WERE 779.309 MM AND 173.358 MM--TEMPERATURE WAS 19.17 DEG. C
MERCURY DENSITY WAS 13.5479 G/CC

GAS DATA

CO2		TOTAL GAS	
VOLUME(CC)	3.7974	VOLUME(CC)	5014.9
TEMPERATURE(C)	19.45	TEMPERATURE(C)	19.17
PRESSURE(DYNE/SC)	.32996E+06	PRESSURE(DYNE/SC)	.80418E+06
VIRIAL(CC/MOLE)	-128.5	VIRIAL(CC/MOLE)	-6.2

GAS CONSTANT = .83144E+08 ERG/MOLE-DEGREE
ACCELERATION OF GRAVITY = 979.558 CM/SEC**2

*** CO2 CONCENTRATION OF THIS GAS IS 310.88 PPM

THIS MEASUREMENT WAS MADE ON 19 OCT 72 (TOTAL GAS) AND 20 OCT 72 (CO2)

OBTAINED FROM CO2 MEASUREMENT NO. 1 AND TOTAL GAS MEASUREMENT NO. 1

NO. OF TESTED CYLINDER = 6078, RUN NO. 1 CO2 IN N2

MENISCUS CORRECTION FOR CO2 VOLUME = -0.392 MM

MENISCUS CORRECTION FOR TOTAL GAS VOLUME = 0.018 MM

MERCURY COLUMN HEIGHTS FOR CO2 VOLUME WERE 619.690 MM AND 370.652 MM--TEMPERATURE WAS 19.45 DEG. C
MERCURY DENSITY WAS 13.5472 G/CC

MERCURY COLUMN HEIGHTS FOR TOTAL GAS VOLUME WERE 779.349 MM AND 173.340 MM--TEMPERATURE WAS 19.20 DEG. C
MERCURY DENSITY WAS 13.5478 G/CC

GAS DATA

CO2		TOTAL GAS	
VOLUME(CC)	3.7974	VOLUME(CC)	5014.9
TEMPERATURE(C)	19.45	TEMPERATURE(C)	19.20
PRESSURE(DYNE/SC)	.32996E+06	PRESSURE(DYNE/SC)	.80425E+06
VIRIAL(CC/MOLE)	128.5	VIRIAL(CC/MOLE)	-6.2

GAS CONSTANT = .83144E+08 ERG/MOLE-DEGREE
ACCELERATION OF GRAVITY = 979.558 CM/SEC**2

*** CO2 CONCENTRATION OF THIS GAS IS 310.88 PPM

THIS MEASUREMENT WAS MADE ON 19 OCT 72 (TOTAL GAS) AND 20 OCT 72 (CO2)

OBTAINED FROM CO2 MEASUREMENT NO. 1 AND TOTAL GAS MEASUREMENT NO. 2

NO. OF TESTED CYLINDER = 6078, RUN NO. 1 CO2 IN N2

MENISCUS CORRECTION FOR CO2 VOLUME = -0.392 MM

MENISCUS CORRECTION FOR TOTAL GAS VOLUME = 0.018 MM

MERCURY COLUMN HEIGHTS FOR CO2 VOLUME WERE 619.609 MM AND 370.648 MM--TEMPERATURE WAS 19.53 DEG. C
MERCURY DENSITY WAS 13.5470 G/CC

MERCURY COLUMN HEIGHTS FOR TOTAL GAS VOLUME WERE 779.309 MM AND 173.358 MM--TEMPERATURE WAS 19.17 DEG. C
MERCURY DENSITY WAS 13.5479 G/CC

GAS DATA

CO2		TOTAL GAS	
VOLUME(CC)	3.7974	VOLUME(CC)	5014.9
TEMPERATURE(C)	19.53	TEMPERATURE(C)	19.17
PRESSURE(DYNE/SC)	.32985E+06	PRESSURE(DYNE/SC)	.80418E+06
VIRIAL(CC/MOLE)	128.4	VIRIAL(CC/MOLE)	-6.2

