



PPG INDUSTRIES, INC.

INDUSTRIAL CHEMICAL DIVISION

P. O. BOX 1000

LAKE CHARLES, LA. 70601

October 19, 1971

Mr. Dick Churns
Continental Oil Company
P. O. Box 37
Westlake, Louisiana 70669

Dear Mr. Churns:

Attached is a tabulation of manual versus computer calculations of chlorine delivery for the month of July. In August we stopped hand calculations.

I hope that this will answer your questions. If you need any other information, please call us.

Very truly yours,

A handwritten signature in black ink, appearing to read 'A. M. Crico'. The signature is stylized with a large, sweeping 'A' and a long, horizontal stroke at the end.

A. M. Crico

AMC:edh

Attachment

CCR 000038710



45-607 EYE BASE
45 707 30/20 BUFF
NATIONAL

CHLORINE TO CONOCO

July, 1971

1	2	3	4	5	6	7
	Manual Calculation	Computer Calculation				
1	950500	948300				
2	789100	790200				
3	966300	965400				
4	954200	953400				
5	923000	922200				
6	919800	919000				
7	925700	924800				
8	918500	917500				
9	906300	905800				
10	831300	830600				
11	901900	901200				
12	890600	888200				
13	903500	903000				
14	895800	895100				
15	884400	883800				
16	903300	902700				
17	910300	909600				
18	907500	906700				
19	877200	878900				
20	886000	885400				
21	889600	889100				
22	903400	902900				
23	884600	884200				
24	894200	893600				
25	890800	890300				
26	887000	886300				
27	876900	876400				
28	832700	832400				
29	880300	879800				
30	898500	897400				
31	915800	915200				
32	27 799 000	27 779 400	= .070556 %			
33						
34						
35						
36						
37						
38						
39						
40						

CCR 000038711

$$Q_h = F_b F_r Y F_{Tf} F_g F_{pr} F_a F_m \sqrt{k_w P_f}$$

$$\text{Let } C = F_b F_r Y F_a F_m$$

$$Q_h = C F_{Tf} F_g F_{pr} \sqrt{k_w P_f}$$

$$F_g = \sqrt{\frac{29}{m}}$$

$$F_{Tf} = \sqrt{\frac{520}{T_f}}$$

$$F_{pr} = \frac{Z_b}{\sqrt{Z_f}}$$

$$Q_h = C \sqrt{\frac{520}{T_f}} \sqrt{\frac{29}{m}} \frac{Z_b}{\sqrt{Z_f}} \sqrt{k_w P_f}$$

$$\text{For 1 mole } V = \frac{ZRT}{P} \quad Y = \frac{m}{V} = \frac{mP}{ZRT}$$

$$W_h = Q_h Y_b = C Y_b \sqrt{\frac{520}{T_f}} \sqrt{\frac{29}{m}} \frac{Z_b}{\sqrt{Z_f}} \sqrt{k_w P_f}$$

$$Y_b Z_b = \frac{Z_b m P_b}{Z_b R T_b} = \frac{m P_b}{R T_b}$$

$$W_h = C \frac{m P_b}{R T_b} \sqrt{\frac{520}{T_f}} \sqrt{\frac{29}{m}} \sqrt{\frac{P_f}{Z_f}} \sqrt{k_w}$$

$$W_h = C \frac{P_b}{T_b} \sqrt{\frac{520}{R}} \sqrt{29} \sqrt{\frac{m P_f}{R T_f Z_f}} \sqrt{k_w}$$

$$W_h = C \frac{P_b}{T_b} \sqrt{\frac{520 \times 29}{R}} \sqrt{Y_f} \sqrt{k_w}$$

$$\text{or } W_L = 1.0618 C \sqrt{h_w Y_f}$$

$$\text{or } W_L = 1.0618 F_L F_m Y F_a F_m \sqrt{h_w Y_f}$$



SEND CORRESPONDENCE TO: PPG INDUSTRIES, INC., P. O. BOX 1000, LAKE CHARLES, LA 70601

SHIPPER'S NO	CUSTOMER ORDER NO	DATE SHIPPED	TERMINAL	SHIP REQ	INV NO
	700653C		NY-2134	AUGUST	LC 8-791
CONTINENTAL OIL CO DIV 719753 BOX 2197, PURCHASING DEPT HOUSTON, TEXAS 77001	CUSTOMER CODE	CLASS/TERR	SHIP NO	SHIP DATE	
	1837200	1 NET 30	23801	8-31-71	
CONTINENTAL OIL CO WESTLAKE, LOUISIANA	DESTINATION CODE	SHIP FROM			
	507017001	03			
ROUTE	LC	LC	COL		

