CASE 2695: In the matter of the hearing called by the OCC to consider revision of R-333-C & D & R-333-E.

2695

...ation, Transcript,
...l Exhibits. Etc.

The deliverability of a gas well is calculated from the formula:

$$D = Q \times \left[\frac{PC^2 - PD^2}{PC^2 - PW^2}\right]^{SN} \qquad (1)$$

WHERE:

D	=	Calculated well deliverability in MCFD.
Q	=	Measured flow in MCFD.
PC	=	Shut-in well head pressure, PSIA
PD	=	Some fraction of PC, currently Pool Percentage x PC. = Deliverability Pres (PD)
PW	=	Well head working pressure, PSIA
SN	=	Slope, determined by well formation.

With the exception of the slope, SN, none of the above variables are raw data, rather, they are the results of intermediate calculations performed on the actual data. The variables which are given as data points are:

METFPRES	Dead weight meter flowing pressure, PSIA. Given as an integer value.
FPRES	Flowing pressure read from meter chart, PSIA. Given as an integer value.
CGAGEPRES	Average gauge pressure during flow test, PSIG. Given as an integer value.
VOLUME	Total gas flow during flow test, MCF. Given as an integer value.
CTESTHRS	Number of hours of flow test. Given as an integer value.
TBGFPRES (CSGFPRES)	Dead weight tubing (casing) flowing pressure, PSIA. Given as an integer value.
TBGLTH (CSGLTH)	Length of tubing (casing) string, feet. Given as an integer value.
SPGRAV	Specific gravity of gas. Given to three decimal places.
TBGSIP (CSGSIP)	Tubing (casing) shut-in pressure, PSIA. Given as an integer value.
SN	Slope. Given to two decimal places.

The following formulas are used to convert the raw data to the variables of equation. (1)

$$Q = \frac{VOLUME \times 24}{CTESTHRS} \times \sqrt{\frac{METFPRES}{FPRES}} \quad (2)$$

PC = TBGSIP OR: ~~Avg. Offset SIP~~ Commission designated value or Avg. offset SIP

OR: PC = CSGSIP (3)

PD = PC x Pool Percentage (4)

PT = (CGAGEPRES + 12) + (METFPRES - FPRES) + (TBGFPRES - METFPRES) (5)

OR:

PT = (CGAGEPRES + 12) + (METFPRES - FPRES) + (CSGFPRES - METFPRES) (6)

* R^2 = FGL x $(FC \times Q)^2$

* Where FGL is a tabular function of SPGRAV x TBGLTH (or SPGRAV x CSGLTH) and FC is a tabular function of TBGOD or CSGOD.

The procedure to be used on the IBM 7070 to implement these formulas are listed below and on the following pages.

1. Meter error is calculated as the difference between the dead weight meter flowing pressure and the flowing pressure read from the chart. This value is carried as a whole number.

   METEROR = METFPRES - FPRES

   XXX = XXXX. - XXXX.

2. The flow rate correction factor is obtained by dividing the dead weight meter flowing pressure by the chart flow pressure. The result is truncated at four places to the right of the decimal.

   CFACT = METFPRESS/FPRESS

   X.XXXX = XXXX./XXXX.

3. The square root of the flow rate correction factor is determined by Newton's Approximation. The result is rounded to four places to the right of the decimal.

   SQRCFACT = $\sqrt{CFACT}$

   X.XXXX = $\sqrt{X.XXXX}$

4. The seven or eight day average flowing pressure is calculated as the 7-day or 8-day average chart pressure plus 12.

   AVGPRES = CGAGEPRES + 12.

   XXXX = XXXX. + XX.

5. The corrected average pressure is obtained by adding the meter error to the calculated average pressure.

CORPRES	=	AVGPRES	+	METERROR
XXXX.	=	XXXX.	+	XXX.

6. The integrated volume is equal to the measured volume, multiplied by 24 and divided by the number of hours the test was run. The result is rounded to the nearest whole number.

QI	=	(VOLUME x 24)/CTESTHRS
XXXXXX.	=	XXXXXXXXXX. x XX./XXXX.

7. The integrated volume is multiplied by the square root of the flow rate factor to give the corrected volume. The corrected volume is rounded to the nearest integer value.

Q	=	QI	x	SQRCFACT
XXXXXX.	=	XXXXXX.	x	X.XXXX

8. The friction loss, the static head, and the proper shut-in pressure are determined as functions of the type of flow in the well:

A. TUBING FLOW:

(1) The friction loss is the difference between the tubing flowing pressure and the meter flowing pressure.

FRLOSS	=	TBGFPRES	-	METFPRES
XXXX.	=	XXXX.	-	XXXX.

(2) The tubing length and the specific gravity are multiplied and the result rounded to the nearest integer value.

GL	=	TBGLTH	x	SPGRAV
XXXX.	=	XXXXX.	x	X.XXX

(3) A friction factor is chosen from a table according to outside tubing diameter and tubing weight. This factor is carried to four places to the right of the decimal.

NOTE: Before each calculation, Gas Engineer needs to be able to delete or add new tubing OD to Table. Therefore, we need a Table size of 40 different entries. It will be necessary to find an equal on TBGOD and TBGWT when using the Table.

FC = XX.XXXX

(4) The shut-in pressure to be used in the calculation is set equal to the greatest of the three shut-in pressures. If the ~~Avg. Offset SIP~~ [Comm. Designated Value] is the greatest, put out message: "~~Average Offset SIP~~ [Comm. Designated Value] used for PC."

PC	=	Greatest SIP
XXXX.	=	XXXX.

B. CASING FLOW:

(1) The friction loss is the difference between the casing flowing pressure and the meter flowing pressure.

FRLOSS	=	CSGFPRES	-	METFPRES
XXXX.	=	XXXX.	-	XXXX.

(2) A comparison is made between the CSGLTH (XXXXX.) and the PAYZNFRM (XXXXX.) and the smaller number is multiplied by the SPGRAV to obtain GL. The result is rounded to the nearest integer value. Do not substitute any indicative data on C-122A Test Sheet.

GL	=	SPGRAV	x	Smaller Length
XXXX.	=	X.XXX	x	XXXXX.

(3) A friction factor is chosen from a Table according to outside casing diameter and casing weight. This factor is carried to four places to the right of the decimal.

NOTE: Before each calculation, Gas Engineer needs to be able to delete or add new casing OD to Table. Therefore, we need a Table size of 125 different entries. It will be necessary to find an equal on CSGOD and CSGWT when using the Table.

FC = XX.XXXX

(4) The shut-in pressure to be used in the calculation is set equal to the greatest of the three shut-in pressures. If the ~~Average Offset SIP~~ [Comm. Designated Value] is the greatest, put out message: "~~Average Offset SIP~~ [Comm. Designated Value] used for PC.

PC	=	Greatest SIP
XXXX.	=	XXXX.

C. ANNULAR FLOW:

(1) The friction is set to the difference between the casing flowing pressure and the meter flowing pressure.

FRLOSS	=	CSGFPRES	-	METFPRES
XXXX.	=	XXXX.	-	XXXX.

(2) A comparison is made between the CSGLTH (XXXXX.) and the PAYZNFRM (XXXXX.) and the smaller number is multiplied by the SPGRAV to obtain GL. The result is rounded to the nearest integer value. Do not substitute any indicative data on C-122A Test Sheet.

GL	=	SPGRAV	x	Smaller Length
XXXX.	=	X.XXX	x	XXXXX.

(3) A friction factor is calculated from one of two formulas:

(a) $$FC = \frac{57.1053794}{(CSGID + TBGOD) \times (CSGID - TBGOD)^{1.612}}$$

OR

(b) $$FC = \frac{54.6724457}{(CSGID + TBGOD) \times (CSGID - TBGOD)^{1.582}}$$

NOTE: If FC by Formula (a) is equal to or less than 1.357 then recalculate FC by Formula (b).

(4) The shut-in pressure to be used in the calculation is set equal to the greatest of the three shut-in pressures. If the ~~Average~~ Offset SIP is the greatest, put out message: "~~Average~~ Offset SIP used for PC."

PC	=	Greatest SIP
XXXX.	=	XXXX.

9. The ~~calculating~~ pressure is set equal to a Pool Percentage of PC. It is rounded to a integral value. Each pool can be a different percentage, therefore, a Table will have to be set up to keep the percentages and before each calculation, Gas Engineers will need the privilege of changing the percentages and/or adding or eliminating a pool from the Table, as necessary, up to a pool limit of sixty. The following is an example of the necessary Table:

POOL	PERCENT	SLOPE	DRAWDOWN
XXX	.XX	.XX	.XX

The formula for PD is as follows:

PD	=	PC	x	Pool Percent
XXXX.	=	XXXX.	x	.XX

NOTE: Slope in this Table will be utilized in Item 20 of this write up. Drawdown Percent will be utilized in Item 17.

10. The well head corrected 7-day average pressure is computed as the corrected average pressure plus the loss due to friction.

PT	=	CORRES	+	FRLOSS
XXXX.	=	XXXX.	+	XXXX.

11. The well head pressure is squared, the decimal is shifted three places to the left.

PT^2	=	PT	x	PT	x	0.001
XXXXXXXX.	=	XXXX.	x	XXXX.	x	.XXX

12. A tabular function of GL is determined. Three decimals are carried in this function. The current Table size will ~~be sufficient~~ have to be expanded.

FGL	=	.XXX

13. The product of the corrected volume and the friction factor is computed, the decimal is shifted three positions to the left and the product is rounded to three decimal places.

FCQ	=	FC	x	Q	x	.001
XXXXX.XXX	=	XX.XXXX	x	XXXXXX.	x	.XXX

14. The value FCQ is squared and the result is rounded to three places to the right of the decimal.

$(FCQ)^2$	=	FCQ	x	FCQ
XXXXX.XXX	=	XXXXX.XXX	x	XXXXX.XXX

15. The friction effect is calculated as the product of the GL factor and the square of the FCQ result. This friction effect is rounded three places to the right of the decimal.

R^2	=	FGL	X	$(FCQ)^2$
XXXXX.XXX	=	.XXX	x	XXXXX.XXX

16. The square of the well head working pressure is computed as the sum of the friction effect and square of the well head flowing pressure.

(1)				
PW^2	=	PT^2	+	R^2
XXXXX.XXX	=	XXXXX.XXX	+	XXXXX.XXX

(1) If the addition of R^2 at this point ~~fails to~~ changes the value of PW^2 by less than - 0.5, i.e. if $R^2 \leq PT$, then R^2 is ignored and PW^2 is set equal to PT^2.

17. The square root of the above result is extracted to give the well head working pressure. The result is rounded to the nearest integral value.

PW	=	$\sqrt{PW^2 \times 10^3}$
XXXX.	=	$\sqrt{XXXXX.XXX \times 10^3}$

NOTE: A comparison is made between the working pressure, PW and PC. If the calculated Drawdown is less than the Drawdown exhibited in the Pool Table (Item 9) a message is to be put out: "Unable to obtain __*__ % Drawdown."

* This percent value is taken from Drawdown in Pool Table.

The following formula should be used to make the comparison:

$$\text{Drawdown} = \frac{PC - PW}{PC}$$

18. The denominator of the deliverability ratio is calculated as the square of the shut-in pressure, (the decimal is shifted three places to the left) less the square of the well head working pressure.

$$\text{DIVHOLD} = (PC \times PC \times .001) - PW^2$$

$$\text{XXXXX.XXX} = (\text{XXXX.} \times \text{XXXX.} \times .\text{XXX}) - \text{XXXXX.XXX}$$

19. The deliverability ratio is calculated as the difference between the square of the shut-in pressure and the square of the ~~calculating~~ flowing, Pd pressure (the decimal is shifted three places to the left) divided by the result obtained in Item 18. This quotient is truncated at four decimal places.

Write Numerator & Denominator values on Test Sheet

$$\text{RATIO1} = \frac{\left[(PC \times PC) - (PD \times PD)\right] \times .001}{\text{DIVHOLD}}$$

$$\text{XX.XXXX} = \frac{\left[(\text{XXXX.} \times \text{XXXX.}) - (\text{XXXX.} \times \text{XXXX.})\right] \times .\text{XXX}}{\text{XXXXX.XXX}}$$

20. The deliverability correction factor is computed by raising the deliverability ratio to a given power. The result is carried to four decimal places.

$$\text{DFACT1} = (\text{RATIO1})^{SN}$$

$$\text{XX.XXXX} = (\text{XX.XXXX})^{.\text{XX}}$$

NOTE: Compare SN to Tabular Value from Pool Table and if equal continue to raise to power. However, if (high or low) variations occur use Slope from Pool Table, and put out message: "Pool Table Slope used for n." This Table is indicated in Item 9.

21. The final deliverability figure is the product of the corrected volume and the deliverability correction factor. The result is rounded to the nearest integral value.

$$\text{D1} = \text{DFACT1} \times Q$$

$$\text{XXXXXX.} = \text{XX.XXXX} \times \text{XXXXXX.}$$

A comparison is made between DFACT1 as calculated in Item 20 to Tabular value of DFACT1 found in (Pool Table under Item 9) & the smaller value of DFACT1 is to be used. If Table value is used - Pd and message "Maximum multiplier used". However, the calculated DFACT will be reflected on the C-122-A Test Sheet.

Memo No. 1-63

NEW MEXICO OIL CONSERVATION COMMISSION
P. O. Box 871
SANTA FE, NEW MEXICO

MEMORANDUM:

TO: ALL OPERATORS AND WELL TESTERS OF THE GAS WELLS IN SAN JUAN BASIN

FROM: A. L. PORTER, JR., SECRETARY-DIRECTOR

SUBJECT: DELIVERABILITY PRESSURES (P_d) AND LIMITING MULTIPLIERS FOR GAS WELLS IN THE SAN JUAN BASIN AS REQUIRED BY ORDER R-333-F

As required by Chapter II, Section 2 of New Mexico Oil Conservation Commission Order R-333-F, a study of 1962 test data has been made for all gas wells tested in 1962. Based on the results of the study, the deliverability pressures (P_d) for calculating 1963 Annual Deliverability Tests are established as follows:

All Dakota gas wells	$P_d = 50\% \; P_c$
All other gas wells	$P_d = 80\% \; P_c$

Multiplier for any gas well shall not exceed 2.0

The value of P_d shall be determined by multiplying the seven-day shut-in pressure, which has been measured for the test being calculated, by the percentage listed above.

When a multiplier $\left[\frac{P_c^2 - P_d^2}{P_c^2 - P_w^2}\right]^n$ is greater than 2.0 for a test being calculated, the test shall not be reported until the supervisor of the Aztec office has given specific permission in writing to do so after he has determined that the shut-in pressure and drawdown conditions are satisfactory and that the use of such a factor will allow the operator to calculate an accurate deliverability for the well.

The above mentioned 1963 Annual Deliverability Tests shall be used for proration purposes effective February 1, 1964.

Any test which is the initial, the first annual test or the first test after workover should be calculated using 50% of the seven-day shut-in pressure (P_c) as the deliverability pressure (P_d). This is done for the reason that the deliverability from such tests will be used for proration purposes in the 1963 calendar year and all such deliverabilities must be calculated to a common base in order to be equitable.

February 25, 1963

BEFORE THE OIL CONSERVATION COMMISSION
OF THE STATE OF NEW MEXICO

IN THE MATTER OF THE HEARING
CALLED BY THE OIL CONSERVATION
COMMISSION OF THE STATE OF NEW
MEXICO FOR THE PURPOSE OF
CONSIDERING:

CASE No. 2695
Order No. R-333-F

THE APPLICATION OF THE OIL CONSERVATION
COMMISSION UPON ITS OWN MOTION FOR AN
ORDER REVISING, AMENDING, OR DELETING
CERTAIN PORTIONS OF ORDER R-333-C & D
AS AMENDED BY ORDER R-333-E PERTAINING
TO GAS WELL TESTING PROCEDURE APPLICABLE
TO GAS WELLS COMPLETED IN SAN JUAN, RIO
ARRIBA, McKINLEY, AND SANDOVAL COUNTIES,
NEW MEXICO.

ORDER OF THE COMMISSION

BY THE COMMISSION:

This cause came on for hearing at 9 o'clock a.m. on November 8, 1962, at Santa Fe, New Mexico, before Daniel S. Nutter, Examiner duly appointed by the Oil Conservation Commission of New Mexico, hereinafter referred to as the "Commission," in accordance with Rule 1214 of the Commission Rules and Regulations.

NOW, on this 30th day of November, 1962, the Commission, a quorum being present, having considered the application, the evidence adduced, and the recommendations of the Examiner, Daniel S. Nutter, and being fully advised in the premises,

FINDS:

(1) That due public notice having been given as required by law, the Commission has jurisdiction of this cause and the subject matter thereof.

(2) That there is need for a number of additions to and revisions of Order No. R-333-C & D as amended by Order No. R-333-E, heretofore entered by the Commission, said order outlining a testing procedure for gas wells completed in the Counties of San Juan, Rio Arriba, McKinley, and Sandoval, New Mexico.

(3) That the following rules and regulations should be adopted, and that said rules and regulations are in the interest of conservation.

IT IS THEREFORE ORDERED:

(1) That the following Special Rules and Regulations governing gas well testing in the San Juan Basin (Counties of San Juan, Rio Arriba, McKinley, and Sandoval, New Mexico), superseding the rules and regulations contained in Commission Order No. R-333-C & D, as amended by Order No. R-333-E, are hereby promulgated and adopted as an exception to Rules 401 and 402 of the general statewide rules and regulations of this Commission relating to gas well testing procedures.

GAS WELL TESTING RULES AND PROCEDURES
SAN JUAN BASIN, NEW MEXICO

CHAPTER I TYPE OF TESTS REQUIRED

Section 1: Initial Deliverability and Shut-In Pressure Tests for Newly Completed Wells

A. Immediately upon completion of each gas well in the San Juan Basin, a shut-in pressure test of at least seven days duration shall be made.

B. Within 60 days after a well is connected to a gas transportation facility, the well shall have been tested in accordance with Section 1 of Chapter II of these rules, "Initial Deliverability and Shut-In Pressure Test Procedures," and the results of the test filed with the Commission's Aztec office and with the gas transportation facility to which the well is connected. Failure to file said test within the above-prescribed 60-day period will subject the well to the loss of one day's allowable for each day the test is late.

C. The requirements for Initial Tests and Annual Deliverability and Shut-In Pressure Tests and the notification requirements and scheduling of such tests which apply to newly completed wells shall also apply to reworked or recompleted wells.

D. Any tests taken for informational purposes prior to pipeline connection shall not be recognized as official tests for the assignment of allowables.

Section 2: Annual Deliverability and Shut-In Pressure Tests

A. Annual Deliverability and Shut-In Pressure Tests shall be made on all gas wells during the period from January 1 through December 31 each year except as follows:

1. An Annual Deliverability and Shut-In Pressure Test will not be required during the current year for any well connected to a gas transportation facility after October 31. Such tests may be taken at the option of the operator of the well, however.

2. When the Initial Deliverability and Shut-In Pressure Test required by Section 1-B above has been taken in accordance with the annual testing procedure outlined in Section 2 of Chapter II of these rules, the initial test may be considered the annual test for the year in which the test was completed. Provided however, that if an operator intends to use such initial test as the first annual test, he must notify the Commission and the gas transportation facility to which the well is connected of his intent in writing prior to the conclusion of the 14-day conditioning period.

B. All Annual Deliverability and Shut-In Pressure Tests required by these rules must be filed with the Commission's Aztec office and with the appropriate gas transportation facility within 30 days after the end of the month during which the test is completed. Provided however, that any test completed between December 1 and December 31 must be filed not later than January 10. Failure to file any test within the above-prescribed times will subject the well to the loss of one day's allowable for each day the test is late. No extension of time for filing tests beyond January 10 will be granted except after notice and hearing.

Section 3: Scheduling of Tests

A. Annual Deliverability Tests

By December 1 of each year, each gas transportation facility shall, in cooperation with the operators involved, prepare and submit a schedule of the wells to which it is connected which are to be tested during the ensuing January and February. Said schedule shall be entitled, "Annual Deliverability and Shut-In Pressure Test Schedule," and shall be submitted in triplicate to the Commission's Aztec office. At least one copy shall also be furnished each operator concerned. The schedule shall indicate the date of tests, pool, operator, lease, well number, and location of each well. At least 30 days prior to the beginning of each succeeding 2-month testing interval, a similar schedule shall be prepared and filed in accordance with the above.

The gas transportation facility shall be notified immediately by any operator unable to conduct any test as scheduled. In the event a well is not tested in accordance with the test schedule, the well shall be re-scheduled by the gas transportation facility, and the Commission and the operator of the well so notified in writing. Notice to the Commission must be received prior to the conclusion of the 14-day conditioning period.

It shall be the responsibility of each operator to determine that all of its wells are properly scheduled for testing by the gas transportation facility to which they are connected, in order that all annual tests may be completed during the testing season.

B. Deliverability Re-Tests

An operator may, in cooperation with the gas transportation facility, schedule a well for a deliverability re-test upon notification to the Commission's Aztec office at least ten days before the test is to be commenced. Such re-test shall be for good and substantial reason and shall be subject to the approval of the Commission. Re-tests shall in all ways be conducted in conformance with the Annual Deliverability Test Procedures of these rules. The Commission, at its discretion, may require the re-testing of any well by notification to the operator to schedule such re-test.

Section 4: Witnessing of Tests

Any Initial or Annual Deliverability and Shut-In Pressure Test may be witnessed by any or all of the following: an agent of the Commission, an offset operator, a representative of the gas transportation facility connected to the well under test, or a representative of the gas transportation facility taking gas from an offset operator.

CHAPTER II PROCEDURE FOR TESTING

Section 1: Initial Deliverability and Shut-In Pressure Test Procedure

A. Within 60 days after a newly completed well is connected to a gas transportation facility, the operator shall complete a deliverability and shut-in pressure test of the well in conformance with the "Annual Deliverability and Shut-In Pressure Test Procedures" prescribed in Section 2 of this chapter. Results of the test shall be filed as required by Section 1 of Chapter I of these rules.

B. In the event it is impractical to test a newly completed well in conformance with Paragraph A above, the operator may conduct the deliverability and shut-in pressure test in the following manner (provided, however, that any test so conducted will not be accepted as the first annual deliverability and shut-in pressure test as described in Paragraph A-2 of Section 2, Chapter I):

1. A 7- or 8-day production chart may be used as the basis for determining the well's deliverability, providing the chart so used is preceded by at least 14 days continuous production. The well should produce through either the casing or tubing, but not both, into a pipeline during these periods. The production valve and the choke settings shall not be changed during either the conditioning or flow period with the exception of the first week of the conditioning period when maximum production would over-range the meter chart or location production equipment.