GAS CONSTANT = .83144E+08 ERG/MOLE-DEGREE
ACCELERATION OF GRAVITY = 979.558 CM/SEC**2

*** CO2 CONCENTRATION OF THIS GAS IS 310.69 PPM

CO2 MEASUREMENT -- MERCURY PREMATURELY CONTACTED POINTER

THIS MEASUREMENT WAS MADE ON 19 OCT 72 (TOTAL GAS) AND 20 OCT 72 (CO2)

OBTAINED FROM CO2 MEASUREMENT NO. 2 AND TOTAL GAS MEASUREMENT NO. 1

NO. OF TESTED CYLINDER = 6078, RUN NO. 1 CO2 IN N2

MENISCUS CORRECTION FOR CO2 VOLUME = -0.392 MM

MENISCUS CORRECTION FOR TOTAL GAS VOLUME = 0.018 MM

MERCURY COLUMN HEIGHTS FOR CO2 VOLUME WERE 619.609 MM AND 370.648 MM--TEMPERATURE WAS 19.53 DEG. C
MERCURY DENSITY WAS 13.5470 G/CC

MERCURY COLUMN HEIGHTS FOR TOTAL GAS VOLUME WERE 779.349 MM AND 173.340 MM--TEMPERATURE WAS 19.20 DEG. C
MERCURY DENSITY WAS 13.5478 G/CC

GAS DATA

CO2		TOTAL GAS	
VOLUME(CC)	3.7974	VOLUME(CC)	5014.9
TEMPERATURE(C)	19.53	TEMPERATURE(C)	19.20
PRESSURE(DYNE/SC)	.32985E+06	PRESSURE(DYNE/SC)	.80425E+06
VIRIAL(CC/MOLE)	-128.4	VIRIAL(CC/MOLE)	-6.2

GAS CONSTANT = .83144E+08 ERG/MOLE-DEGREE
ACCELERATION OF GRAVITY = 979.558 CM/SEC**2

*** CO2 CONCENTRATION OF THIS GAS IS 310.69 PPM

CO2 MEASUREMENT -- MERCURY PREMATURELY CONTACTED POINTER

THIS MEASUREMENT WAS MADE ON 19 OCT 72 (TOTAL GAS) AND 20 OCT 72 (CO2)

OBTAINED FROM CO2 MEASUREMENT NO. 2 AND TOTAL GAS MEASUREMENT NO. 2

SUMMARY OF MANOMETRIC CO2 CONCENTRATIONS ON CYLINDER NO. 6078 RUN NO. 1

TOTAL GAS RUN NO.	CO2 RUN NO.	CONC.
1	1	310.88
2	1	310.88
1	2	310.69
2	2	310.69

NO. OF TESTED CYLINDER = 6078, RUN NO. 2 CO2 IN N2

MENISCUS CORRECTION FOR CO2 VOLUME = -0.392 MM

MENISCUS CORRECTION FOR TOTAL GAS VOLUME = 0.018 MM

MERCURY COLUMN HEIGHTS FOR CO2 VOLUME WERE 623.334 MM AND 370.639 MM--TEMPERATURE WAS 19.35 DEG. C
MERCURY DENSITY WAS 13.5475 G/CC

MERCURY COLUMN HEIGHTS FOR TOTAL GAS VOLUME WERE 789.278 MM AND 173.298 MM--TEMPERATURE WAS 19.42 DEG. C
MERCURY DENSITY WAS 13.5473 G/CC

GAS DATA

CO2		TOTAL GAS	
VOLUME(CC)	3.7974	VOLUME(CC)	5014.9
TEMPERATURE(C)	19.35	TEMPERATURE(C)	19.42
PRESSURE(DYNE/SC)	.33482E+06	PRESSURE(DYNE/SC)	.81745E+06
VIRIAL(CC/MOLE)	128.6	VIRIAL(CC/MOLE)	-6.2

GAS CONSTANT = .83144E+08 ERG/MOLE-DEGREE
ACCELERATION OF GRAVITY = 979.558 CM/SEC**2

*** CO2 CONCENTRATION OF THIS GAS IS 310.71 PPM

CO2 MEASUREMENT -- TEMPERATURE INSTABILITY. FANS TURNED OFF FOR MEASUREMENT.