PIPELINE

51.0304P

Gaseous Chlorine delivered
through pipe line for the
month of August, 1971

30,971,700#

LESS DIAMOND EXCHANGE

Barges

5,545,400#

Tank Cars

3,740,000#

21,686,300# 40.00 433,726.00
NT

Plus 2.00NT Handling Charge
for Unloading 1692.7 Tons

3,385.40

437,111.40

CCR 000038714

INVOICE
COPY

We hereby certify that these goods were produced in compliance with all applicable requirements of sections 6, 7, and 12 of the Fair Labor Standards Act, as amended, and of regulations and orders of the United States Department of Labor issued under section 14 thereof

ALL CLAIMS MUST BE SUPPORTED BY BILL OF LADING AND FREIGHT BILL
SEE REVERSE SIDE

9-23-71

P.P.G.

Conoco

W.B. Graybell

R.H. Derlach

C.W. O Neal

R.W. Churns

R. Mack

A.M. Crico

P.P.G. agreed to change the
FPV subroutine from

$$F_{pv} = \sqrt{Z_B / Z_F}$$

to

$$F_{pv} = Z_B / \sqrt{Z_F}$$

This involves a 0.586 % gain
to Conoco.

They will also change the F_y
subroutine from

$$Y = 1 - (0.41 - 0.35\beta^4) X / K$$

$$X = H_w / P_i / (27.7 + H_w / P_i)$$

to

$$Y = 1 - (0.41 - 0.35\beta^4) X / K$$

$$X = H_w / (27.7 P_i)$$

This involves a ^{0.0799}~~0.0876~~ % gain
to Conoco.

CCR 000038715

The total of these changes involves a ^{0.6684}~~0.6684~~ % gain to Conoco. This is approximately ^{\$46000}~~\$46000~~ based on 500 tons per day of chlorine for 8000 hours per calendar year.

PPG also agreed to supply Conoco with comparisons between the old hand method and the new computer method for the month of August.

All other changes in the new manual were agreed upon by both parties

Y_1 — CORRECT METHOD — p. 508
NORTH 8-1

$$X = h_w / 27.7 \text{ ft}$$

$$= 80.74 / (27.7 \times 54.9) = 0.053093$$

$$\begin{aligned} Y_1 &= 1 - (0.41 + 0.25 \left(\frac{525}{10.52} \right)^4) (0.053093) / 1.355 \\ &= 1 - 0.017099 \\ &= 0.982901 \end{aligned}$$

Y_1 — COMPUTER METHOD

$$Y = 0.983763$$

$$\text{DIFFERENCE} = \frac{0.982901}{0.983763} = 0.999124$$

TOTAL CORRECTION

$$= 0.999124 \times 0.994140 = 0.993269$$

$$1 - 0.993269 = 0.006731$$

SOUTH

$$X = 0.045111$$

$$Y = 0.984506$$

$$\text{DIFFERENCE} = 0.984506 / 0.985217 = 0.999278$$

$$\text{AVERAGE} = (0.999278 + 0.999124) / 2 = 0.999201$$

$$\text{TOTAL CORRECTION} = 0.999201 \times 0.994140 = 0.993346$$

$$\text{COST} = (1 - 0.993346) \times 500 \times \frac{1}{100} \times 42 = 46578$$

RWC

CONTINENTAL OIL COMPANY
CALCULATION SHEET

JOB NO. CHLORINE METERING

MADE BY

CHECKED BY

DATE

9-23-71

TITLE

FIELD

STATE

CCR 000038717

Z = PM / ART

$$= 14.73 \times 10.44 / 0.1879 \times 5.71 \times 0.99917$$

$$= 0.996334$$

$$ZB = 0.9860 \times 0.996334 + 0.0410 \times 0.99917$$
$$= 0.996458$$

$$\sqrt{ZB} = 0.998228$$

Z = PM / ART

$$= 14.73 \times 10.44 / 0.1872 \times 10.72 \times 0.99917$$

$$= 1.000059$$

$$ZB = 1.000059$$

	OLD	OLD * ZB _{OLD}
E-7	1064700	1060924
S-8	1064300	1060520

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CONTINENTAL OIL COMPANY
CALCULATION SHEET

JOB NO

DATE

9-11-71

TITLE

8-7-71 SOUTH METER

PPG "OLD" METHOD

$$\text{Flow} = 5843.6 \times 24 \times .1879 \times 1.001272 \times .9850 \times .9822 \times .6468 \times 1.0150 \times 370931 \\ \times 7.5895 \times .9560$$