2. A shut-in pressure of at least seven days duration shall be taken. This shall be the shut-in test required in Paragraph A, Section 1 of Chapter I of these rules.

3. The average daily static meter pressure shall be determined in accordance with Section 2 of Chapter II of these rules. This pressure shall be used as P_t in calculating P_w for the Deliverability Calculation.

4. The daily average rate of flow shall be determined in accordance with Section 2 of Chapter II.

5. The static wellhead working pressure (P_w) shall be determined in accordance with Section 2 of Chapter II.

6. The deliverability of the well shall be determined by using the data determined in Paragraphs 1 through 5 above, in the deliverability formula in accordance with Section 2 of Chapter II.

7. The data and calculations for Paragraphs 1 through 6 above shall be reported as required in Section 1 of Chapter I of these rules, upon the blue-colored Form C-122-A.

Section 2: Annual Deliverability and Shut-In Pressure Test Procedure

This test shall be taken by producing a well into the pipeline through either the casing or tubing, but not both. The production valve and choke settings shall not be changed during either the conditioning or flow periods except during the first seven days of the conditioning period when maximum production would over-range the meter chart or the location production equipment. The daily flowing rate shall be determined from an average of seven consecutive producing days, following a minimum conditioning period of 14 consecutive days production. The first seven days of said conditioning period shall have not more than one interruption, which interruption shall be no more than 36 continuous hours in duration. The eighth to fourteenth days, inclusive, of said conditioning period shall have no interruptions whatsoever. All production during the 14-day conditioning period plus the 7-day deliverability test period shall be at static wellhead working pressures not in excess of 75 percent of the previous annual 7-day shut-in pressure of the well if such previous annual shut-in pressure information is available; otherwise, the 7-day initial deliverability shut-in pressure of the well shall be used.

In the event that the existing line pressure does not permit a drawdown as specified above with the well producing unrestrictedly into the pipeline, the operator shall request an exception to this requirement on Form C-122-A. The request shall state the reasons for the necessity for the exception.

Instantaneous pressures shall be measured by deadweight gauge during the 7-day flow period at the casinghead, tubinghead, and orifice meter, and shall be recorded along with instantaneous meter-chart static pressure reading.

When it is necessary to restrict the flow of gas between the wellhead and orifice meter, the ratio of the downstream pressure to the upstream pressure shall be determined. When this ratio is 0.57, or less, critical flow conditions shall be considered to exist across the restriction.

When more than one restriction between the wellhead and orifice meter causes the pressures to reflect critical flow between the wellhead and orifice meter, the pressures across each of these restrictions shall be measured to determine whether critical flow exists at any restriction. When critical flow does not exist at any restriction, the pressures taken to disprove critical flow shall be reported to the Commission on Form C-122-A in the "Remarks" section of the form. When critical flow conditions exist, the instantaneous flowing pressures required hereinabove shall be measured during the last 48 hours of the 7-day flow period.

When critical flow exists between the wellhead and orifice meter, the measured wellhead flowing pressure of the string through which the well flowed during test shall be used as P_t when calculating the static wellhead working pressure (P_w) using the method established below.

When critical flow does not exist at any restriction, P_t shall be the corrected average static pressure from the meter chart plus friction loss from the wellhead to the orifice meter.

The static wellhead working pressure (P_w) of any well under test shall be the calculated 7-day average static tubing pressure if the well is flowing through the casing; it shall be the calculated 7-day average static casing pressure if the well is flowing through the tubing. The static wellhead working pressure (P_w) shall be calculated by applying the tables and procedures set out in the New Mexico Oil Conservation Commission Manual entitled "Method of Calculating Pressure Loss Due to Friction in Gas Well Flow Strings for San Juan Basin."

To obtain the shut-in pressure of a well under test, the well shall be shut in immediately after the 7-day deliverability flow test for the full period of seven consecutive days. Such shut-in pressure shall be measured within the next succeeding twenty-four hours following the 7-day shut-in period. The 7-day shut-in pressure shall be measured on both the tubing and the casing when communication exists between the two strings. The higher of such pressures shall be used as P_c in the deliverability calculation. When any such shut-in pressure is determined by the Commission to be abnormally low, the shut-in pressure to be used shall be determined by one of the following methods:

1. A Commission-designated value.

2. An average shut-in pressure of all offset wells completed in the same zone.

3. A calculated surface pressure based on a measured bottom-hole pressure. Such calculation shall be made in accordance with the New Mexico Oil Conservation Commission "Back Pressure Mannual," Example No. 7.

All wellhead pressures as well as the flowing meter pressure tests which are to be taken during the 7-day deliverability test period as required hereinabove shall be taken with a deadweight gauge. The deadweight reading and the date and time according to the chart shall be recorded and maintained in the operator's records with the test information.

Orifice meter charts shall be changed and so arranged as to reflect upon a single chart the flow data for the gas from each well for the full 7-day deliverability test period; however, no tests shall be voided if satisfactory explanation is made as to the necessity for using test volumes through two chart periods. Corrections shall be made for pressure base, measured flowing temperature, specific gravity, and supercompressibility; provided however, if the specific gravity of the gas from any well under test is not available, an estimated specific gravity may be assumed therefor, based upon that of gas from near-by wells, the specific gravity of which has been actually determined by measurement.

The 7-day average flowing meter pressure shall be calculated by taking the average of all consecutive 2-hour flowing meter pressure readings as recorded on the 7-day flow period chart. The pressure so calculated shall be used in calculating the wellhead working pressure, determining supercompressibility factors, and calculating flow volumes.

The 7-day flow period volume shall be calculated from the integrated readings as determined from the flow period orifice meter chart. The volume so calculated shall be divided by the number of testing days on the chart to determine the average daily rate of flow during said flow period. The flow chart shall have a minimum of seven and a maximum of eight legibly recorded flowing days to be acceptable for test purposes. The volume used in this calculation shall be corrected to New Mexico Oil Conservation Commission standard conditions.

The average flowing meter pressure for the 7-day or 8-day flow period and the corrected integrated volume shall be determined by the purchasing company that integrates the flow charts and furnished to the operator or testing agency when such operator or testing agency requests such information.

The daily volume of flow as determined from the flow period chart integrator readings shall be calculated by applying the Basic Orific Meter Formula:

$$Q = C' \sqrt{h_w P_f}$$

Where:

Q = Metered volume of flow Mcfd @ 15.025, 60° F., and 0.60 specific gravity.

C' = The 24-hour basic orifice meter flow factor corrected for flowing temperature, gravity, and supercompressibility.

h_w = Daily average differential meter pressure from flow period chart.

P_f = Daily average flowing meter pressure from flow period chart.

The basic orifice meter flow factors, flowing temperature factor, and specific gravity factor shall be determined from the New Mexico Oil Conservation Commission "Back Pressure Test Manual."

The daily flow period average corrected flowing meter pressure, psig, shall be used to determine the supercompressibility factor. Supercompressibility Tables may be obtained from the New Mexico Oil Conservation Commission.

When supercompressibility correction is made for a gas containing either nitrogen or carbon dioxide in excess of two percent, the supercompressibility factors of such gas shall be determined by the use of Table V of the C.N.G.A. Bulletin TS-402 for pressures 100-500 psig, or Table II, TS-461 for pressures in excess of 500 psig.

The use of tables for calculating rates of flow from integrator readings which do not specifically conform to the New Mexico Oil Conservation Commission "Back Pressure Test Manual" may be approved for determining the daily flow period rates of flow upon a showing that such tables are appropriate and necessary.

The daily average integrated rate of flow for the 7-day flow period shall be corrected for meter error by multiplication by a correction factor. Said correction factor shall be determined by dividing the square root of the chart flowing meter pressure, psia, into the square root of the deadweight flowing meter pressure, psia.

Deliverability pressure, as used herein, is a defined pressure applied to each well and used in the process of comparing the abilities of wells in a pool to produce at static wellhead working pressures equal to a percentage of the 7-day shut-in pressure of the respective individual wells. Such percentage shall be determined and announced periodically by the Commission based on the relationship of the average static wellhead working pressures (P_w) divided by the average 7-day shut-in pressure (P_c) of the pool.

The deliverability of gas at the "deliverability pressure" of any well under test shall be calculated from the test data derived from the tests hereinabove required by use of the following deliverability formula:

$$D = Q \left[\frac{\left(P_c^2 - P_d^2\right)}{\left(P_c^2 - P_w^2\right)}\right]^n$$

Where:

D = Deliverability Mcfd at the deliverability pressure, (P_d), (at Standard Conditions of 15.025 psia and 60°F).

Q = Daily flow rate in Mcfd, at wellhead pressure (P_w).

P_c = 7-day shut-in wellhead pressure, psia, determined in accordance with Section 2 of Chapter II.

P_d = Deliverability pressure, psia, as defined above.

P_w = Average static wellhead working pressure, as determined from 7-day flow period, psia, and calculated from New Mexico Oil Conservation Commission "Pressure Loss Due to Friction" Tables for San Juan Basin.

n = Average pool slope of back pressure curves as follows:

Mesaverde Formation	0.75
Dakota Producing Interval	0.75
Fruitland Formation	0.85
Farmington Formation	0.85
Pictured Cliffs Formation	0.85
Other Formations	0.75

(Note: Special Rules for Any Specific Pool or Formation May Supersede The Above Values. Check Special Rules If In Doubt.)

The value of the multiplier in the above formula (ratio factor after the application of the pool slope) by which Q is multiplied shall not exceed a limiting value to be determined and announced periodically by the Commission. Such determination shall be made after a study of the test data of the pool obtained during the previous testing season. The limiting value of the multiplier may be exceeded only after the operator has conclusively shown to the Commission that the shut-in pressure (P_c) is accurate or that the static wellhead pressure (P_w) cannot be lowered due to existing producing conditions.

Any test prescribed herein will be considered unacceptable if the average flow rate for the final 7-day deliverability test is more than ten percent in excess of any consecutive 7-day average of the preceding two weeks. A deliverability test not meeting this requirement shall be invalid and the well shall be re-tested.

All charts relative to initial or annual deliverability tests or photostats thereof shall be made available to the Commission upon its request.

All testing agencies, whether individuals, companies, pipeline companies, or operators, shall maintain a log of all tests accomplished by them, including all field test data.

All forms heretofore mentioned are hereby adopted for use in the San Juan Basin Area in open form subject to such modification as experience may indicate desirable or necessary.

Initial and Annual Deliverability and Shut-In Pressure Tests for gas wells in all formations shall be conducted and reported in accordance with these rules and procedures. Provided however, these rules shall be subject to any specific modification or change contained in Special Pool Rules adopted for any pool after notice and hearing.

CHAPTER III INFORMATIONAL TESTS

A. A one-point back pressure test may be taken on newly completed wells before their connection or reconnection to a gas transportation facility. This test shall not be a required official test but may be taken for informational purposes at the option of the operator. When taken, this test must be taken and reported as prescribed below:

ONE-POINT BACK PRESSURE POTENTIAL TEST PROCEDURE

1. This test shall be accomplished after a minimum shut-in of seven days. The shut-in pressure shall be measured with a deadweight gauge.

2. The flow rate shall be measured by flowing the well three hours through a positive choke, which has a 3/4-inch orifice.

3. A 2-inch nipple which provides a mechanical means of accurately measuring the pressure and temperature

of the flowing gas shall be installed immediately upstream from the positive choke.

4. The absolute open flow shall be calculated using the conventional back pressure formula as shown in the New Mexico Oil Conservation Commission "Back Pressure Test Manual."

5. The observed data and flow calculations shall be reported in duplicate on Form C-122, "Multi-Point Back Pressure Test for Gas Wells."

6. Non-critical flow shall be considered to exist when the choke pressure is 13 psig or less. When this condition exists the flow rate shall be measured with a pitot tube and nipple as specified in the Commission's Manual of "Tables and Procedure for Pitot Tests." The pitot test nipple shall be installed immediately downstream from the 3/4-inch positive choke.

7. Any well completed with 2-inch nominal size tubing (1.995-inch ID) or larger shall be tested through the tubing.

B. Other tests for informational purposes may be conducted prior to obtaining a pipeline connection for a newly completed well upon receiving specific approval therefor from the Commission's Aztec office. Approval of these tests shall be based primarily upon the volume of gas to be vented.

(2) That jurisdiction of this cause is retained for the entry of such further orders as the Commission may deem necessary.

DONE at Santa Fe, New Mexico, on the day and year hereinabove designated.

STATE OF NEW MEXICO
OIL CONSERVATION COMMISSION

EDWIN L. MECHEM, Chairman

E. S. WALKER, Member

A. L. PORTER, Jr., Member & Secretary

esr/

C O P Y

OIL CONSERVATION COMMISSION
P. O. BOX 871
SANTA FE, NEW MEXICO

December 17, 1962

Mr. Emery C. Arnold
District Supervisor
Oil Conservation Commission
1000 Rio Brazos Road
Aztec, New Mexico

Dear Emery:

Enclosed herewith is Page 6 (revised) of Order No. R-333-F entered by the Commission on November 30, 1962, a copy of which has previously been mailed to you.

A slight typographical error required that Page 6 be done over. Please insert this copy in the order which you received and return the former Page 6 to us.

Very truly yours,

DANIEL S. NUTTER
Chief Engineer

DSN/ear
Enclosure

COPY

OIL CONSERVATION COMMISSION
P. O. BOX 871
SANTA FE, NEW MEXICO

December 17, 1962

Mr. Guy Buell
Pan American Petroleum Corporation
P. O. Box 1410
Fort Worth, Texas

Dear Guy:

Enclosed herewith is Page 6 (revised) of Order No. R-323-F entered by the Commission November 30, 1962, a copy of which has previously been mailed to you.

A slight typographical error required that Page 6 be done over. Please insert this copy in the order which you received and return the former Page 6 to us.

Very truly yours,

DANIEL S. NUTTER
Chief Engineer

DSN/esr
Enclosure

OIL CONSERVATION COMMISSION
P. O. BOX 871
SANTA FE, NEW MEXICO

COPY

December 17, 1962

Mr. R. W. Byram
R. W. Byram & Company
Drawer M - Capitol Station
Austin, Texas

Dear Mr. Byram:

Enclosed herewith is Page 6 (revised) of Order No. R-333-F entered by the Commission on November 30, 1962, a copy of which has previously been mailed to you.

A slight typographical error required that Page 6 be done over. Please insert this copy in the order which you received and return the former Page 6 to us.

Very truly yours,

DANIEL S. NUTTER
Chief Engineer

DSN/esr
Enclosure

OIL CONSERVATION COMMISSION
P. O. BOX 871
SANTA FE, NEW MEXICO

C
O
P
Y

December 17, 1962

Mr. Norman Woodruff
El Paso Natural Gas Company
P. O. Box 1492
El Paso, Texas

Dear Norman:

Enclosed herewith is Page 6 (revised) of Order No. R-333-F entered by the Commission on November 30, 1962, a copy of which has previously been mailed to you.

A slight typographical error required that Page 6 be done over. Please insert this copy in the order which you received and return the former Page 6 to us.

Very truly yours,

DANIEL S. NUTTER
Chief Engineer

DSN/esr
Enclosure

C O P Y

OIL CONSERVATION COMMISSION
P. O. BOX 871
SANTA FE, NEW MEXICO

December 17, 1962

Mr. Bradley H. Keyes
Geolectric, Inc.
Aztec, New Mexico

Dear Brad:

Enclosed herewith is Page 6 (revised) of Order No. R-333-F entered by the Commission on November 30, 1962, a copy of which has previously been mailed to you.

A slight typographical error required that Page 6 be done over. Please insert this copy in the order which you received and return the former Page 6 to us.

Very truly yours,

DANIEL S. NUTTER
Chief Engineer

DSN/esr
Enclosure

COPY

OIL CONSERVATION COMMISSION
P. O. BOX 871
SANTA FE, NEW MEXICO

December 17, 1962

Mr. Ray Bynum
Southern Union Gas Company
1500 Fidelity Union Tower
Dallas, Texas

Dear Mr. Bynum:

Enclosed herewith is Page 6 (revised) of Order No. R-333-F entered by the Commission on November 30, 1962, a copy of which has previously been mailed to you.

A slight typographical error required that Page 6 be done over. Please insert this copy in the order which you received and return the former Page 6 to us.

Very truly yours,

DANIEL S. NUTTER
Chief Engineer

DSN/esr
Enclosure

LAW OFFICES
HOWSER, COUGHLIN & SCHMITT
51 EAST FOOTHILL BOULEVARD
ARCADIA, CALIFORNIA

FRED N. HOWSER
JAMES J. COUGHLIN
WILFRED J. SCHMITT

TELEPHONE
HILLCREST 7-8141
MURRAY 1-9591

November 1, 1962

New Mexico Oil Conservation Commission

Gentlemen:

For and on behalf of A. K. Barbour and Associates, would you please register our objection to the 4th paragraph on page 6 of your proposed revision of Orders R-333-C and D and R-333-E, relating to the seven day shut-in pressure. It is our belief that the use of the highest shut-in pressure would result in a decrease of the calculated deliverability of the well.

Yours very truly,

A. K. BARBOUR & ASSOCIATES

By: [signature]
Attorney

FNH/hc

TIDEWATER OIL COMPANY

BOX 1231, MIDLAND, TEXAS

PRODUCTION DEPARTMENT

R. H. COE, DISTRICT MANAGER
H. G. WESBERRY, ASST. DISTRICT MANAGER
R. N. MILLER, DISTRICT ENGINEER
T. E. [illegible], ADMINISTRATIVE ASST.

November 6, 1962

New Mexico Oil Conservat.ion Commission
Santa Fe, New Mexico
c/o B. H. Keyes
Box 842
Aztec, New Mexico

Gentlemen:

We would like to be placed on record as opposing fourth paragraph of page 6 of proposed revision of orders R-333-C and D, and R-333-E; wherein the higher of shut-in casing and tubing pressure will be used in calculating P_c in deliverability.

Very truly yours,

TIDEWATER OIL COMPANY

R H Coe

R. H. Coe, District
Production Manager

JS:ep

OSCAR ABRAHAM

OIL AND NATURAL GAS PRODUCTION

224 FIRST NATIONAL BANK BUILDING
ALBUQUERQUE, NEW MEXICO
TELEPHONE 247-8815

814 MERCANTILE BANK BUILDING
DALLAS TEXAS
TELEPHONE RI 8-5050

November-2-1962

New Mexico Oil Conservation Commission
Santa Fe, New Mexico

Dear Sirs:

I have read your Oil Commission proposed revision of order R-333C and D and R-333E.

The only revision that I am against appears in the fourth paragraph on page 6, where it states: "The seven-day (7) shut -in pressure shall be measured on both the tubing and the casing when communication exists between the two strings.

The high of such pressures shall be used as Pc in the deliverability calculation.

Using the highest shut-in pressure would decrease the calculated deliverability of the well.

Yours very truly,

J. R. Abraham

J.R. Abraham

2694 + 2695

CONTINENTAL OIL COMPANY

1845 Sherman Street
Columbine Building
Denver 3, Colorado
November 6, 1962

New Mexico Oil Conservation Commission
Post Office Box 871
Santa Fe, New Mexico

Attn: Mr. A. P. Porter, Jr.
Secretary - Director

Re: CASES NO. 2694 AND 2695
TO BE HEARD ON NOV. 8, 1962.

Gentlemen:

Continental Oil Company submits the following concerning Cases No. 2694 and 2695 to be heard on November 8, 1962.

CASE NO. 2694

Continental supports the application of Southern Union Production Company for an amendment to the Northwest New Mexico Gas Proration Rules and Regulations which will permit wells ordered shut-in for extended periods to make up accumulated overproducing to produce a minimum of 500 MCF each month during shut-in. Such a provision will allow an operator to maintain a well bore condition free from accumulated formation water during the shut-in periods which will allow a more economic lease operation and prevent waste which could result from possible damage to the producing formation. Continental does question however, the use of the word minimum in the last sentence of Case No. 2694 as presented on the docket.

CASE NO. 2695

Our comments on the proposed revision are as follows:

1. The use of the word "static" when describing the pressure obtained during a flow period, may better be described by substitution of the word "stabilized". This will eliminate confusion to those who associate static pressure as that obtained during shut-in periods. A minor point and is suggested only to help prevent misunderstanding by some operators.

NMOCC
Page Two

CASE NO. 2695

2. The definition of Deliverability Pressure as offered on the bottom of Page 8 is difficult to interpret and should be explained more clearly.

3. Section "C" on Page 10 should be expanded to indicate that tests other than One-point Back Pressure Test may be run for information purposes at the option of the operator, eg. Four-point Back Pressure and Isochronal Tests. As written this Rule implies that only a One-point Test may be taken and only as prescribed thereunder.

The information obtained from a One-point Test is limited. It may suffice in areas where adequate performance information is available from offsetting wells through previous production history. However, in areas where there are no nearby wells, and consequently no nearby gas transportation lines, additional well performance information may be a vital factor in obtaining a market connection. In these cases both the operator and the potential gas purchaser must have a reasonable prediction of a well's capability to produce before they can determine whether the cost of connections is economically feasible. A Multipoint back pressure test or Isochronal Test can be more useful in such instances. In areas of low permeability reservoirs such as many of those in San Juan Basin the Isochronal Test provides a much better basis for predicting future well performance than does the One-point Test.

In these remote areas, some distance from existing gas production and gas sales facilities, where gas reserves or gas deliverabilities are questionable, provisions should be made for allowing testing by a method or methods selected by the operator.

For this reason we recommend the Rule be modified to permit a seven day period in which the operator may run such tests as he deems necessary on a newly completed well before connection or reconnection to a gas transportation facility. These informational tests to be taken at the option of the operator and if run to be reported to the Commission.

Yours very truly,

R. E. White
Division Superintendent
Production Department

Phone
Federal 4-6580
4-6824

GeoLectric, Inc.

P. O. Box 842 . AZTEC, NEW MEXICO

November 12, 1962

Mr. Dan Nutter, Chief Engineer
New Mexico Oil Conservation Commission
P. O. Box 871
Santa Fe, New Mexico

Dan:

Enclosed is a letter from George D. Locke pertaining to the revised deliverability formula and also some other rather pertinent information for your consideration and guidance.

As you can see from this letter and other letters placed in evidence at the hearing on November 8th, the independent operators do not wholeheartedly and without reservation agree with the proposed change or revision of the Northwest Proration Schedule.

Sincerely,

Brad

B. H. Keyes

Encl.