TOTAL GAS MEASUREMENT - MERCURY CONTACTED POINTER DURING MEASUREMENT.

THIS MEASUREMENT WAS MADE ON 1 NOV 72 (TOTAL GAS) AND 2 NOV 72 (CO2)

OBTAINED FROM CO2 MEASUREMENT NO. 1 AND TOTAL GAS MEASUREMENT NO. 1

NO. OF TESTED CYLINDER = 6078, RUN NO. 2 CO2 IN N2

MENISCUS CORRECTION FOR CO2 VOLUME = -0.392 MM

MENISCUS CORRECTION FOR TOTAL GAS VOLUME = 0.018 MM

MERCURY COLUMN HEIGHTS FOR CO2 VOLUME WERE 624.043 MM AND 370.672 MM--TEMPERATURE WAS 19.80 DEG. C
MERCURY DENSITY WAS 13.5463 G/CC

MERCURY COLUMN HEIGHTS FOR TOTAL GAS VOLUME WERE 789.278 MM AND 173.298 MM--TEMPERATURE WAS 19.42 DEG. C
MERCURY DENSITY WAS 13.5473 G/CC

GAS DATA

CO2		TOTAL GAS	
VOLUME(CC)	3.7974	VOLUME(CC)	5014.9
TEMPERATURE(C)	19.80	TEMPERATURE(C)	19.42
PRESSURE(DYNE/SC)	.33569E+06	PRESSURE(DYNE/SC)	.81745E+06
VIRIAL(CC/MOLE)	128.2	VIRIAL(CC/MOLE)	-6.2

GAS CONSTANT = .83144E+08 ERG/MOLE-DEGREE
ACCELERATION OF GRAVITY = 979.558 CM/SEC**2

*** CO2 CONCENTRATION OF THIS GAS IS 311.04 PPM

CO2 MEASUREMENT -- TEMPERATURE INSTABILITY. FANS TURNED OFF FOR MEASUREMENT.

TOTAL GAS MEASUREMENT -- MERCURY CONTACTED POINTER DURING MEASUREMENT.

THIS MEASUREMENT WAS MADE ON 1 NOV 72 (TOTAL GAS) AND 3 NOV 72 (CO2)

OBTAINED FROM CO2 MEASUREMENT NO. 2 AND TOTAL GAS MEASUREMENT NO. 1

SUMMARY OF MANOMETRIC CO2 CONCENTRATIONS ON CYLINDER NO. 6078 RUN NO. 2

TOTAL GAS RUN NO.	CO2 RUN NO.	CONC.
1	1	310.71
1	2	311.04

NO. OF TESTED CYLINDER = 10069, RUN NO. 1 CO2 IN N2

MENISCUS CORRECTION FOR CO2 VOLUME = -0.392 MM

MENISCUS CORRECTION FOR TOTAL GAS VOLUME = 0.018 MM

MERCURY COLUMN HEIGHTS FOR CO2 VOLUME WERE 667.633 MM AND 370.648 MM--TEMPERATURE WAS 19.96 DEG. C
MERCURY DENSITY WAS 13.5459 G/CC

MERCURY COLUMN HEIGHTS FOR TOTAL GAS VOLUME WERE 803.699 MM AND 173.270 MM--TEMPERATURE WAS 19.16 DEG. C
MERCURY DENSITY WAS 13.5479 G/CC

GAS DATA

CO2		TOTAL GAS	
VOLUME(CC)	3.7974	VOLUME(CC)	5014.9
TEMPERATURE(C)	19.96	TEMPERATURE(C)	19.16
PRESSURE(DYNE/SC)	.39355E+06	PRESSURE(DYNE/SC)	.83667E+06
VIRIAL(CC/MOLE)	128.0	VIRIAL(CC/MOLE)	-6.2