$$= 1062170 = 1062200 \text{ \#}$$

PPG "NEW" METHOD

$$\text{Flow} = 5843.6 \times 1.000335 \times .9850 \times .9822 \times .6468 \times 1.016169 \times 370931$$

$$\times 24 \times .18961 \times .956 = 1068041 \text{ \#}$$

Correction Revision for PPG "New" METHOD

$$\text{Flow} = 1068041 \times .99414 = 1061782$$

Old	Aug 1064700.	1.001272 1.000507
New	1070433.	1.006689 1.005895
Conoco	1063320. 1064160.	

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JOB NO

DATE

9-21-71

TITLE

WELL

STATE

8-7-71 NORTH Meter

PPG "OLD" METHOD

$$\begin{aligned} F_{\text{Calc}} &= F_B \times C_4 \times .1879 \times F_R \times Y_1 \times F_{\phi} \times F_g \times F_{\text{cor}} \times \sqrt{P_{\text{hw}} \times P_F} \times C_1 \\ &= 5843.6 \times 24 \times .1879 \times 1.000312 \times .98339 \times .9812 \times .6428 \times 1.0181 \times 8.98554 \times 7.407 \times 1.0 \\ &= 1067164 = 1067200 \# \end{aligned}$$

PPG "New" METHOD

$$\begin{aligned} F_{\text{Calc}} &= F_B \times F_R \times Y \times F_{TF} \times F_G \times F_{PV} \times \sqrt{H_W \times P_F} \\ &= 5843.6 \times 1.000328 \times .983763 \times .982214 \times .646043 \times 1.01362 \times 66.577 \\ &= 246603.34 \times 24 \times 0.18461 \times .9561 = 1072825 \# \end{aligned}$$

Correction REVISION TO PPG "New" METHOD

$$\begin{aligned} F_{PV} \times \sqrt{\sum X_{2B}^2 Z_{2B}^2} &= \sqrt{0.985375} = 0.994140 \\ F_{\text{Calc}} &= 1072825 \times 0.994140 = 1066538 \# \end{aligned}$$

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CONTINENTAL OIL COMPANY
CALCULATION SHEET

JOB NO. CHLORINE METERING

DATE

9-21-71

TITLE

FILE

STAFF

$\bar{Z}$ BASE

	X ₂	Z ₂
CHLORINE	.7060	.98775
CARBON DIOXIDE	.0214	.99534
NITROGEN	.0123	.99901
OXYGEN	.0074	.99892
AIR	.0029	.99917
	<u>1.0000</u>	<u>.988313</u>

WE CONTENT THAT THE REVISED METHOD
IS HIGH BY : $\frac{Z_B}{\sqrt{Z_B}} = \sqrt{Z_B}$

8-7 $\sqrt{Z_B} = .994140$
8-8 $\sqrt{Z_B} = .994150$

DATE	OLD	$\sqrt{Z_B} \times PPG$	PPG	%
8-7-71	1,064,700	1,064,170	1,070,443	.991
8-8-71	1,064,300	1,064,015	1,070,276	.981