CANDADO PRODUCTION COMPANY

A NEW MEXICO CORPORATION

Producers of Petroleum Products

GEORGE D. LOCKE
PRESIDENT
EDWARD F. WILLIAMS
VICE PRESIDENT
DOROTHY H. EGGERT
SECRETARY

716 FIRST NATIONAL BANK BUILDING · 411 NORTH CENTRAL AVENUE
PHOENIX, ARIZONA

New Mexico Office
AZTEC, NEW MEXICO

November 8, 1962

Mr. B. H. Keyes
GeoLectric, Inc.
P. O. Box 842
Aztec, New Mexico

My dear Brad:

I have considered your letter of October 29, 1962, and also the Oil Commission's proposed provision of Orders R-333-C and D, and R-333-E, and advise you as follows:

That I feel that the provision in the fourth paragraph on page 6, to the effect that,

> "The seven-day (7) shut-in pressure shall be measured on both the tubing and the casing when communication exists between two strings. The high of such pressures shall be used as Pc in the deliverability calculation."

is unfair because to use the highest shown pressure would certainly decrease the calculated deliverability of the well.

Since, under the Commission's regulations, we are already penalized by losing fifty percent of the bottom hole pressure of each well in Largo Canyon, the addition of the foregoing penalty would have the effect of so impairing the income from production as to make future operations unprofitable.

You might also say to the commission that the amendment they should make to their proration orders is on eleminating rationing altogether, and restoring the control of production to the producers and pipe line company under an order requiring a rateable take from each well in the field, this being the only fair and equitable method of controling the production and conserving the resourses of such production to the State of New Mexico.

Very truly yours,

GEORGE D. LOCKE

GDL:gd

PLEASE DIRECT ALL CORRESPONDENCE TO THE ARIZONA OFFICE

No. 32-62

DOCKET: EXAMINER HEARING - THURSDAY - NOVEMBER 8, 1962

9 A.M. - OIL CONSERVATION COMMISSION CONFERENCE ROOM, STATE LAND OFFICE BUILDING, SANTA FE, NEW MEXICO

The following cases will be heard before Daniel S. Nutter, Examiner, or Elvis A. Utz, alternate examiner:

CASE 2682: Application of Pan American Petroleum Corporation for the creation of a new pool and the establishment of special rules and regulations, San Juan County, New Mexico. Applicant, in the above-styled cause, seeks the creation of a new oil pool to be designated the Simpson-Gallup Oil Pool comprising the S/2 of Section 23, SW/4 of Section 24, N/2 of Section 25, and the NE/4 of Section 26, Township 28 North, Range 12 West, San Juan County, New Mexico. Applicant further seeks the establishment of special pool rules including the provisions for 80-acre proration units.

CASE 2683: Application of Curtis R. Inman for approval of a unit agreement, Eddy County, New Mexico. Applicant, in the above-styled cause, seeks approval of the Carnero Peak Unit Area comprising 12,151 acres, more or less, of State, Federal and Fee lands in Townships 22 and 23 South, Ranges 24 and 25 East, Eddy County, New Mexico.

CASE 2684: Application of Gulf Oil Corporation for a triple completion, Lea County, New Mexico. Applicant, in the above-styled cause, seeks authority to complete its H. T. Mattern (NCT-A) Well No. 3, located in Unit P of Section 24, Township 21 South, Range 36 East, Lea County, New Mexico, as a triple completion (conventional) to produce oil from the Paddock, Blinebry, and Drinkard Oil Pools through parallel strings of tubing.

CASE 2685: Application of Gulf Oil Corporation for a triple completion, Lea County, New Mexico. Applicant, in the above-styled cause, seeks authority to complete its Graham State (NCT-I) Well No. 2 located in Unit L of Section 19, Township 21 South, Range 37 East, Lea County, New Mexico, as a triple completion (conventional) to produce oil from the Paddock, Blinebry, and Drinkard Oil Pools through parallel strings of tubing.

CASE 2686: Application of Marathon Oil Company for a dual completion, Lea County, New Mexico. Applicant, in the above-styled cause, seeks authority to complete its State Hansen Well No. 5, located in Unit H of Section 16, Township 20 South, Range 37 East, Lea County, New Mexico, as a dual completion

CASE 2686 (Cont.)
(conventional), to produce oil from the Weir-Blinebry and Monument-Tubb Pools through parallel strings of 1.41 ID and 2-inch ID tubing.

CASE 2687: Application of Shell Oil Company for a dual completion, Lea County, New Mexico. Applicant, in the above-styled cause, seeks authority to complete its Emerald Unit Well No. 1 located in Unit C of Section 23, Township 16 South, Range 32 East, Lea County, New Mexico as a dual completion (Conventional) to produce oil from the Penrose and Wolfcamp formations through parallel strings of tubing.

CASE 2688: Application of Socony Mobil Oil Company for a quadruple Completion, Lea County, New Mexico. Applicant, in the above-styled cause, seeks authority to complete its State Bridges Well No. 95 located in Unit P of Section 26, Township 17 South, Range 34 East, Lea County, New Mexico, as a quadruple completion (conventional) to produce oil from the Abo, Wolfcamp, Pennsylvanian and Devonian formations through parallel strings of tubing.

CASE 2689: Application of Socony Mobil Oil Company for a dual completion and certain administrative procedures, Lea County, New Mexico. Applicant, in the above-styled cause, seeks authority to complete its State Bridges Well No. 27-DD located in Unit H of Section 26, Township 17 South, Range 34 East, Lea County, New Mexico as a dual completion (conventional) to produce oil from the Vacuum (San Andres) Pool and an undesignated Yeso pool through parallel strings of 2 3/8 inch and 2 3/8 x 1 1/4 inch tapered tubing strings. Applicant further seeks the establishment of administrative procedures whereby similar dual completions could be approved in this area.

CASE 2690: Application of Phillips Petroleum Company for a special allowable, Lea County, New Mexico. Applicant, in the above-styled cause, seeks an order authorizing the assignment of a special allowable to its Mexco "A" Well No. 2, located in Unit I of Section 2, Township 17 South, Range 32 East, Maljamar Pool, Lea County, New Mexico. Said well offsets and has received a response from Boller and Nichols Waterflood project in said Section 2.

CASE 2691: Application of El Paso Natural Gas Company for the creation of a new gas pool and establishment of special rules and regulations, Lea County, New Mexico. Applicant, in the above-styled cause, seeks the creation of a new gas pool for the Morrow formation underlying Sections 18, 19, 20, and 29, Township 19 South, Range 32 East, Lea County, New Mexico. Applicant further seeks establishment of special pool rules including provisions for 640-acre proration units and the allocation of allowables to non-marginal wells in the proportion that each well's acreage factor bears to the total of the acreage factors for all non-marginal wells in the pool.

CASE 2692: Application of Amerada Petroleum Corporation for an exception to a Commission shut-in order, Lea County, New Mexico. Applicant, in the above-styled cause, seeks an exception to Rule 15 (A) Order R-1670, Southeast New Mexico Gas Proration Rules and Regulations, to permit its Shell-Amerada State "A" Unit Well No. 1 located in Unit P, Section 33, Township 11 South, Range 33 East, Bagley-Lower Pennsylvanian Gas Pool, Lea County, New Mexico, to produce a minimum of 2000 MCF per month in exception to an overproduction shut-in notice.

CASE 2693: Application of NWJ Producing Company for an unorthodox location, Lea County, New Mexico. Applicant, in the above-styled cause, seeks approval of an unorthodox oil well location 330 feet from the South and West lines of Section 14, Township 15 South, Range 38 East, Medicine Rock-Devonian Pool, Lea County, New Mexico, in exception to Rule 3, Order R-2315, Medicine Rock-Devonian Pool Rules.

CASE 2694: Application of Southern Union Production Company for an amendment to the Northwest New Mexico Gas Proration Rules and Regulations. Applicant, in the above-styled cause, seeks an amendment to Order R-1670 as amended by Order No. R-2086, Rules and Regulations for Prorated Gas Pools, San Juan, Rio Arriba, McKinley and Sandoval Counties, New Mexico, to permit wells ordered shut-in for extended periods to make up accumulated overproduction to produce a minimum of 500 MCF each month during such shut-in.

CASE 2695: In the matter of the hearing called on the motion of the Oil Conservation Commission to consider revising Commission Orders R-333-C & D and R-333-E as the same relate to the season for taking Northwest New Mexico gas well deliverability tests and to the procedure for taking and calculating such tests, San Juan, Rio Arriba, McKinley and Sandoval Counties, New Mexico.

CASE 2670: (Cont)

Application of Elwyn C. Hale for a quadruple completion, Lea County, New Mexico. Applicant, in the above-styled cause, seeks approval of the quadruple completion (combination) of his Hale State Well No. 3, located in Unit H of Section 2, Township 25 South, Range 37 East, Lea County, New Mexico, in such a manner as to produce oil from the Devonian, McKee, Waddell and Ellenburger Pools, North Justis Field, through two strings of 2 7/8 inch casing and two strings of 3 1/2 inch casing all cemented in a common well bore.

iqg/

PROPOSED REVISION OF ORDERS R-333-C&D AND R-333-E

The following is a copy of the proposed Special Rules and Regulations governing gas well testing in the San Juan Basin which will be considered at a hearing to be held in the Oil Conservation Commission Conference Room, State Land Office Building, Santa Fe, New Mexico, at 9:00 a.m., November 8, 1962.

These rules would supersede Commission Orders R-333-C and D and R-333-E and would govern gas well testing in the Counties of San Juan, Rio Arriba, McKinley, and Sandoval.

GAS WELL TESTING RULES AND PROCEDURES FOR SAN JUAN BASIN AREA

SECTION A. TYPE OF GAS WELL TESTS REQUIRED:

I. THE INITIAL DELIVERABILITY AND SHUT-IN PRESSURE TESTS FOR NEWLY COMPLETED GAS WELLS.

(A) Immediately upon completion of each gas well in San Juan Basin, a shut-in pressure test of at least 7 days duration shall be made.

(B) Within 60 days after a well is connected to a gas transportation facility the well shall be tested in accordance with Section B, Subsection I, Paragraph (A) of this order, and the results of the test reported to the Commission, and to the gas transportation facility to which the well is connected. Failure to file the required test within the time prescribed above will subject the delinquent well to the loss of one day's allowable for each day the test is late.

(C) Any tests accomplished for information purposes prior to pipeline connection shall not be recognized as an official test for the establishment of allowables.

II. ANNUAL DELIVERABILITY AND SHUT-IN PRESSURE TESTS:

Annual Deliverability and Shut-In Pressure Tests of all producing

BEFORE EXAMINER NUTTER
OIL CONSERVATION COMMISSION
OCC EXHIBIT NO. 1
CASE NO. 2695

gas wells are required to be made during the period from January 1, through December 31, of each year.

1. Annual Deliverability and Shut-In Pressure tests shall not be required during the current annual test period for wells connected after October 31 to a gas transportation facility but such tests may be taken at the option of operator.

2. An initial deliverability test accomplished in accordance with annual testing procedures set out in this order shall be used as the annual test of the well for the year in which the test was accomplished.

All Annual Deliverability and Shut-In Pressure Tests required by this order shall be filed with the Commission and with the gas transportation facility to which the wells are connected within thirty (30) days after the end of the month during which the test is completed; provided however, that all tests completed during the period from December 1 through December 31, shall be reported not later than January 10 of the following year. Failure to file the required tests within the time prescribed above may subject the delinquent wells to the loss of one day's allowable for each day the test is late. No extension of time will be allowed after January 10, except after notice and hearing.

III. <u>SCHEDULE OF TESTS</u>:

(A) <u>ANNUAL DELIVERABILITY TESTS</u>

At least 30 days prior to the beginning of the tests the gas transportation facilities receiving gas from wells to be tested shall, in cooperation with respective operators, submit to the Commission's Aztec office a testing schedule for the Annual Deliverability and Shut-in Pressure Tests. Three copies of the schedule shall be furnished to the Commission and one copy shall be furnished to each operator concerned. Such schedule shall indicate the dates of tests, pool, operator, lease, well number and location of each well. The gas transportation facility making the schedule of tests shall be notified immediately by any operator unable to take such tests as scheduled.

When an Initial Deliverability Test accomplished in accordance with annual testing procedures is to be used as an annual test the operator shall notify the Commission, and the gas transportation facility to which the well is connected, in writing during the fourteen day conditioning period for said test.

In the event a well is not tested in accordance with the test schedule, the well shall be re-scheduled for testing, and the Commission shall be notified of such fact in writing not later than the fourteen day conditioning period for said test.

It shall be the responsibility of each operator to determine that its wells are properly scheduled by the transportation facility to which its wells are connected, in order that said wells can be tested within the testing season.

(B) DELIVERABILITY RETESTS

An operator may, in cooperation with the transportation facility, schedule a well for a deliverability retest by notification to the Commission ten (10) days before the retest is to commence. Such notification shall consist of scheduling the well as required for the annual deliverability test in subsection III, Paragraph A, above. Such retest shall be for good and substantial reason and shall be subject to the approval of the Commission, and conducted in conformance with the Annual Deliverability Test procedures of this order. The Commission may at its discretion require the retesting of any well by notification to the operator to schedule such retest.

The requirements for Initial and Annual Deliverability Tests and the notification and scheduling of such tests which apply to newly completed wells shall also apply to reworked or recompleted wells.

IV. WHO MAY WITNESS TESTS:

Any initial or annual deliverability and shut-in pressure test may be witnessed by any or all of the following: an agent of the Commission, an offset operator, a representative of the pipeline company taking gas from an offset operator, or a representative of a pipeline company taking gas from the well under test.

SECTION B. PROCEDURE FOR TESTS:

I. MESAVERDE FORMATION:

(A) INITIAL DELIVERABILITY AND SHUT-IN PRESSURE TEST

1. Within sixty days (60) after a newly completed well is connected to a gas transportation facility the operator shall accomplish a deliverability and shut-in pressure test in conformance with annual test procedures

of this order and results reported as required in Section A, Subsection I, or:

2. In the event that it is impractical to test a newly completed well in accordance with paragraph 1 above, the operator may accomplish a deliverability and shut-in pressure test in the following manner:

(a) "A seven or eight day production chart may be used as a basis for determining the well's deliverability, providing the chart so used is preceded by at least fourteen (14) days continuous production. The well shall produce through either the casing or tubing, but not both, into a pipeline during these periods. The production valve and the choke settings shall not be changed during either the conditioning or flow period with the exception of the first week of the conditioning period when maximum production would over-range the meter chart and/or location production equipment."

(b) A shut-in pressure of at least seven days duration shall be taken. This shall be the shut-in test required in Section A, Subsection I, Paragraph (A).

(c) The average daily static meter pressure shall be determined in accordance with Section B, subsection I, Paragraph (B). This pressure shall be used as P_t in calculating P_w for the Deliverability Calculation.

(d) The daily average rate of flow shall be determined in accordance with Section B, Subsection I, Paragraph (B) of this order.

(e) The static wellhead working pressure (P_w) shall be determined in accordance with Section B, Subsection I, Paragraph (B) of this order.

(f) The deliverability of the well shall be determined by using the data determined in Paragraphs (a) through (e) above, in the deliverability formula in accordance with Section B, Subsection I, Paragraph (B) of this order.

(g) The data and calculations for the above Paragraphs (a) through (f) shall be reported as required in Section A, Subsection I, upon the blue colored Form C-122-A.

(B) THE ANNUAL DELIVERABILITY AND SHUT-IN PRESSURE TESTS

This test shall be taken by producing a well into the pipeline through either the casing or tubing, but not both. The production valve and choke settings shall not be changed during either the conditioning or flow periods except during the first seven (7) days of the conditioning period when maximum production would overrange the meter chart and/or the location production equipment. The daily flowing rate shall be determined from an average of seven (7) consecutive producing days, following a minimum conditioning period of fourteen (14) consecutive days production. The first seven (7) days of said conditioning period shall have not more than one (1) interruption, which interruption shall be no longer than 36 continuous hours in duration. The eighth to fourteenth days, inclusive, of said conditioning period shall have no interruptions whatsoever. All such production during the fourteen (14) days conditioning period plus the seven (7) day deliverability test period shall be at static wellhead working pressures not in excess of seventy-five (75) percent of the previous annual seven (7) day shut-in pressure of such well if such previous annual shut-in pressure information is available; otherwise, the seven (7) day initial deliverability shut-in pressure of such well shall be used.

In the event that the existing line pressure does not permit a drawdown as specified above, with the well producing unrestrictedly into the pipeline, the operator shall request an exception to this requirement on the Form C-122-A. The request shall state the reasons for the necessity for the exception.

Instantaneous pressures shall be measured by deadweight gauge during the seven day flow period at the casinghead, tubinghead, and orifice meter and recorded along with the instantaneous meter chart static pressure reading.

When it is necessary to restrict the flow of gas between the wellhead and orifice meter the ratio of the downstream pressure to the upstream pressure shall be determined. When this ratio is 0.57, or less, critical flow conditions shall be considered to exist across the restriction.

When more than one restriction between the wellhead and orifice meter causes the pressures to reflect critical flow between the wellhead and orifice meter the pressures across each of these restrictions shall be measured to determine whether critical flow exists at any restriction. When critical flow does not exist at any restriction the pressures taken to disprove critical flow shall be reported to the Commission on Form C-122-A in the "remarks" section of the form. When critical flow conditions exist, the instantaneous flowing pressures required hereinabove shall be measured during the last forty-eight (48) hours of the seven (7) day flow period.

When critical flow exists between the wellhead and orifice meter, the measured wellhead flowing pressure of the string through which the well flowed during test shall be used as P_t when calculating the static wellhead working pressure (P_w) using the method established below.

When critical flow does not exist at any restriction, P_t shall be the corrected average static pressure from the meter chart plus friction loss from the wellhead to the orifice meter.

The static wellhead working pressure (P_w) of any well under test shall be the calculated seven (7) day average static tubing pressure if the well is flowing through the casing; or the calculated seven (7) day average static casing pressure if the well is flowing through the tubing. The static wellhead working pressure (P_w) shall be calculated by applying the tables and procedures as set out in New Mexico Oil Conservation Commission Manual entitled "Method of Calculating Pressure Loss Due to Friction in Gas Well Flow Strings" for San Juan Basin.

To obtain the shut-in pressure of a well under test the well shall be shut-in immediately after the seven (7) day deliverability test for the full period of seven (7) consecutive days. Such shut-in pressure shall be measured within the next succeeding twenty-four (24) hours following the seven (7) day shut-in period aforesaid. The seven-day (7) shut-in pressure shall be measured on both the tubing and the casing when communication exists between the two strings. The high of such pressures shall be used as P_c in the deliverability calculation. When any such shut-in pressure has been determined by the Commission to be abnormally low, or when only one pressure is available, the shut-in pressure to be used shall be determined by one of the following methods:

1. A Commission designated value.

2. An average shut-in pressure of all offset wells completed in the same zone.

3. A calculated surface pressure based on a measured bottom hole pressure. Such calculation shall be made in accordance with New Mexico Oil Conservation Commission Back Pressure Manual, Example No. 7.

All wellhead pressures as well as the flowing meter pressure tests which are to be taken during the seven (7) day deliverability test period, as required hereinabove, shall be taken with a deadweight gauge. The deadweight reading, the date and time according to the chart shall be recorded and maintained in the companies records with the test information.

Orifice meter charts shall be changed and so arranged as to reflect upon a single chart the flow data for the gas from each well for the full seven-day deliverability test period; except that no tests shall be voided if satisfactory explanation is made as to the necessity for using test volumes through two chart periods. Corrections shall be made for pressure base, measured flowing temperature, specific gravity, and supercompressibility provided however, that if the specific gravity of the gas from any well under test is not available, an estimated specific gravity may be assumed therefor, based upon that of gas from near-by wells, the specific gravity of which has been actually determined by measurement.

The seven (7) day average flowing meter pressure shall be calculated by taking the average of all consecutive 2-hour flowing meter pressure readings as recorded on the seven (7) day flow period chart (test chart #3). The pressure so calculated shall be used in calculating the wellhead working pressure, determining supercompressibility factors and calculating flow volumes.

The seven (7) day flow period volume shall be calculated from the integrated readings as determined from the flow period orifice meter chart, (chart #3). The volume so calculated shall be divided by the number of testing days on the chart to determine the average daily flow period rate of flow. The flow chart shall have legibly recorded a minimum of seven (7) days and a maximum of eight (8) flowing days to be acceptable for test purposes. The volume used in this calculation shall be corrected to New Mexico Oil Conservation Commission standard conditions.

The average flowing meter pressure for the seven (7) day or eight (8) day flow period and the corrected integrated volume shall be determined by the purchasing company that integrates the flow charts and furnished to the operator or testing agency when such operator or testing agency requests such information.

The daily volume of flow as determined from the flow period chart (Test Chart #3) integrator readings shall be calculated by applying the Basic Orifice meter formula.

$$Q = C' \sqrt{h_w \quad P_f}$$

Where:

Q = Metered volume of flow MCFD @ 15.025, 60° F. and .60 specific gravity.

C' = The 24-hour basic orifice meter flow factor corrected for flowing temperature, gravity and supercompressibility.

h_w = Daily average differential meter pressure from flow period chart.

P_f = Daily average flowing meter pressure from flow period chart.

The basic orifice meter flow factors, flowing temperature factor and specific gravity factor shall be determined from New Mexico Oil Conservation Commission Back Pressure Test Manual.

The daily flow period average corrected flowing meter pressure, psig, shall be used to determine the supercompressibility factor. Supercompressibility Tables may be obtained from the New Mexico Oil Conservation Commission.

When supercompressibility correction is made for a gas containing either nitrogen or carbon dioxide in excess of 2 percent, the supercompressibility factors of such gas shall be determined by the use of Table V of the C.N.G.A. Bulletins TS-402 for pressure 100-500 psig or Table II, TS-461 for pressures in excess of 500 psig.

The use of tables for calculating rates of flow from integrator readings, which do not specifically conform to New Mexico Oil Conservation Commission Back Pressure Test Manual may be approved for determining the daily flow period rates of flow upon a showing that such tables are appropriate and necessary.

The daily average integrated rate of flow for the seven-day flow period shall be corrected for meter error by the multiplication by a correction factor determined by dividing the square root of the chart flowing meter pressure psia into the square root of the deadweight flowing meter pressure psia.

Deliverability pressure, as used herein for the Mesaverde formation, is a defined pressure applied to each well and used in the process of comparing the abilities of wells in this formation to produce at static wellhead working pressures equal to a percentage of the seven (7) day shut-in pressure of the respective individual wells. Such percentage shall be determined periodically by the Commission based on the relationship of the average static wellhead working pressures (P_w) divided by the average (P_c) seven-day shut-in pressure of the pool.