GAS CONSTANT = .83144E+08 ERG/MOLE-DEGREE
ACCELERATION OF GRAVITY = 979.558 CM/SEC**2

*** CO2 CONCENTRATION OF THIS GAS IS 355.87 PPM

CO2 MEASUREMENT -- MERCURY BULGING AND JUMPING TOWARD POINTER BADLY. MEASUREMENT MADE AFTER DISLODGING MERCURY FROM CONTACT WITH POINTER.
TEMPERATURE INSTABILITY. FANS TURNED OFF FOR MEASUREMENT.

THIS MEASUREMENT WAS MADE ON 2 NOV 72 (TOTAL GAS) AND 6 NOV 72 (CO2)

OBTAINED FROM CO2 MEASUREMENT NO. 1 AND TOTAL GAS MEASUREMENT NO. 1

NO. OF TESTED CYLINDER = 10069, RUN NO. 1 CO2 IN N2

MENISCUS CORRECTION FOR CO2 VOLUME = -0.392 MM

MENISCUS CORRECTION FOR TOTAL GAS VOLUME = 0.018 MM

MERCURY COLUMN HEIGHTS FOR CO2 VOLUME WERE 667.629 MM AND 370.638 MM--TEMPERATURE WAS 20.01 DEG. C
MERCURY DENSITY WAS 13.5458 G/CC

MERCURY COLUMN HEIGHTS FOR TOTAL GAS VOLUME WERE 803.690 MM AND 173.270 MM--TEMPERATURE WAS 19.16 DEG. C
MERCURY DENSITY WAS 13.5479 G/CC

GAS DATA

CO2		TOTAL GAS	
VOLUME(CC)	3.7974	VOLUME(CC)	5014.9
TEMPERATURE(C)	20.01	TEMPERATURE(C)	19.16
PRESSURE(DYNE/SC)	.39355E+06	PRESSURE(DYNE/SC)	.83667E+06
VIRIAL(CC/MOLE)	128.0	VIRIAL(CC/MOLE)	-6.2

GAS CONSTANT = .83144E+08 ERG/MOLE-DEGREE
ACCELERATION OF GRAVITY = 979.558 CM/SEC**2

*** CO2 CONCENTRATION OF THIS GAS IS 355.81 PPM

CO2 MEASUREMENT -- MERCURY BULGING AND JUMPING TOWARD POINTER BADLY. MEASUREMENT MADE AFTER DISLODGING MERCURY FROM CONTACT WITH POINTER.
TEMPERATURE INSTABILITY. FANS TURNED OFF FOR MEASUREMENT.

THIS MEASUREMENT WAS MADE ON 2 NOV 72 (TOTAL GAS) AND 6 NOV 72 (CO2)

OBTAINED FROM CO2 MEASUREMENT NO. 2 AND TOTAL GAS MEASUREMENT NO. 1

SUMMARY OF MANOMETRIC CO2 CONCENTRATIONS ON CYLINDER NO. 10069 RUN NO. 1

TOTAL GAS RUN NO.	CO2 RUN NO.	CONC.
1	1	355.87
1	2	355.81

NO. OF TESTED CYLINDER = 10069, RUN NO. 2 CO2 IN N2

MENISCUS CORRECTION FOR CO2 VOLUME = -0.392 MM

MENISCUS CORRECTION FOR TOTAL GAS VOLUME = 0.018 MM

MERCURY COLUMN HEIGHTS FOR CO2 VOLUME WERE 667.890 MM AND 370.647 MM--TEMPERATURE WAS 19.73 DEG. C
MERCURY DENSITY WAS 13.5465 G/CC