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CALCULATION SHEET

JOB NO. CHLORINE METERING

DATE

9-10-71

TITLE

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OF

STATE

$$F_{PB} = \sqrt{Z_B/Z_F} = 1.015062$$

$$Z_B/Z_F = 1.030351$$

$$\frac{Z_B}{Z_F} = \frac{0.9560(0.9579) + 0.0214(0.94536) + 0.0173(0.99412) + 0.0057(0.9909)}{0.9560(Z_{CHLOR}) + \sum Z_{IXI} (0.04571253)}$$

$$= 1.030351 = \frac{0.98831311}{0.9560 Z_{CHLOR} + 0.04388071}$$

$$0.98501556 Z_{CHLOR} + 0.04571253 = 0.98831311$$

$$Z_{CHLOR} = 0.95744739$$

$$\bar{V} = ZRT/PM$$

	$\bar{V}$	$\bar{V} XW$
CHLORINE	1.42232577	1.38938613
CARBON DIOXIDE	2.38206610	0.02233380
NITROGEN	3.75672262	0.01865588
OXYGEN	3.28349263	0.01122034
AIR	3.63385005	5.00434692
		<u>1.45599311</u>

$$\bar{V} = 1.45599311$$

$$\gamma_f = 0.68681641$$

$$\sqrt{\gamma_f} = 0.82874387$$

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CONTINENTAL OIL COMPANY
CALCULATION SHEET

JOB NO.

DEVELOPED BY

DATE

TITLE

REVISION

STATUS

ERRORS IN CHLORINE METER CALIBRATION

FLOW TRANSMITTERS (S-7-1)

NORTH 1.00 % HIGH AT FULL
 ASSUME $(.92065 \times 7.16)^2 = 80.74 = \text{Normal}$

SOUTH 0.83 % HIGH AT FULL
 ASSUME $(.92065 \times 9.46)^2 = 75.8528 = \text{Normal}$

PRESSURE TRANSMITTERS

BOTH 1.50 psi high @ full
 ~ 1.00 psi high @ flowing

DEVIATION

$$\text{CORRECTION FACTOR} = \frac{\sqrt{h_w P_f \text{ ACTUAL}}}{\sqrt{h_w P_f \text{ READING}}}$$

NORTH $h_w \text{ ACTUAL} = 80.74 \times \frac{1.00}{1.01} = 79.9406$
 $P_f \text{ ACTUAL} = 54.90 - 1.00 = 53.90$
 $h_w \text{ READING} = 80.74$
 $P_f \text{ READING} = 54.90$

$$\text{CORRECTION FACTOR} = \frac{\sqrt{53.90 \times 79.9406}}{\sqrt{54.90 \times 80.74}} = \sqrt{0.972064} = 0.985933$$

SOUTH $h_w \text{ READING} = 75.8528$ $\text{ACTUAL} = 75.2284$
 $P_f \text{ READING} = 57.60$ $\text{ACTUAL} = 56.60$

$$\text{CORRECTION FACTOR} = \frac{\sqrt{56.60 \times 75.2284}}{\sqrt{57.60 \times 75.8528}} = \sqrt{0.974550} = 0.987173$$

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 CALCULATION SHEET

JOB NO

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9-10-71 TITLE

FIELD

STATE

VALUE OF ERROR

$$\text{NORTH} = .785935 \times 246055 = 243137.$$

$$\text{SOUTH} = .987123 \times 245504 = 242360.$$

AUG 242749

$$\text{FLOW RATE} = 1049314 \#$$

$$- 1070443 \#$$

$$\text{DEVIATION} = -21129 \#$$

$$= -21129 \times .020897 = \$441.50 \text{ per day.}$$

$$= \$13687 \text{ per 31 days}$$

$$(21129 \div 1049314) \times 100\% = 2.0136\%$$

$$(21129 \div 1070443) \times 100\% = 1.9739\%$$

$$\left(\frac{242749 - 246055}{242749} \right) \times 100\% = -1.3621\%$$

$$\text{DEVIATION} = \frac{(246055 - 242749) \times 1070443}{246055} = 14382 \#/\text{DAY}$$

$$14382 \times .020897 = \$300.55$$

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CALCULATION SHEET

JOB NO.

CHECKED BY

DATE 9-10-71

TITLE

PAGE 1 OF

FILE

STATE

SPECIFIC WEIGHTS OF GASES AND VAPORS

Compressibility. No gas or vapor follows the simple laws of Boyle and Charles exactly. The deviation from these laws is called compressibility.

A number of formulae based on theoretical considerations have been developed to supplant Boyle's and Charles' laws at high pressure, but all are cumbersome to use and none gives an exact result over a wide range of conditions for all gases and vapors.

The theorem of corresponding states correlates the deviation from Boyle's and Charles' laws with the ratios of temperature and pressure to pseudocritical temperature and pressure. This correlation is defined by the value of Z shown in Figures B-2519 to B-2524, pages 355-60 inclusive. These Z values substituted in Eq. 47 will give a more accurate value for γ_f , the specific weight at flowing conditions.