The deliverability of gas at the "deliverability pressure" of any well under test shall be calculated from the test data derived from the tests hereinabove required by use of the following deliverability formula:

$$D = Q \left[\frac{\left(P_c^2 - P_d^2 \right)}{\left(P_c^2 - P_w^2 \right)} \right]^n$$

WHERE:

D = Deliverability at the deliverability pressure, (P_d) Mcfd, (at Standard Condition of 15.025 psia and 60° F).

Q = Daily flow rate in Mcfd, at wellhead pressure (P_w).

P_c = 7-day shut-in wellhead pressure, psia, determined in accordance with Section B, Subsection I, Paragraph (B).

P_d = Deliverability pressure; psia, as defined above.

P_w = Average static wellhead working pressure, as determined from 7-day flow period, psia, and calculated from New Mexico Oil Conservation Commission "Pressure Loss Due to Friction" Tables.

n = Average pool slope of back pressure curve (.75) for Mesaverde wells).

The value of the multiplier in the above formula (ratio factor after the application of the pool slope) by which Q is multiplied shall not exceed a limiting value to be determined periodically by the Commission. Such determination shall be made after a study of the test data of the pool obtained during the previous testing season. The limiting value of multiplier may be exceeded only after the operator has conclusively shown to the Commission that the shut-in pressure (P_c) is accurate or that the static wellhead pressure (P_w) cannot be lowered due to existing producing conditions.

Any test hereinabove provided for will be considered unacceptable if the average flow rate for the final 7-day deliverability test is more than 10 percent in excess of any consecutive 7-day average of the preceding two weeks. A deliverability test not meeting this requirement shall be invalid and the well shall be retested.

All charts relative to annual deliverability tests shall be identified by the words "Test Chart No. 1" (2,3,4, etc.), and any or all charts or photostats thereof shall be made available to the Commission upon its request.

II. ALL FORMATIONS OTHER THAN MESAVERDE

(A) Initial and/or annual deliverability and shut-in Pressure Tests:

Except as provided in Special Pool Rules these tests shall be made and reported in accordance with the procedure set out in this order for the Mesaverde formation, provided however, that the exponent "n" for the Pictured Cliffs and Fruitland formations shall be point eight five (0.85).

SECTION C. INFORMATION TEST FOR ALL FORMATIONS

I. TYPE OF TEST:

(A) A one-point back pressure test may be taken on newly completed wells before their connection or reconnection to a gas transportation facility. This test shall not be a required official test but may be taken for information purposes at the option of the operator. When taken, this test must be taken and reported as prescribed below:

(B) ONE-POINT BACK PRESSURE POTENTIAL TEST PROCEDURE

1. This test shall be accomplished after a minimum shut-in of seven days. The shut-in pressure shall be measured with a deadweight gauge.

2. The flow rate shall be measured by flowing the well 3 hours through a positive choke, which has a 3/4 inch orifice.

3. A 2-inch nipple which provides a mechanical means of accurately measuring the pressure and temperature of the flowing gas shall be installed immediately upstream from the positive choke.

4. The absolute open flow shall be calculated using the conventional back pressure formula as shown in New Mexico Oil Conservation Commission Back Pressure Test Manual.

5. The observed data and flow calculations shall be reported in duplicate on Form C-122, "Multi-Point Back Pressure Test for Gas Wells."

6. Non-critical flow exists when the choke pressure is 13 psig or less. When this condition exists the flow rate shall be measured with a pitot tube and nipple as specified in the Commission's manual of "Tables and Procedure for Pitot Tests." The pitot test nipple shall be installed immediately downstream from the 3/4 inch positive choke.

7. Any well completed with two-inch nominal size (1.995 inside diameter) or larger shall be tested through the tubing.

IT IS FURTHER ORDERED:

All forms heretofore mentioned, are hereby adopted for the use in the San Juan Basin Area in open form subject to such modification as experience may indicate.

All testing agencies whether individuals, companies, pipeline companies or operators shall maintain a log of all tests accomplished by them including all field test data.

BEFORE THE
OIL CONSERVATION COMMISSION
Santa Fe, New Mexico
November 8, 1962

EXAMINER HEARING

- -

IN THE MATTER OF:

The hearing called on the motion of the Oil Conservation Commission to consider revising Commission Orders R-333-C & D and R-333-E as the same relate to the season for taking Northwest New Mexico gas well deliverability tests and to the procedure for taking and calculating such tests, San Juan, Rio Arriba, McKinley and Sandoval Counties, New Mexico.

Case 2695

- -

BEFORE: Daniel S. Nutter, Examiner.

TRANSCRIPT OF HEARING

MR. NUTTER: We will call next Case 2695.

MR. DURRETT: In the matter of the hearing called on the motion of the Oil Conservation Commission to consider revising Commission Orders R-333-C & D and R-333-E as the same relate to the season for taking Northwest New Mexico gas well deliverability tests and to the procedure for taking and calculating such tests, San Juan, Rio Arriba, McKinley and Sandoval Counties, New Mexico.

May it please the Commission, my name is James Durrett, appearing on behalf of the Commission and its staff. I have one witness, Mr. Utz, who I will swear in at this time.

(Witness sworn.)

ELVIS A. UTZ

called as a witness, having been first duly sworn, testified as follows:

DIRECT EXAMINATION

BY MR. DURRETT:

Q Will you please state your name and position for the record?

A Elvis A. Utz, Engineer for the New Mexico Oil Conservation Commission.

Q Mr. Utz, have you prepared proposed gas well testing rules and procedures for the San Juan Basin area in the State of New Mexico?

A Yes, I have.

Q Does this area cover the counties as advertised on the docket of this case, that would be San Juan, Rio Arriba, McKinley and Sandoval Counties?

A Yes, it does.

Q Have you prepared your proposed rules in the form of an exhibit for the purpose of this case?

A Yes, I have, and they have so been marked.

Q Mr. Utz, will your proposed rules supersede certain existing orders previously issued by the Commission and now in effect in the San Juan Basin area?

A Yes, they will. If adopted they will supersede R-333-C and D, R-333-E, and a memorandum known as Memorandum 1-56, which has to do with initial potential tests.

Q Mr. Utz, I would like to proceed with you through these rules. I would like to ask you as we go through them to explain the major changes or revisions that these rules will cover.

First, let me ask you this, do your proposed rules clarify the penalty to be imposed for delinquent test?

A Yes, they do. They do that with wording to this effect: "Failure to file the required test within the time prescribed above will subject the delinquent well to the loss of one day's allowable for each day the test is late."

MR. NUTTER: Where is that provision?

A That's on page one, subsection I, paragraph (B). In other words, it's about the third paragraph up on page 1. Heretofore on tests that were late, at the end of the testing season they have been penalized the month of February and each month thereafter that they were late. In this manner, by penalizing a well one day's allowable for each day the test is late, they will all be penalized for the amount of time that the test is actually late rather than being penalized

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one month's allowable if he only happens to be late three or four days.

Q Do your proposed rules clarify the responsibility for scheduling tests?

A Yes, they do. On page 2, about the middle of the page, we have the same wording as previously read as to the loss of one day's allowable. I'm sorry, that is another rule which describes the penalty rather than the question asked. I would like to comment on that paragraph, however, that the last sentence in that paragraph relates that "No extension of time will be allowed after January 10, except after notice and hearing."

To answer the question that you asked, at the top of page 3, the second paragraph, that paragraph has been added to the previous rule and states that "It shall be the responsibility of each operator to determine that its wells are properly scheduled by the transportation facility to which its wells are connected, in order that said wells can be tested within the testing season." I think that clarifies the vagueness that I feel sure, and I feel that a lot of other people thought, was in the previous order.

Q Do your proposed rules revise the existing extensions of time for taking tests?

A Yes, sir. In relation to the period of time after a well is connected to the pipeline system, as well as the period of time that a well is reconnected to the pipeline system after workover. At the bottom of page 3 you'll note the words "Within sixty days after a newly completed --" and so forth. The previous rule stated forty-five days plus an extension time of fifteen days, which had to be applied for and given administratively. In my opinion that was somewhat of an administrative burden to apply for the additional fifteen days. If we are going to grant them sixty days, I say let's just grant them sixty days and say so.

Q Have you found it necessary to restrict the flow of wells into the pipeline under these rules?

A Yes. Since we have quite a number of Dakota wells connected now, we have determined, well, first, let me say the previous rules stated that a well must be produced unrestrictedly into the pipeline. Due to the higher pressure of the Dakota formation it was found that the, not only the separation equipment and production equipment, heaters, treaters and separators as well as the meters which were installed to handle the average range of production was not capable of handling the volume of gas that these wells will produce unrestrictedly. Therefore, they had to be squeezed somewhere between the well head and production meter. That wording has been taken care of in the second paragraph of page 4.

Q Now, referring to restricting the flow between the well head and the meter, do your rules define critical flow and outline procedure to calculate tests when critical flow exists?

A Yes. And due to the choking, yes, they do. Our district office discovered that in some cases we actually had critical flow in this area. Critical flow, generally pressure is twice the downstream pressure. Therefore, the measurement that we had to take between the well head and the meter in order to correct for friction loss was no longer applicable under critical flow conditions, and we had to devise a method in order to eliminate that.

Q Do your rules provide methods for taking shut-in pressure on wells which cannot have both casing and tubing measured and shut-in pressures which appear to be low due to liquids in the bore?

A Yes. On page 6, down about the fourth paragraph, the latter part of that paragraph we have entered this wording, some of which I will recommend a deletion, the second word, beginning with "the high of such pressures", that should be "the higher of such pressures shall be used as P_c in the deliverability calculation. When any such shut-in pressure has been determined by the Commission to be abnormally low, the shut-in pressure to be used shall be determined by one of the following methods:", then we list three methods.

These three methods are as follows: "A Commission designated value." Well, first, I had better elaborate slightly on the portion that I would like deleted from this paragraph. After the words "abnormally low" I would suggest that we delete "or when only one pressure is available". In some instances it is not possible to get the second pressure or annular pressure normally on conventional wells, and even on dual completions where you can take but one pressure, if that pressure appears to be a normal shut-in pressure I doubt the feasibility of compelling the operator to prove that it is actually an accurate pressure by some other means.

The first method would be "A Commission designated value." This would be, it would have to be done only in instances where the shut-in pressure appeared to be abnormally low. The Commission may designate a value from its records. In other words, it is our intention to contour the previous year's pressures for each pool, which would give you a very good indication by location as to whether or not the pressure was abnormally low.

The second would be an average shut-in pressure of all offset wells completed in the same zone. Where this is possible the average shut-in pressure from all offset wells would be applicable pressure or acceptable pressure. The third method would be the calculation of surface pressure based on a measured bottom hole pressure, and this calculation should be made in accordance with the Example No. 7 in the Commission Back Pressure Manual, which simply means that you would run a bomb and determine the bottom hole pressure and calculate back to the surface on a gas gradient.

Q Do your rules provide whether casing pressure or tubing pressure shall be used in the deliverability calculation?

A The rules would provide that the higher of the tubing or casing pressures be used in the deliverability calculation. Perhaps it would be well to give just a little background on why that rule change is necessary at this time. Prior to 1956, that was exactly the way that we required these wells to be tested. It was that we use the higher pressure. It is fairly common knowledge in my opinion that the higher pressure on a well is always the most accurate pressure. There can be a number of things cause the pressure to be low, but there's not very many things that can cause a pressure to be high and inaccurately high.

Due to the advent of long open hole completions and terrific shots of nitroglycerine that were used in order to make these wells more productive in which tubing was run, and to our consternation, and I'm quite sure to a number of operators'

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consternation we found we had a very effective bridging around the tubing. Quite often the annular pressure was original pressures. In other words, that part of the formation had not yet had time to be drained and they were much higher than the producing zone pressures. Therefore, we changed our rule sometime during 1956 to state that only the pressure through the string through which the well flowed could be used, thereby allowing the operator to make use of the shut-in pressure which was applicable to the area in which the well was producing.

Since that time and since sand fracking has been in use for a number of years and shots are no longer used in the area, and since such a large number of these cased in wells have been, if not all, have been remedied where we have communication in most cases between the tubing and annulus, we now feel also because of liquid problems which we are now encountering, we again feel that the most equitable way and the most accurate way to calculate deliverabilities is by using the higher pressure.

Q Under your rules, will a pool deliverability pressure be used in lieu of 50% of individual well seven-day shut-in pressure?

A Yes. Due to liquid problems and in particular some pools in which the shut-in pressures are now approaching closely to the pipeline pressures, we have found that 50% gives us such a high multiplier that in some cases we feel quite sure that this multiplier gives us an extremely exaggerated deliverability. Therefore, in order to relieve the need of having to have so much drawdown and/or using these high multipliers, we believe that on a pool basis that we should determine a deliverability pressure which would be applicable to all wells in that pool, and this would be based on previous years' shut-in pressure and static well head working pressure averages. This will cause the deliverability pressure to be closer to conditions under which the well is produced. In other words, the correction from actual test conditions to deliverability conditions will be much less and have a much less chance of error.

Q What method will be used to determine pool deliverability pressure?

A The rules state, the proposed rules state that "Such percentage shall be determined periodically by the Commission based on the relationship of the average static wellhead working pressures (P_w) divided by the average (P_c) seven-day shut-in pressure of the pool."

Q Do your rules propose that a limiting multiplier be used concerning wells which report a very low shut-in pressure or that cannot achieve a 25% drawdown?

A Yes, they do. Even though we propose a deliverability

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pressure determined as stated, we know that in some instances where we have liquid problems and known liquid problems, that we will have shut-in pressure, surface shut-in pressures that are abnormally low. These surface shut-in pressures we know are not accurate.

The deliverability formula itself presumes that the P_c in the formula be an accurate indication of the reservoir pressure, static reservoir pressure. Therefore, to take care of these instances where we have abnormally low shut-in pressures, and in order to control those exaggerated deliverabilities, we believe that the multiplier, which is the value inside the brackets of the deliverability formula, after it's been raised to the power, should be limited to some value to be determined by the Commission.

To go a little farther with that, while the rule does not specifically state how that should be done, I believe that I will recommend that multiplier be, the maximum multiplier be determined in this manner, by the use of the lowest seven-day shut-in pressure in the pool which is determined to be accurate. In other words, no other reservoir conditions affecting that pressure. And the pool average working pressure be put in the deliverability formula to determine what the multiplier is under those conditions, and that no multiplier should be used higher than that.

Q Do your proposed rules provide for a revision of the test period of flow rate previously allowed?

A Yes, they do. This has been brought on to some extent by the fact that our previous rules allowed that the seven-day flow rate not be any higher than 25% above any seven-day period for the previous fourteen-day conditioning period. Some operators, my understanding, actually took advantage of this to try to rest their wells a little bit during the conditioning period. However, the major reason for this change is that due to the higher pressure, Dakota wells again, and the ease of which it is to twist a valve an eighth of a turn and get your 25%. So we have lowered that to 10% rather than 25%.

Q Is the Initial Potential Memo which was issued by the Commission, that's Memo No. 1-56, incorporated into your proposed order?

A Yes, it is. And that memo was brought about also, well, it was Memo 1-56, so it had to be the first memo of 1956, it was brought about by the advent of sand fracking. Previous to this our approved method of taking absolute open flows in the San Juan Basin was using a three-hour open flow through the tubing and taking a Peto test at the end of three hours. Of course, this aggravated the waste of gas and vented to the air

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much more gas than this rule stipulates.

Also due to the high velocity of gas flowing unrestrictedly through two inch tubing, it cut out a lot of wellheads, and actually the wellhead cut out, the operator finds himself in pretty serious condition to stop the flow of gas.

So this memorandum was promulgated and suggested as the official means of taking absolute open flow tests for any well which was completed, and before it was connected to a pipeline system. These are only for information purposes and are not required, but are required to be reported and taken in this manner when they are taken.

This test, briefly, requires that the well be flowed through a 3/4" positive choke for a period of three hours, the pressure at the end of three hours taken and corrected through absolute.

Q Do your rules exempt the Barker Dome-Dakota Pool and the Pennsylvanian formation from testing requirements?

A Yes, they do. At the time the previous order was written it was conceived that it might be necessary to prorate the Barker Dome-Dakota-Pennsylvanian, or Barker Dome-Pennsylvanian Gas Pool, and the Barker Dome-Dakota storage area. At least we felt we needed some productivity information on the Barker Dome storage area, but due to the fact that Barker Dome is on its last legs now, and we have now determined that we have no particular use for availability information from the Barker Dome storage area, I recommend that those testing requirements be removed from the rule.

Q Mr. Utz, do you have any typographical changes or corrections that you would like to make at this time on your Exhibit No. 1?

A Yes. I'll start over at the first again. It would be the fourth paragraph down on page 2. Where we use the word "may subject the delinquent wells to the loss of one day's allowable for each day the test is late", the word may to me implies that any individual or agent of the Commission may at his own discretion subjugate a well to this penalty. I think if we are going to have a penalty it ought to be for everybody. I suggest that we use the word "will".

Q What other changes would you like to make at this time?

A Over on page 4, the second full paragraph down where we use the words "and/or", in other words, we're referring to overrange meter charts, and our location production equipment, the wording "and/or" from a legal standpoint has been attacked, and I think properly so, on numerous occasions, and I suggest that we strike the word "and" and say "or". The word "or" to me means either or both.

MR. NUTTER: How about the little mark, do you want to strike it too?

A Well, I think it would come out too, also. The same correction on the top of page 5 down about five lines where we use the word "and/or".

MR. NUTTER: What comes out there, the "and"?

A Same words, "and/". I believe I've already covered the one on page 6 where I suggested we delete "or when only one pressure is available." At the top of page 10 I would suggest we change the first paragraph to read as follows: "All charts relative to initial or annual deliverability tests, or photostats thereof, shall be made available to the Commission upon its request." These charts are all dated and I see no particular reason why we have to number the charts 1, 2, 3, 4. We know what dates the test was run and we can tag the charts by dates.

MR. NUTTER: What's your recommendation there then?

A I just read it.

REPORTER: (Reading) "All charts relative to initial or annual deliverability tests, or photostats thereof, shall be made available to the Commission upon its request."

A Now, under subsection II, the heading of paragraph (A) where we say "Initial and/or annual deliverability test", we make the usual deletion of "and/". In the paragraph following that, in the last line of that paragraph beginning with the

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words "the Pictured Cliffs, comma, and Farmington formations shall be point eight five." In other words, we've added the Farmington formation. By inference, with the heading "All Formations Other Than Mesaverde", that means that all other formations except the three mentioned here will have the slope of point seven five.

Now, under information tests for all formations, paragraph (A) under I, I would suggest that we add a sentence at the end of this paragraph to this effect: "This rule does not preclude the taking of information tests in addition to this test." Somehow or other someone interpreted this to mean that this was the only type of information test that could be taken, and that was not true. I believe that covers all my typographical errors.

Q (By Mr. Durrett) Mr. Utz, in your opinion will the adoption of these proposed gas well testing rules and procedures for the San Juan Basin area be in the interest of conservation of natural resources, protection of correlative rights, and prevention of waste?

A Yes, I believe they will. I also believe they will give us more accurate deliverability test.

Q Now, for the purpose of clarification, on your sentence you just added on page 10 to the effect that additional tests could be taken, would that be at the option of the operator?

A Certainly.

Q Not to be required?

A No. As a matter of fact, this test mentioned here is not required.

MR. DURRETT: If the Examiner please, I would like to move the introduction of Exhibit No. 1, and that concludes our direct examination.

MR. NUTTER: Exhibit No. 1 will be admitted in evidence in this case.

(Whereupon, Commission's Exhibit No. 1 was admitted into evidence.)

MR. NUTTER: Does anyone have any questions of Mr. Utz? Mr. Arnold.

CROSS EXAMINATION

BY MR. ARNOLD:

Q Mr. Utz, on page 10, Section II, the paragraph that you were just amending, didn't you also intend to add the exponent for the Dakota formation in that?

A No. As I explained, the heading "All Formations Other Than Mesaverde" takes care of the Dakota.

Q But the Dakota doesn't use a point eight five.

A It simply means that it would use the same as the Mesaverde, which has been prescribed in the many previous pages. In other words, this whole sentence here from II down to Section C has to deal with the testing of all formations other than Mesaverde.

Q Is it your point that nowhere does it actually say what the Dakota exponent is?

MR. NUTTER: That's a point that is confusing to me.

A Well, this is a wording "Except as provided in Special Pool Rules these tests shall be made and reported in accordance with the procedure set out in this order for the Mesaverde formation, provided however, that the exponent 'n' for the Pictured Cliffs, Fruitland and Farmington formations shall be point eight five."

MR. NUTTER: Any further questions of Mr. Utz?

BY MR. NUTTER:

Q I want to clarify some things in my own mind on this order. Getting over here to the first page of it, for example, in Section (B) of Roman numeral I, it says "the results of the test reported to the Commission". Where does the operator file the test results with the Commission, with the district office?

A Well, he files them with the Aztec office, and I believe that's covered somewhere in here, but I'm not real sure I can put my finger on it at the moment.

Q It's the district office, though?

A It's the district office in Aztec. Unless somehow or other in the revision we inadvertently eliminated it, it's in here.

Q Over on page 4 I presume that in Section 2 there of little (a) --

A If I may interrupt, it's on "shall submit to the Commission's Aztec office", that is on page 2, next to the last paragraph.

Q That's applicable to the annual deliverability test, and I presume the initial deliverability tests, shut-in pressure tests?

A If you will read down the next paragraph where it reads "When an Initial Deliverability Test accomplished in accordance with annual testing procedures is to be used as an annual test the operator shall notify the Commission, and the gas transportation facility to which the well is connected, in writing during the fourteen day conditioning period for said test."

Q Now we are on page 4. Is there any special reason why subparagraph (a) there is outlined in quotation marks?

A I don't think it is a quotation. I don't believe they ought to be there.

Q You wouldn't object to the deletion of the quotation marks?

A No, I wouldn't object at all. It's just one of those things you don't know how it got in there.

Q It is permissible in that paragraph to change the production valve and the choke setting if your production is over-running your meter chart, or the location production equipment, so I presume that one type of change only is permissible and that would be to curtail the rate of production, that would be a change downward only?

A No, sir. We allow them, due to, well, it's mainly due to, now this was discussed among the staff to quite some degree. We allow them over on page 9, the last paragraph, to over-range the conditioning period by 10%. Now, we allowed that, as a matter of fact, we discussed not allowing any over-range at all. But if a tester has a well stabilized and a choke set for fourteen-day period and then something happens to the pipeline pressure where it goes down and causes the well to exceed that amount, we don't feel he ought to be caused to retest the well because it wouldn't be his fault. But if the pipeline pressure should go down to over-range him to more than 10%, then it would invalidate the test.