MERCURY COLUMN HEIGHTS FOR TOTAL GAS VOLUME WERE 805.530 MM AND 173.312 MM--TEMPERATURE WAS 19.75 DEG. C
MERCURY DENSITY WAS 13.5465 G/CC

GAS DATA

CO2		TOTAL GAS	
VOLUME(CC)	3.7974	VOLUME(CC)	5014.9
TEMPERATURE(C)	19.73	TEMPERATURE(C)	19.75
PRESSURE(DYNE/SC)	.39391E+06	PRESSURE(DYNE/SC)	.83895E+06
VIRIAL(CC/MOLE)	128.2	VIRIAL(CC/MOLE)	-6.1

GAS CONSTANT = .83144E+08 ERG/MOLE-DEGREE
ACCELERATION OF GRAVITY = 979.558 CM/SEC**2

*** CO2 CONCENTRATION OF THIS GAS IS 356.23 PPM

CO2 MEASUREMENT -- MERCURY BULGING AND JUMPING TOWARD POINTER BADLY. MEASUREMENT MADE AFTER DISLODGING MERCURY FROM CONTACT WITH POINTER.
TEMPERATURE INSTABILITY. FANS TURNED OFF FOR MEASUREMENT.

TOTAL GAS MEASUREMENT -- TEMPERATURE INSTABILITY. FANS TURNED OFF FOR MEASUREMENT.

THIS MEASUREMENT WAS MADE ON 8 NOV 72 (TOTAL GAS) AND 9 NOV 72 (CO2)

OBTAINED FROM CO2 MEASUREMENT NO. 1 AND TOTAL GAS MEASUREMENT NO. 1

NO. OF TESTED CYLINDER = 10069, RUN NO. 2 CO2 IN N2

MENISCUS CORRECTION FOR CO2 VOLUME = -0.392 MM

MENISCUS CORRECTION FOR TOTAL GAS VOLUME = 0.018 MM

MERCURY COLUMN HEIGHTS FOR CO2 VOLUME WERE 667.847 MM AND 370.632 MM--TEMPERATURE WAS 19.78 DEG. C
MERCURY DENSITY WAS 13.5464 G/CC

MERCURY COLUMN HEIGHTS FOR TOTAL GAS VOLUME WERE 805.530 MM AND 173.312 MM--TEMPERATURE WAS 19.75 DEG. C
MERCURY DENSITY WAS 13.5465 G/CC

GAS DATA

CO2		TOTAL GAS	
VOLUME(CC)	3.7974	VOLUME(CC)	5014.9
TEMPERATURE(C)	19.78	TEMPERATURE(C)	19.75
PRESSURE(DYNE/SC)	.39387E+06	PRESSURE(DYNE/SC)	.83895E+06
VIRIAL(CC/MOLE)	128.2	VIRIAL(CC/MOLE)	-6.1

GAS CONSTANT = .83144E+08 ERG/MOLE-DEGREE
ACCELERATION OF GRAVITY = 979.558 CM/SEC**2

*** CO2 CONCENTRATION OF THIS GAS IS 356.13 PPM

CO2 MEASUREMENT -- MERCURY BULGING AND JUMPING TOWARD POINTER BADLY. MEASUREMENT MADE AFTER
DISLODGING MERCURY FROM CONTACT WITH POINTER.
TEMPERATURE INSTABILITY. FANS TURNED OFF FOR MEASUREMENT.

TOTAL GAS MEASUREMENT -- TEMPERATURE INSTABILITY. FANS TURNED OFF FOR MEASUREMENT.

THIS MEASUREMENT WAS MADE ON 8 NOV 72 (TOTAL GAS) AND 9 NOV 72 (CO2)

OBTAINED FROM CO2 MEASUREMENT NO. 2 AND TOTAL GAS MEASUREMENT NO. 1

SUMMARY OF MANOMETRIC CO2 CONCENTRATIONS ON CYLINDER NO. 10069 RUN NO. 2

TOTAL GAS RUN NO.	CO2 RUN NO.	CONC.
1	1	356.23
1	2	356.13