For gases of known molecular weight, m_w , the specific weight can be computed from the formula

$$\gamma_f = \frac{m_w p_f}{10.73 T_f Z_f} \quad (\text{Eq. 47})$$

in which p_f is the flowing pressure, psia; T_f is flowing absolute temperature °R. $\approx$ °F. + 460°; and Z_f is the compressibility ratio at flowing conditions.

When measuring gas in volume units, both base and flowing conditions must be corrected when using compressibility ratio data. On wet gas, Z_b , the compressibility ratio at base conditions may be appreciably less than 1.0. The combined correction factor is F_{pv} . (See pp. 402, 403, and 411.)

If a specific gravity, G , calculated from the known m_w of the gas as is common when measuring some industrial gases, is substituted for G in the gas flow equations,

$$F_{pv} = \frac{Z_b}{\sqrt{Z_f}} \quad (\text{Eq. 51})$$

The specific gravity of natural gas is usually determined by test. Hence, G includes any effect of compressibility at test conditions and $m_w \approx 29 G Z_b$. Substituting in Eq. 47,

$$\gamma_f = \frac{29 p_f G Z_b}{10.73 T_f Z_f} = \frac{2.702 p_f G Z_b}{T_f Z_f} \quad (\text{Eq. 50})$$

Since γ_f is a half power term in the flow equation (see Eq. 78, p. 406), the supercompressibility factor when using an experimentally determined specific gravity is

$$F_{pv} = \sqrt{\frac{Z_b}{Z_f}} \quad (\text{Eq. 51a})$$

CHARTS USED TO DETERMINE Z

Figure B-2518, page 353, is a chart based on the average characteristics of refinery gas. It permits the quick reading of an estimated value of reduced pressure (p_r) and reduced temperature, (T_R) for the use of the compressibility curves, if the flowing fluid is a refinery gas. Follow up the abscissa corresponding to the flowing temperature to the diagonal line corresponding to the molecular weight of the gas or vapor, and read from the ordinate the value of T_R . Determine p_r in a similar manner. Refer these values to the compressibility curve of the most readable reduced pressure range and read the value of Z_f for use in Eq. 47, page 351.

If the composition of the gas is known, the pseudocritical absolute temperature (T_{ca}) and the pseudocritical absolute pressure (p_c) should be estimated from a weighted average of the critical constants on a volumetric or mol fraction basis.

$$T_R = \frac{T_f}{T_{ca}} \quad (\text{Eq. 28})$$

$$p_r = \frac{p_f}{p_c} \quad (\text{Eq. 27})$$

Figures B-2519 to B-2524, pages 355-60 inclusive, show the average correlation according to the theorem of corresponding states of the 30 gases and vapors listed in Table 28, page 354, except as listed. From the correlations, it would appear that these curves could be used with reasonable accuracy for most gases. The exceptions listed under the titles should be observed.

More accurate correlations for some conditions may be obtained from plots based on kinetic parameters. If interested in further study of the subject, see Reference No. 30, page 537.

Figures B-2519, B-2520, B-2521, B-2522, B-2523, and B-2524, pages 355-60, are the Compressibility Charts of Nelson and Obert, Northwestern Technological Institute, Evanston, Ill.

VIII. GRAVITY CORRECTION FACTOR, F_G

In the chlorine supply contract it is stated that "The gravity correction factor, F_G , will be the calculated ideal specific gravity using molecular weights and calculated daily from the gas composition."

Therefore, subroutine "FACTG" computes F_G by the equation

$$F_G = \sqrt{\frac{M_{air}}{\sum X_i M_i}} \quad (5)$$

Where $M_{air} = 28.966$

X_i = Vol. fraction of component i by daily analysis

M_i = Molecular weight of component i

When $\sum X_i$ does not equal 1, the balance is assumed to be air.

IX. SUPERCOMPRESSIBILITY FACTOR, F_{PV}

By definition, the supercompressibility factor is

$$F_{PV} = \sqrt{\frac{Z_B}{Z_F}} \quad (6)$$

Where Z_B is the compressibility factor of the metered gas at standard conditions (60°F. and 14.73 PSIA), and Z_F is the compressibility factor at actual flow temperature and pressure.