Q Supposing an operator got in a position, back on page 4, where his rate of production is under-ranging the chart, would he be permitted to open it up a little bit more?

A Yes, I'm sure he would.

Q It would be a change in the flow rate for under-range and over-range of the chart as well as over-ranging the production equipment?

A This is the way the rule reads, Mr. Nutter: "Any test hereinabove provided for will be considered unacceptable if the average flow rate for the final 7-day deliverability test is more than 10 percent in excess of any consecutive 7-day average of the preceding two weeks."

In other words, for the seven days immediately preceding the flow period he cannot over-range. He has to have seven consecutive days of flow.

Q At a given rate?

A Yes.

Q Now, on page 5, well, that's the same question, up at the top of (B) there on the changing of the choke setting?

A Yes.

Q Now, down here on page 5, the third paragraph down, you refer to instantaneous pressures. Are the instantaneous pressures actually defined, and just exactly what pressures are those instantaneous pressures?

A Well, we quibbled around over that wording too. As we know from a practical standpoint, you can't take three instantaneous pressures with one deadweight gauge. We mean when you go on the lease or meter set to take pressures, that you shall take all three pressures as rapidly as it's possible to take them.

Q Now, that isn't spelled out in so many words here. That would also apply to the instantaneous flowing pressures down on the last line on that page?

A Yes.

Q Over on page 6, when we say here that if the shut-in pressure is determined by the Commission to be abnormally low, then one of these three alternate methods may be used?

A Yes.

Q When and by what procedure will the Commission determine the pressure to be abnormally low?

A When a pressure in an area is lower than the contour pressure would show, or by experience he would know that it was substantially lower than the average pressures in the area.

Q How will the Commission notify the operators that the pressure there is abnormally low?

A If the operator sends the test in to the district office, his notification will be either by letter or note on the test returned to the operator.

Q Or possible retest?

A Yes, or use another pressure.

Q For the calculation of the test?

A Yes. The chances are pretty good that he'll already have that other pressure to use and won't have to retest.

Q Now, on this first alternative, a Commission designated value, you mentioned that the Commission would have a pressure contour map?

A It's our intention to contour the shut-in pressures on each pool. Not only for purposes of the testing, but for other information purposes.

Q When will that be available, do you have any idea at this time?

A That will be available probably sometime in January or February at the latest when all the previous test information is in.

Q I see. Now, on page 7, in the third full paragraph down, the last sentence says "The volume used in this calculation shall be corrected to New Mexico Oil Conservation Commission standard conditions." Are the standard conditions actually innumerated anywhere in this order? Would they be the conditions in the definition of D deliverability on page 9? The 15.025 and the sixty degrees are the standard conditions, isn't that right?

A Yes, they are. I believe they, that would include all necessary standard conditions. They're outlined in Back Pressure

Manual.

Q On page 8, the fourth paragraph, where it states that The use of tables for calculating rates of flow from integrator readings, which do not specifically conform to New Mexico Oil Conservation Commission Back Pressure Test Manual may be approved for determining the daily flow period rates of flow upon a showing that such tables are appropriate and necessary." Now, what procedure would be followed to show that the tables are appropriate and necessary?

A Well, several years ago I administratively approved, and I think that paragraph would give me the authority to administratively approve El Paso's tables, for example. The way I made a determination as to whether they were applicable or not, I used their tables and made some calculations and came out with the same answer as ours.

Q So, if the operator --

A All the factors are in a little different form, but they get the same answer.

Q So, by this we would presume that the operator would show you that the tables are appropriate and necessary?

A Yes, sir.

Q At their tables. Would the same apply also on page 9 in the second paragraph from the bottom where it says that "The limiting value of multiplier may be exceeded only after the operator has conclusively shown to the Commission", and how would he show and who would he show?

A Well, it was my intention that he show the district office those matters pertaining to the test, they're on the ground, they are in a better position to analyze them than I am. The chances are if it's somewhat of an exceptional situation I will be consulted before the decision is made.

MR. NUTTER: Does anyone else have any questions of Mr. Utz? You may be excused.

(Witness excused.)

MR. NUTTER: Do you have anything further, Mr. Durrett?

MR. DURRETT: I have some statements I would like to read into the record at this time. The first statement is a statement I have been authorized to read on behalf of Pan American Petroleum Corporation reading as follows: "Pan American Petroleum Corporation concurs with the amendment as proposed by Mr. Utz and recommends its adoption by the Commission."

I would like to read a portion of the letter from Continental Oil Company. This letter is quite lengthy, so I will only read pertinent parts of it and ask the Examiner to take administrative notice of its contents as it appears in the file, for what it's worth. This reads "Case No. 2695. The use of the word "static" when describing the pressure obtained during a flow period, may better be described by substitution of the word "stabilized". Reading from another paragraph in the letter, "The definition of Deliverability Pressure as offered on the bottom of Page 8 is difficult to interpret and should be explained more clearly."

Another paragraph in the letter, a portion of it reads as follows: "Section "C" on Page 10 should be expanded to indicate that tests other than One-point Back Pressure Test may be run for information purposes at the option of the operator, eg. Four-point Back Pressure and Isochronal Tests." "The information obtained from a One-point Test is limited."

I'm skipping a portion of the letter now and reading down lower. "In these remote areas, some distance from existing gas production and gas sales facilities, where gas reserves or gas deliverabilities are questionable, provisions should be made for allowing testing by a method or methods selected by the operator. For this reason we recommend the Rule be modified to permit a seven day period in which the operator may run such tests as he deems necessary." This letter is signed by R. E. White, Division Superintendent, Production Department, and was received by the Commission on November 7.

I would like to state also for the record that I believe that the requirement or the suggestion in this letter as to optional test by the operator was covered by Mr. Utz.

MR. UTZ: May I make a comment on those suggestions?

MR. NUTTER: Yes, sir.

MR. UTZ: In regard to the use of the word "static", I would object to eliminating it from the thing due to the fact that P_w is actually a static pressure, and I support that contention by the fact that better brains than I have promulgated the Interstate Oil Compact Manual and they describe P_w as static column wellhead pressure.

As to his other suggestion as to the information tests, I believe the paragraph that I added on page 10 would cover that.

MR. NUTTER: Do you have anything further, Mr. Durrett?

MR. DURRETT: No, sir, that's all I have.

MR. NUTTER: Does anyone have anything they wish to offer in the case?

MR. KEYES: Keyes speaking on behalf of Tidewater. Still on page 6, it says seven day on both the tubing and casing when communication exists between the two strings. "The high of such pressures shall be used as P_c in the deliverability calculation." We feel that there's a possibility by using this that a well could be hurt because of liquids, a well that is managed correctly, produced, looked after, and you will have to blow that thing manually or use an intermitter on it, and when you use a higher pressure on your deliverability calculation, it's going to lower your calculated deliverability, and it could possibly lower that calculated deliverability quite a bit lower than what the well is capable of producing. There's some argument or discussion that where you do have a real low pressure well that is taken care of in the subsequent 1, 2 and 3. Where the Commission, if they feel that you are using the wrong pressure, they have the right to change that.

I can see where you are working taking care of wells and testing those wells that you will come up with a calculated deliverability quite a bit lower than what the well is capable of producing.

I have three letters I would like to read into the record. "For and on behalf of A. K. Barbour and Associates, would you please register our objection to the 4th paragraph on page 6 of your proposed revision of Orders R-333-C and D and R-333-E, relating to the seven day shut in pressure. It is our belief that the use of the highest shut-in pressure would result in a decrease of the calculated deliverability of the well. Yours very truly" by Fred Howser, Attorney.

I have another one here. "I have read your Oil Commission proposed revision of order R-333C and D and R-333E. The only revision that I am against appears in the fourth paragraph on page 6, where it states: "The seven-day (7) shut-in pressure shall be measured on both the tubing and the casing when communication exists between the two strings. The high of such pressures shall be used as P_c in the deliverability calculation. Using the highest shut-in pressure would decrease the calculated deliverability of the well. Yours very truly, J. R. Abraham."

Third one, "We would like to be placed on record as opposing fourth paragraph of page 6 of proposed revision of orders R-333-C and D, and R-333-E; wherein the higher of shut-in casing and tubing pressure will be used in calculating P_c in deliverability." Tidewater Oil Company, R. N. Coe, District Production Manager.

MR. NUTTER: Does anyone have anything further? We will take the case under advisement. Mr. Woodruff.

MR. WOODRUFF: Norman Woodruff, representing El Paso Natural Gas Company. El Paso Natural Gas Company concurs in the recommendations of Mr. Utz considering that the tests that we will receive will be more accurate and resulting in a more equitable distribution of the allowable between wells in the pool, and urges that the Commission adopt such recommendation.

MR. NUTTER: Thank you. Anybody else? We will take the case under advisement and the hearing is adjourned.

STATE OF NEW MEXICO)
) ss
COUNTY OF BERNALILLO)

I, ADA DEARNLEY, Court Reporter, do hereby certify that the foregoing and attached transcript of proceedings before the New Mexico Oil Conservation Commission at Santa Fe, New Mexico, is a true and correct record to the best of my knowledge, skill and ability.

IN WITNESS WHEREOF I have affixed my hand and notarial seal this 12th day of December, 1962.

Ada Dearnley
Notary Public-Court Reporter

My commission expires:
June 19, 1963.

I do hereby certify that the foregoing is a complete record of the proceedings in the Examiner hearing of Case No. 2695, heard by me on 11-8, 1962.
[signature], Examiner
New Mexico Oil Conservation Commission

BEFORE THE OIL CONSERVATION COMMISSION
OF THE STATE OF NEW MEXICO

IN THE MATTER OF THE HEARING CALLED BY THE OIL CONSERVATION COMMISSION OF THE STATE OF NEW MEXICO FOR THE PURPOSE OF CONSIDERING:

CASE NO. 1378
Order No. R-333-E
Amends R-333-C & D

APPLICATION OF EL PASO NATURAL GAS COMPANY FOR AN ORDER REVISING, AMENDING OR DELETING CERTAIN PORTIONS OF ORDER R-333-C & D PERTAINING TO GAS WELL TESTING PROCEDURE APPLICABLE TO GAS WELLS COMPLETED IN SAN JUAN, RIO ARRIBA AND McKINLEY COUNTIES, NEW MEXICO.

ORDER OF THE COMMISSION

BY THE COMMISSION:

This cause came on for hearing at 9 o'clock a.m. on February 13, 1958, at Santa Fe, New Mexico, before the Oil Conservation Commission of New Mexico, hereinafter referred to as the "Commission."

NOW, on this 28th. day of February, 1958, the Commission, a quorum being present, having considered the evidence adduced and being fully advised in the premises,

FINDS:

(1) That due notice of the time and place of hearing and the purpose thereof having been given as required by law, the Commission has jurisdiction of this case and the subject matter thereof.

(2) That there is need for a number of amendments to Order R-333-C & D, heretofore entered by the Commission, said order outlining the gas testing procedure of gas wells completed in San Juan, McKinley and Rio Arriba Counties, New Mexico.

(3) That the following amendments should be adopted, in the interests of conservation.

IT IS THEREFORE ORDERED:

(1) That the gas well testing period of April 1 through October 31 as established by Order No. R-333-C & D be and the same is hereby amended to read, "February 1 through December 15."

(2) The Sub-Sections II and III of Section A of Order R-333-C & D be and the same are hereby amended to read as follows:

II. ANNUAL DELIVERABILITY AND SHUT-IN PRESSURE TESTS:

Annual Deliverability and Shut-In Pressure Tests of all producing gas wells are required to be made during the period from February 1 through December 15 of each year.

All wells making connection to a gas transportation facility between October 31 and December 31 of any calendar year shall be tested during the following annual testing period. All wells making connection to a gas transportation facility between January 1 and February 1 of any calendar year shall be tested during the testing period of that year.

An Initial Deliverability Test accomplished in accordance with Section B, Sub-paragraph 1, Paragraph (A), Subparagraph 1, may be used as an annual test when the initial connection to a gas transportation facility is made between February 1 and October 31 of the test year.

All Annual Deliverability and Shut-in Pressure Tests required by this order shall be filed with the Commission and with the gas transportation facility to which the well is connected within thirty (30) days after the end of the month during which the test is completed; provided however, that all tests completed during the period from December 1 through December 15 shall be reported not later than ~~January 10 of~~ the following year. Failure to file the required tests within the time prescribed above will subject the delinquent wells to cancellation of allowable.

III. SCHEDULE OF TESTS:

(A) ANNUAL DELIVERABILITY TESTS

At least thirty days (30) days prior to the beginning of the test period each gas transportation facility shall to the Commission's Aztec Office (1000 Rio Brazos Road) submit a complete list of wells connected to its system, said wells to be grouped according to the pools in which they are located. All undesignated wells shall be listed separately.

At least 30 days prior to the beginning of the test period the gas transportation facilities receiving gas from wells to be tested shall, in cooperation with respective operators, submit to the Commission's Aztec office a testing schedule for the Annual Deliverability and Shut-in Pressure Tests for all wells connected to their respective pipeline systems which are to be tested during the succeeding two months. ~~Five~~ three copies of the schedule shall be furnished to the Commission and one copy shall be furnished to each operator concerned. A similar schedule shall be submitted at least 30 days prior to the beginning of each two-month testing interval. Such schedule shall indicate the pool, operator, lease, well number and location of each well. The gas transportation facility making the schedule of tests shall be notified immediately by any operator unable to take such tests as scheduled.

When an Initial Deliverability Test accomplished in accordance [illegible] Section [illegible], Sub-section [illegible], Paragraph (A), Sub-paragraph 1 is to be used [illegible] annual [illegible] for wells connected to a gas transportation facility during the period between February 1, and October 31, then the operator shall notify the Commission in writing during the fourteen day conditioning period for said test,

In the event a well is not tested in accordance with the test schedule, the well shall be re-scheduled for testing, and the Commission shall be notified of such fact in writing during the fourteen day conditioning period for said test.

(3) That the sixth sub-paragraph of Paragraph (B) of Sub-Section I of Section B of Order No. R-333-C & D be and the same is hereby amended to read as follows;

Orifice meter charts shall be changed and so arranged as to reflect upon a single chart the flow data for the gas from each well for the full seven-day deliverability test period; except that no tests shall be voided if satisfactory explanation is made as to the necessity for using test volumes through two chart periods. Corrections shall be made for pressure base, measured flowing temperature, specific gravity, and supercompressibility, provided however, that if the specific gravity of the gas from any well under test is not available, then and in that event an estimated specific gravity may be assumed therefor, based upon that of gas from nearby wells, the specific gravity of which has been actually determined by measurement.

DONE at Santa Fe, New Mexico, on the day and year hereinabove designated.

STATE OF NEW MEXICO
OIL CONSERVATION COMMISSION

EDWIN L. MECHEM, Chairman

MURRAY E. MORGAN, Member

A. L. PORTER, Jr., Member & Secretary

S E A L

ir/

TESTIMONY FOR CASE 2695 - REVISION OF ORDERS R-333-C, D & E

1. Clarifies the Rule as to penalty for delinquent tests. One day allowable for each day the test is late on a well.

2. Clarifies responsibility of scheduling tests.

3. Rather than 45 days + 15 days extension for test or retest after workover or initial connection allow 60 days without an extension of time.

4. The proposal now recognizes the fact that some wells must be choked in order not to overrange the charts and/or production equipment. Dakota wells in particular.

5. Defines critical flow when well is restricted between W. H. and meter, and outlines procedure to calculate tests when critical flow exists.

6. Proposes that shut-in pressure on wells which cannot have both casing and tubing measured and pressures which appear to be low due to liquids in the well bore be by one of 3 methods outlined.

7. Also proposes that the higher S.I. pressure of the casing or tubing be used in the deliverability calculation.

8. Use a pool deliverability pressure instead of 50% of individual well 7 day Shut-in pressure. This pressure to be determined by Oil Conservation Commission by using the average pool shut-in pressure and average static wellhead pressure.

9. It is proposed that a limiting multiplier be used in order that wells which report a very low shut-in pressure or cannot achieve a 25% drawdown will not have an unrealistic deliverability number.

10. Lowered % of test period flow rate as compared to preflow period rate from 25% to 10%.

11. Incorporated the Initial Potential memo into order. 1-5

12. Deleted testing requirements in Barker Dome Dakota and Penn.

BEFORE THE OIL CONSERVATION COMMISSION
OF THE STATE OF NEW MEXICO

IN THE MATTER OF THE HEARING CALLED BY THE OIL CONSERVATION COMMISSION OF THE STATE OF NEW MEXICO FOR THE PURPOSE OF CONSIDERING:

CASES NO. 882) Consolidated
941)
Order No. R-333-C and D
(Supersedes R-333-B)

THE APPLICATION OF THE OIL CONSERVATION COMMISSION UPON ITS OWN MOTION FOR AN ORDER REVISING, AMENDING OR DELETING CERTAIN PORTIONS OF ORDER R-333-B PERTAINING TO GAS WELL TESTING PROCEDURE APPLICABLE TO GAS WELLS COMPLETED IN SAN JUAN, RIO ARRIBA AND McKINLEY COUNTIES, NEW MEXICO.

ORDER OF THE COMMISSION

BY THE COMMISSION:

This cause having come on for hearing at 9 o'clock a. m. on August 17, 1955, at Santa Fe, New Mexico, before the Oil Conservation Commission of New Mexico, hereinafter referred to as the "Commission".

NOW, on this 13th., day of October, 1955, the Commission, a quorum being present, having considered the records and testimony adduced and being fully advised in the premises,

FINDS:

(1) That due notice of the time and place of hearing and the purpose thereof having been given as required by law, the Commission has jurisdiction of this case and the subject matter thereof.

C, D + E

(2) That there is need for a number of additions to and revisions of Order R-333-~~B~~ heretofore entered by the Commission, said order outlining a gas testing procedure of gas wells completed in San Juan, McKinley and Rio Arriba Counties, New Mexico.

(3) That the following rules and regulations should be adopted, and that said rules and regulations are in the interests of conservation.

IT IS THEREFORE ORDERED:

That the following Special Rules and Regulations governing gas well testing in the San Juan Basin (Counties of San Juan, Rio Arriba and McKinley, New Mexico,) C, D & E

superseding the rules and regulations contained in Order No. R-333-~~B~~, be and the same hereby are promulgated and adopted as an exception to the general statewide rules and regulations of this Commission relating to gas well testing procedures, Rules (401 et seq.):

GAS WELL TESTING RULES AND PROCEDURES FOR SAN JUAN BASIN AREA

SECTION A. TYPE OF GAS WELL TESTS REQUIRED:

I. THE INITIAL DELIVERABILITY AND SHUT-IN PRESSURE TESTS FOR NEWLY COMPLETED GAS WELLS.

(A) Immediately upon completion of each gas well in San Juan Basin, a shut-in pressure test of at least 7-days duration shall be made.

(B) Within 45 days after a well is connected to a gas transportation facility the well shall be tested in accordance with Section B, Subsection I, Paragraph (A) of this order, and the results of the test reported to the Commission. An operator may request an extension of time in which to accomplish this test provided such request is made in writing to the Commission's Aztec Office before the expiration of the 45 day period following connection of the well to a gas transportation facility. Such request for extension must be for substantial reason and approved by the Commission, or its duly authorized representative. Said extension shall not be for more than fifteen days.

(C) Any tests accomplished for information purposes prior to pipeline connection shall not be recognized as an official test for the establishment of allowables.

II. ANNUAL DELIVERABILITY AND SHUT-IN PRESSURE TESTS:

Annual deliverability and shut-in pressure tests of all producing gas wells are required to be made during the period from ~~April~~ 1 through ~~October 31~~ Dec. 15 of each year.

All wells connected to a pipeline system between November 1 and December 31, of any calendar year shall be tested during the following annual testing period. All wells connected to a pipeline system between January 1 and April 1 of any calendar year shall be tested during the testing period of that calendar year.

An Initial Deliverability Test accomplished in accordance with Section B, Subsection I, Paragraph (A), Subparagraph 1, may be used as an annual test when the test is taken on wells connected to a transportation facility during the regular annual testing season from April 1, to October 31.

III. SCHEDULE OF TESTS

(A) ANNUAL DELIVERABILITY TESTS

On or before ~~February~~ June 15 of each year, the pipeline companies receiving gas from wells to be tested shall, in cooperation with respective operators, submit a testing schedule for the annual deliverability and shut-in pressure tests for all wells connected to their respective pipeline systems as of February 1 of the year for which the schedule is applicable; such test schedules shall be filed promptly with the Commission for approval, and if approved, the Commission shall furnish each operator, as identified by lists of names and addresses furnished by the respective pipeline companies, with a copy of such schedule as approved by the Commission, or a part thereof pertinent to such operator's wells, on or before March 15, of each year.

Such schedules shall be filed with the Commission for each Gas Pool as designated by the New Mexico Oil Conservation Commission listing under the heading of each pool the operator, lease, well number and location of each well. Should the pipeline company elect to file schedules by areas then the above listed information shall be listed under the heading of each area in the order listed above.

All wells connected to a pipeline system during the period of February 1 to October 31, both inclusive, of any year shall be scheduled for testing during the testing period for that particular year. Then and in that event the pipeline in cooperation with the operator shall notify the Commission in writing at least (10) ten days before the Commencement of the conditioning period for any tests.

Provided however, that when an Initial Deliverability Test accomplished in accordance with Section B, Subsection I, Paragraph (A), Subparagraph 1 is to be used as an annual test for wells connected to a gas transportation facility during the period between April 1 and October 31, then the operator shall notify the Commission in writing at any time during the fourteen day conditioning period.

In event changes for substantial reasons are necessary in the annual test schedule, the Commission shall be notified (10) ten days before tests are scheduled to commence.

(B) DELIVERABILITY RETESTS.

An operator may retest the deliverability of a well at any time for substantial reason by the notification to the Commission (10) ten days before the retest is scheduled to commence. Such notification shall consist of scheduling the well as required for the annual deliverability test in subsection III, Paragraph A, above. Such retest shall be subject to the approval of the Commission, and conducted in conformance with Section B, Subsection I, Paragraph (B) of this order. The Commission may require the retesting of any well at its discretion by the notification of the operator to schedule such retest.

The requirements for Initial and Annual Deliverability Tests and the notification and scheduling of such tests which apply to newly completed wells shall also apply to reworked or recompleted wells.

IV. WHO MAY WITNESS TESTS:

Any initial or annual deliverability and shut-in pressure test may be witnessed by any or all of the following: an agent of the Commission, an offset operator, a representative of the pipeline company taking gas from an offset operator, or a representative of a pipeline company taking gas from the well under test.