Subroutine "FACTZ" contains a table of components compressibility factors at 60°F. and 14.73 PSIA. They are:

Chlorine	$Z_1 = 0.98790$
Carbon Dioxide	$Z_2 = 0.99536$
Nitrogen	$Z_3 = 0.99922$
Oxygen	$Z_4 = 0.99892$
Hydrogen	$Z_5 = 1.00068$
Carbon Monoxide	$Z_6 = 0.99906$
Air	$Z_7 = 0.99917$

Calculation starts by computing Z_B

$$Z_B = \sum X_i Z_i \quad (7)$$

Then the compressibility factors at actual flow temperature and pressure are calculated by calling two special subprograms. They are

"ZCHLR" for compressibility factor of Cl_2
 "ZINER" for compressibility factors of all other components

Then the value of Z_F is computed by

$$Z_F = \sum X_i Z_{Fi} \quad (8)$$

And F_{PV} is calculated by Equation 6.

X. COMPRESSIBILITY FACTOR OF CHLORINE

According to the chlorine supply contract, the compressibility of chlorine is calculated as in Kapoor-Martin Thermodynamic Properties of Chlorine, University of Michigan Press, 1957. In this book the gaseous volumes are calculated by the Martin-Hou equation-of-state.

$$\begin{aligned} P(V-b)^5 - RT(V-b)^4 - \left[A_2 + B_2 T + C_2 e^{-K \frac{T}{T_C}} \right] (V-b)^3 - \\ - \left[A_3 + B_3 T + C_3 e^{-K \frac{T}{T_C}} \right] (V-b)^2 - A_4 (V-b) - \\ - \left[B_5 T + C_5 e^{-K \frac{T}{T_C}} \right] = 0 \end{aligned} \quad (9)$$

Special subroutine "ZCHLR" solves Equation 9 by a trial-and-error method based upon Newton-Raphson Algorithm. Since Equation 9 is of the fifth order for V , it has five roots. In order to avoid that the solution may diverge toward an unwanted root, provision is introduced so that the solution be in the range of compressibility 0.275 (critical point) to 1.5.

The constants for Equation 9, as given by Kapoor-Martin, are as follows:

$$\begin{aligned} A_2 &= 0.46496772246 \\ B_2 &= 2.129865506 \times 10^{-4} \\ C_2 &= 0.098636526 \\ A_3 &= 8.8856032387 \times 10^{-3} \\ B_3 &= 0.35635855479 \times 10^{-5} \\ C_3 &= 2.252937606 \times 10^{-3} \\ A_4 &= 6.60499557 \times 10^{-5} \\ B_5 &= 0.3692381884 \times 10^{-9} \\ C_5 &= 0.45521856137 \times 10^{-7} \\ R &= 0.010296 \text{ (ATM)(CuFt.)/(Lb)(}^\circ\text{R)} \\ b &= 0.00608353 \\ K &= 2.3 \\ T_C &= 750.9^\circ\text{R} \end{aligned}$$

CCR 000038727

AUG 7, 1971

$$Q_h = (F_{h1})(Y_1)(F_{h2})(F_{h3})(F_{h4})(\sqrt{A_1})(\sqrt{P})(\%Cl_2)(F_{h5})$$

$$Flow = Q_h \times 24 \times 0.1892$$

Chart Reading	9.76	9.46
P/A	54.9	57.6
°F	539	(79)?
%Cl ₂	0.9560	

$$Q_h = (1.0003127)(0.98312)(0.9822)(0.6462)(1.0210834)(0.9955) \times$$

$$(0.92065)(9.76)(7.409453)(0.9560)(5843.6)$$

$$= 253983.03301633$$

$$= \underline{\underline{1153286.16}}$$

POE: method

$$Q_h = (1.0003127)(0.98312)(0.9822)(0.6462)(1.0210834)$$

$$\times (0.92065)(9.76)(7.409453)(0.9560)(5843.6)$$

$$\times (24)(0.1879)$$

$$= \underline{\underline{1068999}}$$

CCR 000038728

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CONTINENTAL OIL COMPANY
CALCULATION SHEET

JOB NO. CHLORINE METERING

8-23-71

TITLE

FIELD

STATE

$$Q_R = F_e F_n Y_1 F_{ef} F_g F_{pr} \sqrt{J_R} \sqrt{P} \quad \text{eq 77}$$

$$\text{Total F. Chlor} = 24 Q_R (\% \text{Cl}_2) (.1879)$$

$$= 5843.6 (1.000328) (0.983763) (0.982216) (0.646043) \\ \times (1.015062) (66.571) (24) (0.18961) (0.9560)$$

$$= 1072824. \quad \#/\text{DAY} \quad \text{CONTAINED CHLORINE}$$

$$W_R = 359 \sqrt{D^2 F_a F_m F_c Y \sqrt{\delta_f} \sqrt{J_R}}$$

$$\sqrt{P} = 5.25 \div 10.020 = 0.52373210$$

$$\sqrt{\delta_f} = 0.173766$$

$$D^2 = (10.02)^2 = 100.4004$$

$$F_a = 1.000$$

$$F_m = 1.000$$

$$F_c = (0.988 + 0.993) / 2 \quad NRE = 0.31 \times 1072824 / 24 \times 0.976841 \times 10.02 \times 1.001 \\ = 0.9905 \quad = 21,344,232$$

$$Y = 0.983763$$

$$\sqrt{J_R} = 0.92065 \times 9.76 = 8.985544$$

$$\sqrt{\delta_f} = 0.82874387$$

$$W_R = 359 (0.173766) (100.4004) (0.9905) (0.983763) (8.985544) (0.82874387)$$

$$= 45446.9168 \quad \#/\text{HR} \quad \text{TOTAL}$$

$$\text{TOTAL} = 45446.9168 \times 24 \times 0.976841$$

$$= 1065466 \quad \#/\text{DAY} \quad \text{CONTAINED CHLORINE}$$

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CHANGE BASE CONDITIONS FROM
14.73 PSIA TO 60.00 PSIA

	X_i	$Z_{\text{BASE}}^{14.73}$	Z_{BASE}^{60}	
CHLORINE	.9560	.98790	.74017	$\frac{60}{14.73}$
CARBON DIOXIDE	.0214	.99441	.9774	$\frac{58.72}{62}$
NITROGEN	.0123	.99973	.99995	
OXYGEN	.0074	.99428	.99713	
AIR	.0029	.99960	.79341	
		<u>.98830</u>	<u>.75023</u>	

$$Q_R = \text{CONSTANT} \times F_{\text{pl}} \times F_{\text{pr}}$$

$$L_{\text{pl}} = \text{CONSTANT} \times F_{\text{pl}} \times F_{\text{pr}} \times P_{\text{pr}}$$

PPG METHOD

$$\cancel{\text{CONSTANT}} \times 1.0 \times \sqrt{.98830} \times .18961 = \cancel{\text{CONSTANT}} \times \frac{14.73}{60} \times \sqrt{.75023} \times .00211$$

$$0.187498 = 0.192403 \quad 1.022116$$

CONOCO METHOD

$$\text{CONSTANT} \times 1.0 \times .98830 \times .18961 = \text{CONSTANT} \times \frac{14.73}{60} \times .95023 \times .00211$$

$$0.187392 = 0.187556 \quad 1.000371$$

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VALUE OF ERRORS

$$\text{NORTH} = .985933 \times 246606 = 243137.$$

$$\text{SOUTH} = \begin{matrix} .974563 \\ .987193 \end{matrix} \times 245504 = \begin{matrix} 239259 \\ 242360 \end{matrix}.$$

$$\text{AUG} \quad \begin{matrix} 241198 \\ 242749 \end{matrix}$$

$$\text{FLOWRATE} = 1049314 \#$$

$$- 1070443 \#$$

$$\text{DEVIATION} = -21129 \#$$

$$= -21129 \times 0.020897 = \$441.50 \text{ per day}$$

$$\underline{\underline{\$13687 \text{ per 31 days}}}$$

$$(21129 \div 1049314) \times 100\% = 2.0136\%$$

$$(21129 \div 1070443) \times 100\% = 1.9739\%$$

$$\left(\frac{242749 - 246055}{242749} \right) \times 100\% = -1.3621\%$$

$$\text{DEVIATION} = \frac{(246055 - 242749) \times 1070443}{246055} = 14382 \#/\text{DAY}$$

$$14382 \times 0.020897 = \$300.55$$

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