Deliverability tests required hereinabove in Subsection I and II of this section shall determine the calculated deliverability of each gas well, which shall be reported to the Commission by converting actual deliverability against existing line pressures to the calculated deliverability at a pressure equal to fifty (50) percent of the shut-in pressure of each well in the manner hereinafter specified below. Such calculated deliverability so determined, and hereinafter so referred to, shall not be considered as the actual deliverability of any well into a gas transportation facility, but shall be used by the Commission as an index to determine the well's ability to produce at assumed static wellhead working pressures, as compared to other wells in the pool under like conditions.

SECTION B. PROCEDURE FOR TESTS:

The several known gas producing formations of the San Juan Basin represent a variety of testing situations, and each is treated separately.

I. MESAVERDE FORMATION:

(A) INITIAL DELIVERABILITY AND SHUT-IN PRESSURE TEST.

1. Within ~~(45) forty-five~~ 60 days after a newly completed well is connected to a gas transportation facility the operator shall accomplish a deliverability and shut-in pressure test in conformance with ~~Section B, sub-section I, paragraph (B)~~ of this order

2. In the event that testing a newly completed well in accordance with paragraph 1 above~~, is impractical,~~ the operator may accomplish a deliverability and shut-in pressure test in the following manner:

   a. A seven or eight day production chart may be used as a basis for determining the wells deliverability provided the chart so used is preceded by at least (14) fourteen days continuous production. The well shall produce unrestricted through either the casing or tubing, but not both, into a pipeline during these periods.

   b. A shut-in pressure of at least seven days duration shall be taken. This shall be the shut-in test required in Section A, subsection I, Paragraph (A).

   c. The average daily static meter pressure shall be determined in accordance with Section B, subsection I, Paragraph (B). This pressure shall be used as P_t in calculating P_w for the Deliverability Calculation.

d. The daily average rate of flow shall be determined in accordance with Section B, Subsection I, Paragraph (B), of this order.

e. The static wellhead working pressure (P_w) shall be determined in accordance with Section B, subsection I, paragraph (B), of this order.

f. The deliverability of the well shall be determined by using the data determined in paragraphs a through f, above, in the deliverability formula in accordance with Section B, subsection I, paragraph (B), of this order.

g. The data and calculations for the above paragraphs a through f shall be reported to the Commission upon the blue colored Form C-122-A and filed in triplicate with the Commission within the forty-five day period after connection of the well. Form C-122-A shall be signed by the operator or an agent designated by the operator.

(B) THE ANNUAL DELIVERABILITY AND SHUT-IN PRESSURE TESTS.

These tests shall be taken by unrestrictedly producing the well into the pipeline through either the casing or tubing, but not both. The daily flowing rate shall be determined from an average of seven (7) consecutive producing days, following a minimum conditioning period of fourteen (14) consecutive days production. The first seven (7) days of said conditioning period shall have not more than one (1) interruption, which interruption shall be no longer than 36 hours continuous duration. The eighth to fourteenth days, inclusive, of said conditioning period shall have no interruptions whatsoever. All such production during the fourteen (14) day conditioning period plus the seven (7) day deliverability test period shall be a static wellhead working pressures not in excess of seventy-five (75) per cent of the previous annual seven (7) day shut-in pressure of such well if such previous annual shut-in pressure information is available; otherwise, the seven (7) day initial deliverability shut-in pressure of such well shall be used.

In the event that existing line pressure does not permit a drawdown as specified above, with the well producing unrestrictedly into the pipeline, the operator shall request an exception to this requirement on the Form C-122-A. The request shall state the reasons for the necessity for the exception.

The static wellhead working pressure (P_w) of any well under test shall be the calculated seven (7) day average static tubing pressure if the well is flowing through the casing; or the calculated seven (7) day average static casing pressure if the well is flowing through the tubing. The static wellhead working pressure (P_w) shall be calculated by applying the tables and procedures as set out in New Mexico Oil Conservation Commission manual entitled "Method of Calculating Pressure Loss Due to Friction in Gas Well Flow Strings". This manual is more specifically known as release 4-G-9-FLT-NW, a copy of which is attached hereto and made a part hereof.

To obtain the shut-in pressure of a well under test the well shall be shut-in immediately after the seven (7) day deliverability test for the full period of seven (7) consecutive days. Such shut-in pressure shall be measured within the next succeeding twenty-four (24) hours following the seven (7) day shut-in period aforesaid. The seven (7) day shut-in pressure shall be measured on the string through which the well flowed during the conditioning and seven (7) day flow period.

All wellhead pressures as well as the flowing meter pressure tests which are to be taken during the seven (7) day deliverability test period, as required herein above, shall be taken with a dead-weight gauge. The dead-weight readings taken shall be recorded on the flow chart in psia. The time and point on chart flowing pressure curve at which these readings are taken shall be indicated with an arrow.

Orifice meter charts shall be changed, and so arranged as to reflect upon a single chart the flow data for the gas from each well for the full seven day deliverability test period. Corrections shall be made for pressure base, measured flowing temperature, specific gravity and supercompressibility (superexpansibility), provided however, that if the specific gravity of gas from any well under test is not available, then and in that event an estimated specific gravity may be assumed therefor, based upon that of gas from nearby wells, the specific gravity of which has been actually determined by measurement.

The seven (7) day average flowing meter pressure shall be calculated by taking the average of all consecutive 2-hour flowing meter pressure readings as recorded on the seven (7) day flow period chart (test chart #3). The pressure so calculated shall be used in calculating the wellhead working pressure, determining supercompressibility factors and calculating flow volumes.

The seven (7) day flow period volume shall be calculated from the integrated readings as determined from the flow period orifice meter chart, (Chart #3). The volume so calculated shall be divided by the number of testing days on the chart to determine the average daily flow period rate of flow. The flow chart shall have legibly recorded a minimum of seven (7) days and a maximum of eight (8) flowing days to be acceptable for test purposes. The volume used in this calculation shall be corrected to New Mexico Oil Conservation Commission standard conditions.

The average flowing meter pressure for the seven (7) day or eight (8) day flow period and the corrected integrated volume shall be determined by the purchasing company that integrates the flow charts and furnished to the operator or testing agency when such operator or testing agency requests such information.

The daily average integrated flow period rate of flow shall be corrected for meter error by the multiplication by a correction factor determined by dividing the square root of the chart flowing meter pressure psia into the square root of the dead-weight flowing meter pressure psia,

The daily volume of flow as determined from the flow period chart (Test Chart #3) integrator readings shall be calculated by applying the Basic Orifice meter formula.

$$Q = C' \sqrt{h_w \; P_f}$$

Where:

Q = Metered volume of flow MCFD @ 15.025, 60°F. and .60 specific gravity.

C' = The 24 hour basic orifice meter flow factor as taken from New Mexico Oil Conservation Commission release [redacted] and corrected for flowing temperature, gravity and supercompressibility.

h_w = Daily average differential meter pressure from flow period chart.

Pf = Daily average flowing meter pressure from flow period chart.

The basic orifice meter flow factors, flowing temperature factor and specific gravity factor shall be determined from New Mexico Oil Conservation Commission release No. "4G-12-BPT-State". The four tables in said release are based on "gas measurement committee report No. 2" (Revised 1948) of the American Gas Association, New York 17, New York. A copy of said New Mexico Oil Conservation Commission release is attached hereto and made a part hereof.

The daily flow period average corrected flowing meter pressure, psig, shall be used to determine the supercompressibility factor. Correction shall be made for supercompressibility (deviation from Boyle's law) for flowing meter pressures in excess of 100 psig by the use of Simplified Supercompressibility Tables, compiled from C. N. G. A. Bulletins TS-402 and TS-461, published by John P. Squier Company, Dallas, Texas. These tables have been reproduced by specific permission from John P. Squier Company, a copy of which is attached hereto and made a part hereof.

When supercompressibility (superexpansibility) correction is made for a gas containing either nitrogen or carbon dioxide in excess of 2 per cent, the supercompressibility factors of such gas shall be determined by the use of Table V of the above mentioned TS-402 for pressure 100-500 psig or Table II, TS-461 for pressures in excess of 500 psig.

The use of tables for calculating rates of flow from integrator readings, which do not specifically conform to New Mexico Oil Conservation Commission release "4-G-12-BPT-State", may be approved for determining the daily flow period rates of flow upon a showing that such tables are appropriate and necessary.

Insert (5) Deliverability pressure, as used herein for Mesaverde production, is a defined pressure applied to each well and used in the process of comparing the abilities of wells in this formation to produce at static wellhead working pressures equal to ~~fifty (50)~~ per cent, of the seven (7) day shut-in pressure of the respective individual wells as percentage.

The deliverability of gas at the "deliverability pressure" of any well under test shall be calculated from the test data derived from the tests hereinabove required by use of the following deliverability formula:

$$D = Q \left[\frac{\left(P_c^2 - P_d^2\right)}{\left(P_c^2 - P_w^2\right)} \right]^n$$

WHERE:

D	=	Deliverability at the deliverability pressure, (P_d) MCF/da, (at Standard Condition of 15.025 psia and 60 °F).
Q	=	Daily flow rate in MCF/da, at wellhead pressure (P_w)
P_c	=	7-day shut-in ~~casing (or tubing)~~ wellhead pressure, psia, determined in accordance with section B, subsection I, Paragraph (B).
P_d	=	Deliverability pressure, psia ~~half of the individual well 7-day shut-in pressure, P_c, psia~~. as defined above.
P_w	=	Average static wellhead working pressure, as determined from 7-day flow period, psia and calculated from New Mexico Oil Conservation Commission Pressure Loss Due to Friction Tables. ~~(Casing pressure if flowing through the tubing, or~~ tubing pressure if flowing ~~through the casing)~~.
n	=	Average pool slope of back pressure curve (.75) for Mesaverde wells).

Any test hereinabove provided for will be considered unacceptable if the average flow rate for the final 7-day deliverability test is 25 per cent in excess of any consecutive 7-day average of the preceding two weeks. "A deliverability test" not meeting this requirement shall be retested.

The annual deliverability and shut-in pressure tests as required hereinabove shall be reported upon Commission Form C-122-A and filed in triplicate, with the Commission within the month next after completion of such tests. Form C-122-A shall be signed by the operator or agent designated as the operator.

All charts relative to annual deliverability tests shall be identified by the words "Test Chart No. 1" (2, 3, 4, etc.), and any or all charts or photostats thereof shall be made available to the Commission upon its request.

II. PICTURED CLIFFS FORMATION:

(A) INITIAL DELIVERABILITY AND SHUT-IN PRESSURE TEST:

Same as prescribed for Mesaverde formation; see Section B, subsection I, Paragraph (A).

(B) ANNUAL DELIVERABILITY AND SHUT-IN PRESSURE TESTS:

In all respects the deliverability and shut-in pressure tests of wells in the Pictured Cliffs formation shall be made in conformity with the procedures set out in Section B, Subsection I, paragraph (B) of the Mesaverde formation procedures, except that in the back pressure formula, the exponent "n" shall have the value of point eighty-five (.85).

III. FRUITLAND FORMATION:

(A) All initial and annual deliverability and shut-in pressure tests of gas wells producing from the Fruitland formation shall be identical in all respects to those requirements and procedures hereinabove set out and required for the Pictured Cliffs formation in Section B, Subsection II, paragraphs (A) and (B).

IV THE DAKOTA FORMATION:

All tests of Dakota wells shall be in conformity with requirements and procedures provided hereinabove for the Mesaverde formation, except as follows:

(A) BARKER DOME - DAKOTA: (Storage Area)

1. INITIAL OPEN FLOW POTENTIAL TEST:

An average "pool slope", based upon bottom-hole conditions, shall be established by the Commission after consideration of data to be provided by the operators; these data shall be based upon tests taken in conformity with the conventional back pressure method, indicated in Commission Rule 401. This "slope" shall be applied to each well in the Barker-Dome Dakota Area, as if such slope were the actual performance back pressure slope of each such well, in the following manner:

This back pressure slope so established shall be plotted through a point predetermined by one stabilized flow rate at a static wellhead working pressure not in excess of seventy-five (75) per cent of the seven (7) day shut-in pressure of such well.

The flowing rates (Q) shall be corrected for pressure base, measured flowing temperature, specific gravity and supercompressibility, by the use of methods of calculation and tables hereinabove referred to and approved in Section B, Subsection I, paragraph (B), of the Mesaverde procedures.

A seven (7) day shut-in pressure test shall be made for each well in the Barker Dome-Dakota Area, provided however, that where the shut-in period exceeds seven days such fact shall be reported to the Commission.

The values of the seven (7) day shut-in pressure (P_c) and the working wellhead pressure (P_w) shall be corrected to bottom hole conditions.

A schedule of tests shall be prepared by the transporter and approved by the Commission, and reports of such tests shall be signed by the operator or his designated agent and duly filed with the Commission, on Form C-122, the regular state-wide form.

2. ANNUAL OPEN FLOW POTENTIAL TEST:

This test shall be made of all wells producing from the Barker Dome-Dakota Storage Area by obtaining seven (7) day shut-in pressures of all Dakota wells, converting the same to bottom hole pressures (P_f) computing the squares of such bottom hole pressures, (P_f^2) and applying the same to the original average "pool slope" to obtain an adjusted open flow. If so desired as an alternate method an adjusted open flow may be computed from the following equation:

$$O_{f_2} = O_{f_1} \left[\frac{\left(P_{f_2}\right)^2}{\left(P_{f_1}\right)^2} \right]^n$$

WHERE:

O_{f_2} = Adjusted absolute open flow.

O_{f_2} = Original absolute open flow.

P_{f_1} = New bottom hole shut-in (psia.)

P_{f_2} = Old bottom hole shut-in (psia.)

n = Slope of back pressure curve.

Tests of all wells in the Barker Dome-Dakota storage area shall be made during the period of April 1 through October 31 of each year and reports made to the Commission within the next succeeding month after test is made.

V. PENNSYLVANIAN FORMATION:

All tests of wells producing from the Pennsylvanian formation of the San Juan Basin Area shall be as follows:

(A) INITIAL OPEN FLOW POTENTIAL TEST:

Immediately after completion of each new well an absolute open flow shall be determined by the conventional back-pressure method indicated by Rule 401 of the Commission's Rules and Regulations.

Seven day shut-in pressures will be used in all cases, and, if for any reason the shut-in period exceeds seven days, then, the actual shut-in time shall be reported.

(B) ANNUAL OPEN FLOW POTENTIAL TEST:

This test shall be made of all wells producing from the Pennsylvanian formation of the San Juan Basin Area, and such tests shall conform in all respects with the procedure set out next above under initial open flow potential test or in the alternative, by obtaining a seven day shut-in pressure of each well and converting the same to bottom hole pressure (P_f). The square of the bottom hole pressure (P_f^2) will be computed and applied to the original back pressure curve and an adjusted absolute open flow will be obtained.

If shut-in pressure time is in excess of seven (7) days, then the actual shut-in time shall be reported.

There is no objection to the use of an adjusted absolute open flow calculated from the equation as set out hereinabove under Dakota formation, Section B, Subsection IV, paragraph (A) - subparagraph 2.

All tests hereunder shall be made during the period from April 1 through October 31 of each year, and reported to the Commission upon regular Form C-122 during the month succeeding the month in which the tests are made.

SECTION C. INFORMATION TEST FOR ALL FORMATIONS.

I. TYPE OF TEST:

(A) A pitot potential test may be taken on newly completed wells before their connection to a gas transportation facility. This test shall not be a required official test but may be taken for information purposes at the option of the operator. When taken, this test shall be made and reported as prescribed in paragraph (B) following.

(B) PITOT POTENTIAL TEST:

The pitot potential test shall be made after a minimum shut-in time of seven (7) days. The shut-in pressure shall be measured by the use of a dead-weight gauge. The rate of flow shall be determined by a pitot tube measurement after unrestricted flowing of gas to the air for a period of three (3) hours; the flow nipple shall be at least eight (8) diameters long. The pitot tube shall be constructed of one-eight (1/8) inch pipe (nominal diameter). Standard tables (Reids) will be provided by the Commission on request.

Any well completed with two-inch nominal size tubing (1.995 inside diameter) or larger shall be tested through the tubing. Any well completed with tubing smaller than two-inch nominal shall be tested through the casing.

(C) REPORTING OF TEST.

When the pitot potential test is taken the results shall be calculated as prescribed in the Commission's Manual of Tables and Procedure and reported to the Commission on Form C-122-B.

IT IS FURTHER ORDERED:

(1) That Form C-122-A entitled "Gas Well Test Data Sheet, San Juan Basin", a copy of which is attached hereto and made a part hereof, be, and the same hereby is approved in open form subject to minor modifications as experience may indicate and the same shall be used only for the area heretofore indicated, excepting therefrom only the Barker Dome-Dakota storage area, and the Pennsylvanian formation, all within the said San Juan Basin.

(2) That this order shall modify Rule 1121 of the Rules and Regulations of the Commission only to the extent of requiring reports upon Form C-122, a copy of which is attached hereto and made a part hereof. Such Form C-122 is hereby approved in open form subject to minor changes and additions as experience may indicate necessary.

(3) All forms heretofore mentioned, are hereby adopted for the use in the San Juan Basin Area in open form subject minor modification as experience may indicate.

(4) All testing agencies whether individuals, companies, pipeline companies or operators shall maintain a record of all tests accomplished by them including all field testing data. This log shall show the operator, lease, well number, section unit letter, section, township, range and pool as defined by New Mexico Oil Conservation Commission, for each well tested. The log shall further show the date the flow period pressures (psia.) and shut-in pressures are measured and the values thereof. A copy of this log shall be made available to the Commission or a Commission representative at any time during any testing season. A copy of this log shall be filed with supervisor of District III, Box 697, Aztec, New Mexico, by the 10th of December following each testing season. A log form setting out the date required shall be furnished by the New Mexico Oil Conservation Commission to all testers, a copy of this form is attached hereto and made a part hereof.

IT IS FURTHER ORDERED:

That other formations in the San Juan Basin Area which may in the future be found to be productive will be provided with testing programs on the basis of formation characteristics.

DONE at Santa Fe, New Mexico, on the day and year hereinabove designated.

STATE OF NEW MEXICO
OIL CONSERVATION COMMISSION

JOHN F. SIMMS, Chairman

E. S. WALKER, Member

W. B. MACEY, Member and Secretary

SEAL

da/

Insert (1)

Instantaneous pressures shall be measured by deadweight gauge during the seven day flow period at the casing head, tubing head, and orifice meter and recorded along with the instantaneous meter chart static pressure reading.

When it is necessary to restrict the flow of gas between the wellhead and orifice meter the ratio of the downstream pressure to the upstream pressure shall be determined. When this ratio is o.57, or less, critical flow conditions shall be considered to exist accross the restriction. When this condition exists the flowing separator and/or dehydrator pressure is to be measured and recorded on Form C-122-A immediately above line (a) and identified as "flowing separator pressure__________psia." When critical flow conditions exist, the instantaneous flowing pressures required hereinabove shall be measured during the last forty-eight (48) hours of the seven (7) day flow period.

When critical flow exists between the wellhead and orifice meter, the measured wellhead flowing pressure of the string thru which the well flowed during test shall be used as P_t when calculating the static wellhead working pressure (P_w) using the method established below.

Memo

10-11-62

From
A. R. Kendrick
Engineer

To Elvis:

This is a copy of the proposed 333-F which is a "re hashed rehash."

We have discussed this with "Babe" and Rainey. Rainey may send you other notes tomorrow when he has had more time to look at the entire order.

We will be ready to discuss the "thing" when you have time to look it over.

Al

Memo

From
A. R. Kendrick
Engineer

To Elvis:

We like your words for Insert #1.

A sentence similar to the one we added might help make the order more clear.

Or, maybe the enclosed copy of Babe's idea is usable.

Memo

From
E. A. UTZ
GAS ENGINEER

To Emery,

I've rewritten the attached paragraph. I have had [illegible] Wayne check it to see if this fills the bill.

[illegible]

of seventy-five (75) per cent of the previous annual seven (7) day shut-in pressure of such well if such previous annual shut-in pressure information is available; otherwise, the seven (7) day initial deliverability shut-in pressure of such well shall be used.

In the event that existing line pressure does not permit a drawdown as specified above, with the well producing unrestrictedly into the pipeline, the operator shall request an exception to this requirement on the Form C-122-A. The request shall state the reasons for the necessity for the exception.

Instantaneous pressures shall be measured by deadweight gauge during the seven-day flow period at the casing head, tubing head, and orifice meter and recorded along with the instantaneous meter chart static pressure reading.

When a restriction, or a series of restrictions, to the flow of gas occurs between the wellhead and the orifice meter of sufficient magnitude to cause the ratio of the orifice meter pressure to the flowing string wellhead pressure to be 0.57 or less, it is possible for critical flow conditions to exist. To prove whether or not critical flow conditions exists, intermediate pressures are to be measured between the wellhead and the orifice meter (i.e. at the heater, or production unit, or separator, or dehydrator, or at each) to determine if at ANY restriction of flow the rate of the downstream pressure to the upstream pressure at this point is 0.57 or less. Critical flow does exist if this ratio of pressures is 0.57 or less.

When critical flow conditions exist, the flowing pressures, as required hereinabove, shall be measured during the last forty-eight (48) hours of the seven (7) day flow period. Pressure measurements are to be made at a sufficient number of intermediate points to determine if critical flow does or does not exist and these pressures shall be entered on Form C-122-A, immediately above line (a) and identified as "Flowing Separator Pressure ______ psia."

When critical flow conditions exist, the actual measured wellhead flowing string pressure (either line a or b) shall be used as P_t (line 1) when calculating the static wellhead working pressure (P_w).

When critical flow conditions do not exist, the average wellhead flowing pressure (P_t) shall be determined by adding the meter error and friction loss to the seven day average meter pressure (line g).

Inter-Office Transmittal Slip
TO Mr. Utz
AT Santa Fe
FROM El NG

( ) For Approval
( ) For Signature
( ) Note and Advise
( ) Note and Return
( ) For Your Files
( ) For Your Handling
( ) For Your Reply

Remarks:

FORM 1-5 (REV. 4-52)

The static wellhead working pressure (P_w) of any well under test shall be the calculated seven (7) day average static tubing pressure if the well was flowing through the casing; or the calculated seven (7) day average static casing pressure if the well was flowing through the tubing. The static wellhead working pressure (P_w) shall be calculated by applying the tables and procedures as set out in the New Mexico Oil Conservation Commission manual entitled "Method of Calculating Pressure Loss Due to Friction in Gas Well Flowing Strings for San Juan Basin."

To obtain the shut-in pressure of a well under test, the well shall be shut-in immediately after the seven (7) day deliverability test for a full period of seven (7) consecutive days. Such shut-in pressure shall be measured within the next succeeding twenty-four (24) hours following the seven (7) day shut-in period aforesaid. The seven day shut-in pressure shall be measured on both tubing and casing when available. The higher of such pressures shall be used as P_c in the deliverability calculation, provided communication between the casing and tubing is known to exist. When any such shut-in pressure has been determined by the Commission to be abnormally low, the shut-in pressure to be used shall be determined by one of the following methods:

1. A Commission designated value.
2. An average shut-in pressure of all offset wells completed in the same zone.
3. A calculated surface pressure based on a measured bottom hole pressure. Such calculation shall be made in accordance with New Mexico Oil Conservation Back Pressure Manual.

All wellhead pressures as well as the flowing meter pressure tests which are to be taken during the seven (7) day deliverability test period, as required hereinabove, shall be taken with a deadweight gauge. The deadweight reading, the date and time according to the chart shall be recorded and maintained in the company's records with the test information.

Orifice meter charts shall be changed and so arranged as to reflect upon a single chart the flow data for the gas from each well for the full seven day deliverability test period; except that no tests shall be voided if satisfactory explanation is made as to the necessity for using test volumes through two chart periods. Corrections shall be made for pressure base, measured flowing temperature,

(6) Continued:

specific gravity, and supercompressibility provided however, that if the specific gravity of the gas from any well under test is not available, an estimated specific gravity may be assumed therefore, based upon that of gas from near-by wells, the specific gravity of which

STATE OF NEW MEXICO
OIL CONSERVATION COMMISSION

Compiled by E.A. Utz, Gas Engineer

SAN JUAN BASIN

METHOD OF CALCULATING PRESSURE LOSS DUE TO FRICTION IN GAS WELL STRINGS

ACKNOWLEDGMENT

The Commission and its Engineering staff wish to express their appreciation to Mr. M. H. Cullender, Phillips Petroleum Company, for compiling the Basic Tables and offering invaluable counsel and advise regarding the following tables.

Like appreciation is also expressed to Mr. Norman Woodruff, El Paso Natural Gas Company, Chairman of the Industry Committee appointed by the Commission to study gas well testing in Southeast New Mexico, and to the following committee members for their willing and effective work in analyzing the various methods of calculating pressure loss due to friction.

W. G. Abbott
Amerada Petroleum Corporation

J. W. Cole, Jr.,
Gulf Oil Corporation

M. H. Cullender
Phillips Petroleum Company

M. N. Purkaple
Shell Oil Company

C. L. Quast
Sinclair Oil & Gas Company

Max Curry
Buffalo Oil Company

Dave Nichols
Southern Union Gas Company

D. L. Henry
Gulf Oil Corporation

William Randolph
Continental Oil Company

G. L. Tribble
Permian Basin Pipeline Company

A.M. Wiederkehr
Southern Union Gas Company

Fred Bernard
El Paso Natural Gas Company

W. L. Smith
Gulf Oil Corporation

USE OF THE TABLES

Nomenclature

Q	=	M^2cfd @ 15.025 and 60° F. (Measured Flow)
P_c	=	Shut-in wellhead pressure, psia. (7 day)
P_w	=	Static wellhead working pressure, psia.
P_t	=	Flowing wellhead working pressure, psia (7 day average meter pressure plus measured friction loss between meter and wellhead.
F_c	=	Factor dependent upon size of flow string, pressure base, temperature and compressibility factor. See Table I of F_c values.
$(1 - e^{-s})$	=	Factor dependent upon GL, temperature and compressibility factor. See Table II of $(1-e^{-s})$ values.
G	=	Specific gravity of gas. (Air = 1.00)
L	=	Length of flowing column, ft.

Tables

I. Values of F_c for various sizes of flow strings.

II. Values of $(1 - e^{-s})$ for various values of GL.

Procedure

1. From Table I, obtain the value of F_c corresponding to the internal diameter of the pipe.
2. From Table II, obtain the value of $(1-e^{-s})$ corresponding to the value of GL.
3. From the test data, obtain the rate of flow (Q) and the corresponding Working Pressure. (P_t)
4. Multiply F_c (Table I value) times Q.
5. Square the term F_cQ.
6. Multiply $(F_cQ)^2$ by $(1-e^{-s})$. Table II value.
7. Add the value of $(F_cQ)^2$ $(1-e^{-s})$ to P_t^2 to obtain P_w^2.
8. Extract square root of P_w^2 to obtain P_w.

EXAMPLE FOR CALCULATING STATIC WELLHEAD WORKING PRESSURE (P_w) FOR GAS WELLS IN SAN JUAN BASIN NORTHWEST NEW MEXICO.

Test Data from Form C-122-A (Revised 8-1-54) necessary for P_w calculation.

1. 1.995" = Size of Flow String I.D. (if not known I.D. may be determined from Table I by referring to O.D. and #/ft. columns.)
2. L = 5000' = Length of Flow String (If lower sections of tubing is perforated, the top of perforations shall determine L. Where flow is through the casing and casing is set above producing formation the casing shoe shall determine L. For casing flow where casing is set through producing formation and slotted or perforated the top of the perforations shall determine L.)
3. G = .861 = Specific gravity of flowing gas. (Air = 1.0)
4. P_t = 565 = 7 day average wellhead flowing pressure. (Column j Form C-122-A)
5. Q = 2.500 = 7 day average volume of flow M^2CFD. (Volume shown under flow rate calculation in millions cu. ft. per day.)

Begin calculation as follows:

6. Determine Table I value (F_c) for 1.995' I.D. Tubing. This is 9.402.
7. Multiply G x L. GL = 3405. Show this value in GL column at bottom of C-122-A.
8. Determine Table II value ($1-e^{-s}$) for GL of 3405. This is .219. Show this value in ($1-e^{-s}$) column at bottom of C-122-A.

9. Multiply Table I value of 9.402 (F_c) by Q (2.500) and square the product. $(9.402 \times 2.500)^2 = 552.5$. Show this value in $(F_cQ)^2$ column at bottom of C-122-A.

10. Multiply 552.5 by Table II value of .219 $(1-e^{-s})$. 552.5 x .219 = 120.9 (thousands). Show this value in R^2 column at bottom of C-122-A.

11. Square 565 (P_t, item 4 above, column j on C-122-A). $(565)^2$ = 319.2 (thousands). Show 319.2 in P_t^2 column C-122-A.

12. Add 319.2 (P_t^2) to 120.9 (R^2) and extract the square root of the sum. 319.2 + 120.9 = 440.1 (thousands).

    $\sqrt{440.1} = 663.4 = P_w$ (Calculated static wellhead working pressure). Show 663.4 in P_w column C-122-A. Note that 440.1 is in thousands and therefore is an even number for square root extraction.

13. This is the P_w value to be used in the deliverability calculation on Form C-122-A.

TABLE I

Values of F_c for Various Tubing Sizes

(Use only for internal diameters less than 4. 277 in.)

Note: $$F_c = \left(\frac{0.10797}{d^{2.612}}\right)\left(\frac{P_b}{14.65}\right)(T)\ (Z)$$

Values shown based on P_b = 15.025
T = 573
Z = 0.90

Nominal Size, In.	O.D. In.	#/Ft.	I.D. In.	F_c
1	1.315	1.80	1.049	50.40
1 1/4	1.660	2.40	1.380	24.62
1 1/2	1.990	2.75	1.610	16.46
2	2.375	4.70	1.995	9.402
2 1/2	2.875	6.50	2.441	5.551
	3.500	9.30	2.992	3.262
	4.000	11.00	3.476	2.205
	4.500	12.70	3.958	1.571
	4.750	16.25	4.082	1.450
	4.750	18.00	4.000	1.528
	5.000	18.00	4.276	1.284
	5.000	21.00	4.154	1.384

$$F_c \text{ (for Annulus)} = \left[\frac{0.10797}{\left[(d_1 + d_2)(d_1 - d_2)\right]^{1.612}}\right]\left(\frac{P_b}{14.65}\right)(T)\ (Z)$$

d_1 = I.D. of casing - in.

d_2 = O.D. of tubing - in.

TABLE I

(Continued)

Values of F_c for Various Casing Sizes

(Use only for Internal Diameters greater than 4.277 in.)

Note: $F_c = \left(\frac{0.10337}{d^{2.582}}\right) \left(\frac{P_b}{14.65}\right) (T) \; (Z)$

Values shown based on P_b = 15.025
T = 573
Z = 0.90

O.D. In.	#/Ft.	I.D. In.	F_c
5.000	13.00	4.494	1.129
5.000	15.00	4.408	1.187
5.500	14.00	5.012	0.8518
5.500	15.00	4.976	0.8678
5.500	17.00	4.892	0.9068
5.500	20.00	4.778	0.9633
5.500	23.00	4.670	1.022
5.500	25.00	4.580	1.075
6.000	15.00	5.524	0.6627
6.000	17.00	5.450	0.6861
6.000	20.00	5.352	0.7190
6.000	23.00	5.240	0.7594
6.000	26.00	5.140	0.7982
6.625	20.00	6.049	0.5241
6.625	22.00	5.989	0.5378
6.625	24.00	5.921	0.5539
6.625	26.00	5.855	0.5702
6.625	28.00	5.791	0.5866
6.625	31.80	5.675	0.6181
6.625	34.00	5.595	0.6412
7.000	20.00	6.456	0.4430
7.000	22.00	6.398	0.4534
7.000	24.00	6.336	0.4651
7.000	26.00	6.276	0.4766
7.000	28.00	6.214	0.4890
7.000	30.00	6.154	0.5014

TABLE I

(Continued)

Values of F_c for Various Casing Sizes

O.D. In.	#/Ft.	I.D. In.	F_c
7.000	40.00	5.836	0.5749
7.625	26.40	6.969	0.3636
7.625	29.70	6.875	0.3766
7.625	33.70	6.765	0.3927
7.625	38.70	6.625	0.4145
7.625	45.00	6.445	0.4450
8.000	26.00	7.386	0.3130
8.125	28.00	7.485	0.3024
8.125	32.00	7.385	0.3131
8.125	35.50	7.285	0.3243
8.125	39.50	7.185	0.3361
8.625	17.50	8.249	0.2353
8.625	20.00	8.191	0.2396
8.625	24.00	8.097	0.2469
8.625	28.00	8.003	0.2544
8.625	32.00	7.907	0.2625
8.625	36.00	7.825	0.2697
8.625	38.00	7.775	0.2741
8.625	43.00	7.651	0.2858
9.000	34.00	8.290	0.2323
9.000	38.00	8.196	0.2392
9.000	40.00	8.150	0.2427
9.000	45.00	8.032	0.2521
9.625	36.00	8.921	0.1922
9.625	40.00	8.835	0.1971
9.625	43.50	8.755	0.2017
9.625	47.00	8.681	0.2063
9.625	53.50	8.535	0.2155
9.625	58.00	8.435	0.2222
10.000	33.00	9.384	0.2204
10.000	55.50	8.908	0.1929
10.000	61.20	8.790	0.1998
10.750	32.75	10.192	0.1363
10.750	35.75	10.136	0.1382
10.750	40.00	10.050	0.1413
10.750	45.50	9.950	0.1450
10.750	48.00	9.902	0.1469
10.750	54.00	9.784	0.1514

TABLE I

(Continued)

Values of F_c for various casing-tubing combinations. (Annular Flow).

CASING			TUBING			
O.D. In.	I.D. In.	#/Ft.	O.D. In.	I.D. In.	#/Ft.	F_c
7.625	6.625	39	2.375	1.995	4.7	.651
7.000	6.366	23	2.375	1.995	4.7	.740
7.000	6.276	26	2.375	1.995	4.7	.744
7.000	6.366	23	2.875	2.441	6.5	.865
6.625	6.049	20	2.375	1.995	4.7	.875
7.000	6.276	26	2.875	2.441	6.5	.910
6.625	6.049	20	2.875	2.441	6.5	1.041
6.625	5.921	24	3.500	2.992	9.3	1.540
5.500	4.892	17	2.375	1.995	4.7	1.812
5.500	4.892	17	3.000	-	-	2.735
7.750	6.456	20	1.315	1.049	1.68	.527
6.155	4.976	15	1.315	1.049	1.68	1.117

$$F_c \text{ (for Annulus)} = \left[\frac{0.10337}{(d_1 + d_2)(d_1 - d_2)^{1.582}} \right] \left(\frac{P_b}{14.65} \right) (T)\ (Z)$$

d_1 = I.D. of casing - in.

d_2 = O.D. of tubing - in.

TABLE II

Values of $(1 - e^{-S})$ for Various Values of GL

Note: $S = \left(\frac{0.0375\ GL}{TZ} \right)$

Values shown based on $T = 573$
$Z = 0.90$

From	To	$(1 - e^{-S})$	From	To	$(1 - e^{-S})$
947	960	0.067	1549	1564	0.107
961	976	0.068	1565	1579	0.108
977	990	0.069	1580	1594	0.109
991	1005	0.070	1595	1609	0.110
1006	1020	0.071	1610	1624	0.111
1021	1034	0.072	1625	1641	0.112
1035	1049	0.073	1642	1657	0.113
1050	1065	0.074	1658	1672	0.114
1065	1080	0.075	1673	1687	0.115
1081	1094	0.076	1688	1703	0.116
1095	1109	0.077	1704	1718	0.117
1110	1124	0.078	1719	1734	0.118
1125	1138	0.079	1735	1750	0.119
1139	1153	0.080	1751	1766	0.120
1154	1169	0.081	1767	1781	0.121
1170	1184	0.082	1782	1797	0.122
1185	1199	0.083	1798	1812	0.123
1200	1214	0.084	1813	1828	0.124
1215	1228	0.085	1829	1844	0.125
1229	1243	0.086	1845	1859	0.126
1244	1258	0.087	1860	1875	0.127
1259	1274	0.088	1876	1891	0.128
1275	1289	0.089	1892	1907	0.129
1290	1304	0.090	1908	1923	0.130
1305	1319	0.091	1924	1939	0.131
1320	1334	0.092	1940	1954	0.132
1335	1349	0.093	1955	1970	0.133
1350	1364	0.094	1971	1986	0.134
1365	1380	0.095	1987	2002	0.135
1381	1395	0.096	2003	2017	0.136
1396	1410	0.097	2018	2033	0.137
1411	1426	0.098	2034	2050	0.138
1427	1441	0.099	2050	2066	0.139
1442	1456	0.100	2067	2082	0.140
1457	1474	0.101	2083	2098	0.141
1475	1487	0.102	2099	2114	0.142
1488	1502	0.103	2115	2130	0.143
1503	1518	0.104	2131	2146	0.144
1519	1533	0.105	2147	2162	0.145
1534	1548	0.106	2163	2178	0.146

TABLE II
(Continued)

Values of $(1 - e^{-s})$ for Various Values of GL

GL From	GL To	$(1 - e^{-s})$	GL From	GL To	$(1 - e^{-s})$
2179	2194	0.147	3026	3042	0.198
2195	2210	0.148	3043	3060	0.199
2211	2227	0.149	3061	3077	0.200
2227	2243	0.150	3078	3094	0.201
2244	2259	0.151	3095	3111	0.202
2260	2275	0.152	3112	3128	0.203
2276	2292	0.153	3129	3146	0.204
2293	2308	0.154	3147	3163	0.205
2309	2324	0.155	3164	3180	0.206
2325	2340	0.156	3181	3197	0.207
2341	2356	0.157	3198	3215	0.208
2357	2373	0.158	3216	3232	0.209
2374	2389	0.159	3233	3250	0.210
2390	2405	0.160	3251	3267	0.211
2406	2422	0.161	3268	3284	0.212
2423	2438	0.162	3285	3303	0.213
2439	2455	0.163	3304	3318	0.214
2455	2471	0.164	3319	3336	0.215
2472	2488	0.165	3337	3354	0.216
2489	2504	0.166	3355	3372	0.217
2505	2521	0.167	3373	3389	0.218
2522	2537	0.168	3390	3407	0.219
2538	2554	0.169	3408	3425	0.220
2555	2570	0.170	3426	3442	0.221
2571	2587	0.171	3443	3460	0.222
2588	2603	0.172	3461	3478	0.223
2604	2620	0.173	3479	3496	0.224
2621	2637	0.174	3497	3513	0.225
2638	2653	0.175	3514	3531	0.226
2654	2670	0.176	3532	3549	0.227
2671	2687	0.177	3550	3567	0.228
2688	2703	0.178	3568	3585	0.229
2704	2720	0.179	3586	3602	0.230
2721	2737	0.180	3603	3620	0.231
2738	2754	0.181	3621	3638	0.232
2755	2771	0.182	3639	3656	0.233
2772	2788	0.183	3657	3674	0.234
2789	2805	0.184	3675	3692	0.235
2806	2822	0.185	3693	3710	0.236
2823	2838	0.186	3711	3728	0.237
2838	2855	0.187	3729	3747	0.238
2855	2872	0.188	3748	3765	0.239
2873	2889	0.189	3766	3783	0.240
2890	2906	0.190	3784	3801	0.241
2907	2923	0.191	3802	3819	0.242
2924	2940	0.192	3820	3837	0.243
2941	2957	0.193	3838	3855	0.244
2958	2975	0.194	3856	3874	0.245
2976	2991	0.195	3875	3892	0.246
2992	3008	0.196	3893	3910	0.247
3009	3025	0.197	3911	3928	0.248

TABLE II
(Continued)

Values of $(1 - e^{-s})$ for Various Values of GL

GL From	GL To	$(1 - e^{-s})$	GL From	GL To	$(1 - e^{-s})$
3929	3947	0.249	4896	4915	0.300
3948	3965	0.250	4916	4934	0.301
3966	3984	0.251	4935	4954	0.302
3985	4002	0.252	4955	4973	0.303
4003	4021	0.253	4974	4993	0.304
4022	4039	0.254	4994	5013	0.305
4040	4057	0.255	5014	5033	0.306
4058	4075	0.256	5034	5053	0.307
4076	4094	0.257	5054	5073	0.308
4095	4112	0.258	5074	5093	0.309
4113	4131	0.259	5094	5113	0.310
4132	4150	0.260	5114	5132	0.311
4151	4168	0.261	5133	5152	0.312
4169	4187	0.262	5153	5172	0.313
4188	4205	0.263	5173	5193	0.314
4206	4224	0.264	5194	5213	0.315
4225	4243	0.265	5214	5233	0.316
4244	4262	0.266	5234	5253	0.317
4263	4281	0.267	5254	5273	0.318
4282	4300	0.268	5274	5293	0.319
4301	4318	0.269	5294	5313	0.320
4319	4337	0.270	5314	5334	0.321
4338	4356	0.271	5335	5354	0.322
4357	4374	0.272	5355	5374	0.323
4375	4393	0.273	5375	5395	0.324
4394	4412	0.274	5396	5415	0.325
4413	4431	0.275	5416	5435	0.326
4432	4450	0.276	5436	5456	0.327
4451	4469	0.277	5457	5476	0.328
4470	4488	0.278	5477	5497	0.329
4489	4508	0.279	5498	5518	0.330
4509	4527	0.280	5519	5537	0.331
4528	4546	0.281	5538	5558	0.332
4547	4565	0.282	5559	5579	0.333
4566	4585	0.283	5580	5600	0.334
4586	4603	0.284	5601	5621	0.335
4604	4622	0.285	5622	5641	0.336
4623	4642	0.286	5642	5662	0.337
4643	4661	0.287	5663	5682	0.338
4662	4680	0.288	5683	5704	0.339
4681	4700	0.289	5705	5724	0.340
4701	4719	0.290	5725	5745	0.341
4720	4739	0.291	5746	5765	0.342
4740	4758	0.292	5766	5787	0.343
4759	4778	0.293	5788	5808	0.344
4779	4797	0.294	5809	5829	0.345
4798	4816	0.295	5830	5850	0.346
4817	4836	0.296	5851	5871	0.347
4837	4855	0.297	5872	5892	0.348
4856	4875	0.298	5893	5913	0.349
4876	4895	0.299	5914	5935	0.350

SOURCE OF THE TERM F_c USED IN THE CALCULATION OF EQUIVALENT STATIC COLUMN WELLHEAD PRESSURES

The calculation of the equivalent static column wellhead pressure corresponding to a flowing wellhead pressure is carried out through use of the following equation:

$$P_w^2 = P_t^2 + F^2T^2Z^2 \left(1 - e^{-s}\right) \quad \text{--------(1)}$$

where:

$$F^2 = \frac{2.6665 \; f \; Q^2}{d^5}$$

$$S = \frac{0.0375 \; GL}{TZ}$$

G = specific gravity (air = 1.00)
L = length of flow string, ft.
P = pressure, psia (P^2 in thousands)
Q = rate of flow, M^2cfd @ 14.65 psia, and 60°F.
T = effective absolute temperature, °R.
Z = effective compressibility factor.
d = internal diameter of flow string, in.
f = coefficient of friction, dimensionless.

Through use of the complete turbulence portion of the curves published by Lewis F. Moody in November 1944, Transactions of the A.S.M.E., it is possible to determine the value of (f) for various sizes of pipe at a constant absolute roughness of 0.0006 in., which value is considered valid for clean pipe.

Using the values of (f) so determined, it is possible to arrive at a correlation of friction coefficient (f) vs. internal diameter (d) which is reasonably correct. It was found for an absolute roughness of 0.0006 in. that the value of (f) could be expressed as follows:

$$f = \left[\frac{4.372 \times 10^{-3}}{d^{0.224}}\right] \quad \text{for diameters less than 4.277 in.}$$

and,

$$f = \left[\frac{4.007 \times 10^{-3}}{d^{0.164}}\right] \quad \text{for diameters greater than 4.277 in.}$$

If the expression $(F_cQ)^2$ is allowed to represent the expression $(F^2T^2Z^2)$ in Equation (1), then the value of F_c can be shown to be those given in Table I.

EL PASO NATURAL GAS COMPANY

Memorandum

To: Mr. L. D. Galloway
Date: August 30, 1962
From: Gas Engineering
Place: Farmington, New Mexico

A meeting was held in Farmington on August 1, 1962 to discuss possible changes in the mode of calculation of the deliverability tests for wells in the San Juan Basin. At this meeting I was asked to compile certain data regarding "Multipliers" used in converting from the actual flow rates (Q) to the deliverability (D) for wells in certain pools. The 1960 Annual Deliverability Test for 3859 wells was used in this study. The multiplier for each well was converted from a basis of Pd = 50% Pc to a value of Pd = 75% Pc. Then a count was made of the number of wells in brackets as: Under 1.0, 1.0 to 1.5, 1.5 to 2.0, etc. A tabulation was made for the South Blanco Pictured Cliff Pool using Pd = 65% Pc.

The results of these converted multipliers are attached hereto.

H. L. Kendrick
Sr. Gas Engineer

HLK:slm
cc: Mr. E. C. Arnold
Mr. A. R. Kendrick
Mr. W. B. Smith
Mr. Elvis Utz
--
Mr. Gerald Hickson
Mr. R. F. Lemon
Mr. J. B. Magruder
Mr. D. H. Rainey
Mr. G. C. Whitworth
Mr. F. N. Woodruff
--
Mr. W. G. Cutler
File (2)

SOUTH BLANCO PICTURED CLIFF POOL

Using 0.75 P_c for P_d

LOCATION TOWNSHIP	NUMBER OF WELLS	MULTIPLIER UNDER 1.0	MULTIPLIER 1.0 - 1.5	MULTIPLIER 1.5 - 2.0	MULTIPLIER 2.0 - 2.5	MULT. 2.5 & OVER
24-2	21	19	1	1		
24-3	46	35	4		1	6
24-4	22	8	9	1	2	2
25-3	40	31	2	1	2	4
25-4	61	44	10	3	2	2
25-5	58	35	16	5		2
25-6	30	26	4			
26-4	11		2	6	2	1
26-5	76	58	7	6	1	4
26-6	78	55	21	2		
26-7	65	58	3	2		2
26-8	6	3	3			
27-5	10	7	2	1		
27-6	57	51	6			
27-7	92	91	1			
27-8	96	90	4	1	1	
27-9	63	49	13	1		
28-6	2	1	1			
28-7	10	6	3			1
28-8	15	11	1	2	1	
28-9	14	14				
TOTALS:	873	692	113	32	12	24
PER-CENTS:		79.3	12.9	3.7	1.4	2.7

30 wells with multipliers greater than 1.5 are classified as exempt marginal.

24/872 =

$P_c - P_d$

TAPACITO PICTURED CLIFF POOL

Using 0.75 Pc for Pd

LOCATION TOWNSHIP	NUMBER OF WELLS	MULTIPLIER UNDER 1.0	MULTIPLIER 1.0 - 1.5	MULTIPLIER 1.5 - 2.0	MULTIPLIER 2.0 - 2.5	MULT. 2.5 & OVER
25-3	22	14	6		1	1
26-3	20	9	7	3	1	
26-4	27	3	9	9	2	4
26-5	1					1
27-4	11	2	8	1		
27-5	17	2	6	6	3	
TOTALS:	98	30	36	19	7	6
PER-CENTS:		30.6	36.7	19.4	7.1	6.1

6 wells with multipliers greater than 1.5 are classified as exempt marginal.

UNDESIGNATED PICTURED CLIFF POOL

Using 0.75 Pc for Pd

LOCATION TOWNSHIP	NUMBER OF WELLS	MULTIPLIER UNDER 1.0	MULTIPLIER 1.0 - 1.5	MULTIPLIER 1.5 - 2.0	MULTIPLIER 2.0 - 2.5	MULT. 2.5 & OVER
25-10	1	1				
26-9	1	1				
26-10	1	1				
27-4	1		1			
28-3	1	1				
29-8	1	1				
30-9	3	3				
TOTALS:	9	8	1			
PER-CENTS:		88.9	11.1			

WEST KUTZ PICTURED CLIFF POOL

Using 0.75 P_c for P_a

LOCATION TOWNSHIP	NUMBER OF WELLS	MULTIPLIER UNDER 1.0	MULTIPLIER 1.0 - 1.5	MULTIPLIER 1.5 - 2.0	MULTIPLIER 2.0 - 2.5	MULT. 2.5 & OVER
26-10	14	1	12	1		
26-11	2	2				
27-10	12	6	5			1
27-11	40	26	6	7		1
27-12	30	16	3	4	3	4
28-11	2	1		1		
28-12	33	1	6	13	5	8
28-13	4				1	3
39-12	6	5	1			
29-13	6			5	1	
TOTALS:	149	58	33	31	10	17
PER-CENTS:		38.9	22.1	20.8	6.7	11.4

38 wells with multipliers greater than 1.5 are classified as exempt marginal.

BLANCO MESA VERDE POOL

Using 0.75 P_c for P_u

LOCATION TOWNSHIP	NUMBER OF WELLS	MULTIPLIER UNDER 1.0	MULTIPLIER 1.0 - 1.5	MULTIPLIER 1.5 - 2.0	MULTIPLIER 2.0 - 2.5	MULT. 2.5 & OVER
26-2	3	3				
26-3	21	18	2	1		
26-4	10	3	6	1		
26-5	6	5	1			
26-6	2	1	1			
26-7	3	1	1		1	
27-3	20	19	1			
27-4	16	8	5	1	1	1
27-5	44	13	26	5		
27-6	48	17	18	11	1	1
27-7	29	10	11	5	2	1
27-8	36	21	13	2		
27-9	8	7	1			
28-3	2	2				
28-4	14	6	5	2	1	
28-5	44	16	23	4	1	
28-6	43	15	23	4	1	
28-7	47	16	25	4		2
28-8	45	34	10		1	
28-9	39	15	23			1
29-4	6	1	2	1	2	
29-5	38	17	19	1	1	
29-6	54	30	23	1		
29-7	65	27	34	4		
29-8	64	52	11			1
29-9	63	38	21	3	1	
29-10	7	4	1	1		1
30-4	2	1	1			
30-5	23	9	11	1	2	
30-6	60	37	19	3		1
30-7	68	44	18	6		
30-8	62	42	19	1		
30-9	64	36	26	1	1	
30-10	55	34	13	5	1	2
30-11	12	3	6	2	1	
30-12	2	2				
31-5	7		4	1	2	
31-6	20	3	8	5	3	1
31-7	28	6	8	9	2	3
31-8	48	21	17	5	4	1
31-9	65	39	15	5	4	2
31-10	71	64	7			
31-11	56	40	10	4	2	
31-12	45	24	15	4	1	1
31-13	4	4				
32-5	2		2			
32-6	11	8	3			
32-7	17	9	4	1	1	2
32-8	9	2	1	4		2
32-9	25	9	8	8		
32-10	49	23	14	5	6	1

BLANCO MESA VERDE POOL

Using 0.75 P_c for P_d

Page 2

LOCATION TOWNSHIP	NUMBER OF WELLS	MULTIPLIER UNDER 1.0	MULTIPLIER 1.0 - 1.5	MULTIPLIER 1.5 - 2.0	MULTIPLIER 2.0 - 2.5	MULT 2.5 & OVER
32-11	51	26	21	3	1	
32-12	35	24	10			1
32-13	7	4	2	1		
TOTALS:						
	1675	913	568	125	44	25
Per Cents:		54.51	33.91	7.46	2.63	1.49

107 wells with multipliers greater than 1.5 are NOT classified as exempt marginal.

87 wells that are classified as exempt marginal had a shut-in pressure of 600 psia or less.

AZTEC PICTURED CLIFF POOL

Using 0.75 P_c for P_d

LOCATION TOWNSHIP	NUMBER OF WELLS	MULTIPLIER UNDER 1.0	MULTIPLIER 1.0 - 1.5	MULTIPLIER 1.5 - 2.0	MULTIPLIER 2.0 - 2.5	MULT. 2.5 & OVER
28-8	5	3		1	1	
28-9	53	50	1	1	1	
28-10	18	16	2			
29-8	1	1				
29-9	8	4	1	2	1	
29-10	81	75	5	1		
29-11	18	14	2	1		1
30-10	42	39	2		1	
30-11	85	78	5		1	1
31-11	12	10	1		1	
31-12	1				1	
TOTALS:	324	290	19	6	7	2
PER-CENTS:		89.5	5.9	1.9	2.2	0.6

6 wells with multipliers greater than 1.5 are classified as exempt marginal.

BALLARD PICTURED CLIFF POOL

Using 0.75 P_c for P_d

LOCATION TOWNSHIP	NUMBER OF WELLS	MULTIPLIER UNDER 1.0	MULTIPLIER 1.0 - 1.5	MULTIPLIER 1.5 - 2.0	MULTIPLIER 2.0 - 2.5	MULT. 2.5 & OVER
23-3	8	8				
23-4	3	3				
23-5	16	15	1			
23-6	3	2	1			
24-4	2	2				
24-5	44	32	11		1	
24-6	42	33	8	1		
24-7	7	7				
25-6	14	10	4			
25-7	40	36	4			
25-8	33	12	12	8	1	
26-7	16	15	1			
26-8	58	53	5			
26-9	68	62	6			
27-8	4	4				
27-9	23	15	6	2		
TOTALS:	381	309	59	11	2	
PER-CENTS:		81.1	15.5	2.9	0.5	

5 wells with multipliers greater than 1.5 are classified as exempt marginal.

BLANCO PICTURED CLIFF POOL

Using 0.75 P_c for P_d

LOCATION TOWNSHIP	NUMBER OF WELLS	MULTIPLIER UNDER 1.0	MULTIPLIER 1.0 - 1.5	MULTIPLIER 1.5 - 2.0	MULTIPLIER 2.0 - 2.5	MULT. 2.5 & OVER
29-8	2	2				
29-9	20	20				
30-9	13	13				
30-10	1	1				
TOTALS:	36	36				
PER-CENT:		100				

CHOZA MESA PICTURED CLIFF POOL

Using 0.75 Pc for Pd

LOCATION TOWNSHIP	NUMBER OF WELLS	MULTIPLIER UNDER 1.0	MULTIPLIER 1.0 - 1.5	MULTIPLIER 1.5 - 2.0	MULTIPLIER 2.0 - 2.5	MULT. 2.5 & OVER
28-4	2	2				
29-3	1	1				
29-4	4	3	1			
TOTALS:	7	6	1			
PER-CENTS		85.7	14.3			

EAST BLANCO PICTURED CLIFF POOL

Using 0.75 P_c for Pd

LOCATION TOWNSHIP	NUMBER OF WELLS	MULTIPLIER UNDER 1.0	MULTIPLIER 1.0 - 1.5	MULTIPLIER 1.5 - 2.0	MULTIPLIER 2.0 - 2.5	MULT. 2.5 & OVER
30-4	21	18	1	1		1
TOTALS:	21	18	1	1		1
PER-CENTS		85.7	4.8	4.8		4.8

FULCHER KUTZ PICTURED CLIFF POOL

Using 0.75 Pc for Pd

LOCATION TOWNSHIP	NUMBER OF WELLS	MULTIPLIER UNDER 1.0	MULTIPLIER 1.0 - 1.5	MULTIPLIER 1.5 - 2.0	MULTIPLIER 2.0 - 2.5	MULT. 2.5 & OVER
27-9	28	18	10			
27-10	83	72	7	2	2	
28-10	62	59	3			
28-11	14	13	1			
29-10	1	1				
29-11	17	12	4	1		
29-12	17	8	7	2		
29-13	1	1				
30-12	2	2				
TOTALS:	225	186	32	5	2	
PER-CENTS:		82.7	14.2	2.2	0.9	

7 wells with multipliers greater than 1.5 are classified as exempt marginal

GAVILAN PICTURED CLIFF POOL

Using 0.75 Pc for Pa

LOCATION TOWNSHIP	NUMBER OF WELLS	MULTIPLIER UNDER 1.0	MULTIPLIER 1.0 - 1.5	MULTIPLIER 1.5 - 2.0	MULTIPLIER 2.0 - 2.5	MULT. 2.5 & OVER
24-1	2	2				
25-1	5	5				
25-2	20	20				
26-2	9	9				
26-3	13	10	3			
27-3	12	12				
TOTALS:	61	58	3			
PER-CENTS:		95.1	4.9			

SOUTH BLANCO PICTURED CLIFF POOL

Using 0.65 Pc for Pd

LOCATION TOWNSHIP	NUMBER OF WELLS	MULTIPLIER UNDER 1.0	MULTIPLIER 1.0 - 1.5	MULTIPLIER 1.5 - 2.0	MULTIPLIER 2.0 - 2.5	MULT. 2.5 & OVER
24-2	21	18	1	1	1	0
24-3	46	31	6	2	0	7
24-4	22	4	9	4	1	4
25-3	40	23	8	3	0	6
25-4	61	35	17	2	2	5
25-5	58	25	17	11	3	2
25-6	30	21	7	2	0	0
26-4	11	0	1	2	5	3
26-5	76	46	12	10	2	6
26-6	78	44	21	12	1	0
26-7	65	44	14	3	2	2
26-8	6	2	2	2	0	0
27-5	10	6	2	1	1	0
27-6	57	47	9	1	0	0
27-7	92	82	9	1	0	0
27-8	96	71	20	3	1	1
27-9	63	33	26	3	1	0
28-6	2	0	2	0	0	0
28-7	10	1	6	2	0	1
28-8	15	9	3	1	1	1
28-9	14	8	6	0	0	0
TOTALS:	873	550	198	66	21	38
PER-CENTS:		63.0	22.7	7.6	2.4	4.3

EL PASO NATURAL GAS COMPANY

Memorandum

MAIN OFFICE OCC

To	Mr. L. D. Galloway	Date	March 23, 1962
From:	Gas & Production Engineering	Place	Farmington, New Mexico

'62 MAR 23 PM 1 40

A conference was held in Farmington on March 8, 1962, to discuss possible changes to be made in the manner of conducting, calculating and reporting of Annual Deliverability and Shut-in Pressure tests in the San Juan Basin Area. The names of persons in attendance from the New Mexico Oil Conservation Commission and El Paso Natural Gas Company are listed at the end of this memorandum.

The conclusions reached at this time were:

1. No shortening of flow or pre-flow periods should be made at this time.
2. Use either casing or tubing shut-in pressure, whichever is higher, provided the well is not bridged, for P_c. (The present rules stipulate that the shut-in pressure of the flowing string be used for P_c);
3. Bridged wells and the lower zone of dually completed wells are to use a value of P_c as determined from:
   a. Actual wellhead pressure, if the Deliverability Multiplier Factor is below a yet to be determined value. (i.e. figures of 1.50 and 2.00 were discussed), or
   b. Average pressure of off-set wells, or
   c. Correct wellhead pressure determined by calculations from bottom hole pressure bomb data eliminating effects of liquid accumulation in the wellbore;
4. To recommend the changing of the deliverability pressure (P_d) from the presently stipulated 50% $P_c = P_d$ in each pool to the ratio that the calculated working pressure (P_w) bears to the shut-in pressure (P_c) based on a summation of the previous years actual values of shut-in and working pressures as taken from the Annual Deliverability Tests.

This would raise the deliverability pressure from 50% of shut-in pressure to approximately 70% of shut-in pressure, thus eliminating the large multipliers now occuring where the seven day shut-in pressure is approaching the working pressure. (See attached Table)

It was felt that the data presented may not be completely adequate in all respects. El Paso, therefore, plans to conduct more bottom hole pressure surveys in areas where low wellhead shut-in pressures have been measured. This survey is needed to help evaluate the above recommendations.

Thirteen bottom hole pressure surveys were conducted just prior to this meeting. A copy of these surveys are included with this memorandum.

A table of "Deliverability Multiplier Factors" has been calculated and a copy is attached hereto.

Those in attendance at this meeting were:

New Mexico Oil Conservation Commission, Santa Fe, New Mexico
Mr. Elvis Utz

New Mexico Oil Conservation Commission, Aztec, New Mexico
Mr. Emery C. Arnold
Mr. A. R. Kendrick
Mr. W. B. Smith

El Paso Natural Gas Company, El Paso, Texas
Gerald Hickson
R. F. Lemon
J. B. Magruder
D. H. Rainey
G. C. Whitworth
T. N. Woodruff

El Paso Natural Gas Company, Farmington, New Mexico
L. D. Galloway
H. L. Kendrick

H. L. Kendrick
H. L. Kendrick
Sr. Gas Engineer

HLK:bjo

cc: Above Names (1)
W. G. Cutler
File - 2

DELIVERABILITY MULTIPLIER FACTORS

$$D = Q \frac{P_c^2 - P_d^2}{P_c^2 - P_w^2}$$

Q = Average Daily Volume, MCF/D
P_c = Wellhead Shut-in Pressure, PSIA
P_d = Deliverability Pressure, PSIA
P_w = Working Pressure, PSIA
n = Slope (0.75 or 0.85)

P_d - % of P_c	P_w - % of P_c	Multiplier (Q x M = D) n = 0.75	Multiplier (Q x M = D) n = 0.85
50	50	1.0000	1.0000
50	55	1.0559	1.0636
50	60	1.1269	1.1445
50	65	1.2166	1.2486
50	70	1.3354	1.3879
50	75	1.4961	1.5611
50	80	1.7341	1.8661
50	85	2.1079	2.3282
50	90	2.8004	3.2126
50	95	4.6189	5.6643
50	85.61	2.0000	------
50	75.65	1.5000	------
50	81.74	------	2.0000
50	73.12	------	1.5000
55	55	1.0000	1.0000
55	60	1.0666	1.0758
55	65	1.1520	1.1740
55	70	1.2646	1.3049
55	75	1.4188	1.4865
55	80	1.6422	1.7545
55	85	1.9962	2.1690
55	90	2.6571	3.0204
55	95	4.5742	5.3955
55	85.04	2.0000	------
55	77.06	1.5000	------
55	83.15	------	2.0000
55	75.32	------	1.5000
60	60	1.0000	1.0000
60	65	1.0801	1.0913
60	70	1.1857	1.2129
60	75	1.3301	1.3817
60	80	1.5396	1.6307
60	85	1.8715	2.0546
60	90	2.4864	2.8074
60	95	4.1009	4.9499
60	86.38	2.0000	------
60	79.20	1.5000	------
60	84.67	------	2.0000
60	77.61	------	1.5000

DELIVERABILITY MULTIPLIER FACTORS

PAGE 2

P_a [illegible] of P_c	P_w [illegible] of P_c	Multiplier (Q x M = D) n = 0.75	n = 0.85
65	65	1.0000	1.0000
65	70	1.0977	1.1114
65	75	1.2315	1.2662
65	80	1.4254	1.4943
65	85	1.7326	1.8644
65	90	2.3019	2.5726
65	95	3.7967	4.5359
65	87.80	2.0000	------
65	81.47	1.5000	------
65	86.28	------	2.0000
65	80.10	------	1.5000
70	70	1.0000	1.0000
70	75	1.1219	1.1392
70	80	1.2985	1.3445
70	85	1.5704	1.6775
70	90	2.0971	2.3147
70	95	3.4538	4.0311
70	89.31	2.0000	------
70	83.39	1.5000	------
70	88.00	------	2.0000
70	82.67	------	1.5000
75	75	1.0000	1.0000
75	80	1.1574	1.1802
75	85	1.4069	1.4724
75	90	1.8692	2.0318
75	95	3.0830	3.5824
75	90.11	2.0000	------
75	86.33	1.5000	------
75	89.61	------	2.0000
75	85.35	------	1.5000
80	80	1.0000	1.0000
80	85	1.2155	1.2475
80	90	1.6149	1.7215
80	95	2.6636	3.0353
80	92.59	2.0000	------
80	88.90	1.5000	------
80	91.70	------	2.0000
80	88.13	------	1.5000

DELIVERABILITY MULTIPLIER FACTORS

PAGE 3

Pd % of Pc	Pw % of Pc	Multiplier (Q x M = D) n = 0.75	Multiplier (Q x M = D) n = 0.85
85	85	1.0000	1.0000
85	90	1.3285	1.3798
85	95	2.1912	2.4328
85	94.33	2.0000	------
85	91.56	1.5000	------
85	93.66	------	2.0000
85	90.98	------	1.5000
90	90	1.0000	1.0000
90	95	1.6495	1.7631
90	96.16	2.0000	------
90	94.31	1.5000	------
90	95.71	------	2.0000
90	93.92	------	1.5000
95	95	1.0000	1.0000
95	98.05	2.0000	------
95	97.12	1.5000	------
95	97.32	------	2.0000
95	96.95	------	1.5000

EL PASO NATURAL GAS COMPANY

BOTTOM HOLE PRESSURE REPORT

Company: EPNG — W.O. No.

Field: Blanco — NE Sec. 24-31-10

Lease: Atlantic — Well No. 2

Date: 2-27-62 — Status of Well: Shut-in 11 days

Pay: MV — Top: 5119 ft. Bottom: 5760 ft. T.D. 5760 ft. Datum ft.

Tubing: 2.375 — Depth: 5734 ft. — ft. Packer ft.

Casing: 7 — Depth: 5075 ft. Perfs: open ft. Liner — Tree Connection

Depth Feet	Pressure Lbs. Sq. In.	Pressure	Gradient Lbs. Ft.
Lube	835		
1000	867		.032
2000	892		.025
3000	917		.025
5500	972		.022
5550	975		.060
5600	975		----
5650	977		.040
5712	985		.129

Casing Press. 836 D.A.T.
Tubing Press. 836 D.A.T.
Oil Level: none ft.
Water Level — ft.
Element No.: 5712 — 168 ft.
Gas Gravity .685

PRODUCTIVITY INDEX — BBLS. DAY LBS. DROP

Operator: Humble — No. 1222

Engineer: T. B. Grant — Calibration No. 30862

Calculated BHP = 984 psia

EL PASO NATURAL GAS COMPANY

BOTTOM HOLE PRESSURE REPORT

Company **KPNG** W.O. No.

Field **Blanco** NE Sec. 26-31-10

Lease **Atlantic** Well No. **6-A**

Date 2-27-62 Time Status of Well **Shut-in 8 days**

Pay **MV** Top 4798 ft. Bottom 5492 ft. T.D. 5492 ft. Datum ft.

Tubing 2.375 Depth 5487 ft. B.H.C. ft. Plug or Pin Packer ft.

Casing 7 Depth 4700 ft. Perfs. open ft. Liner Tree Connection

Depth Feet	Pressure	Pressure	Gradient
Lube	865		
1000	897		.032
2000	925		.028
3000	951		.026
5200	1007		.025
5300	1009		.020
5400	1021		.120
5438	1043		.579

Casing Press. 833 D.W.T.
Tubing Press. 867 D.W.T.
Oil Level ft.
Water Level 5385 (Mud) ft.
Hours Shut In Flowing
Temp. 5430 ft. 171 F.
Elevation ft. Ground ft.
Last Test Date
Press. Last Test Psig
B.H.P. Change Days
Loss day
Choke Size
Oil Bbls. Day
Water Bbls. Day
Total Bbls. Day
Line in.
Static Differential in.
Gas Spec. Gr. .695
GOR cu. ft. Bbl.

PRODUCTIVITY INDEX BBLS. DAY LBS. DROP

Last Cumulative Production | Present Cumulative Production | Production Between Tests

Instrument **Humble** Number 1222 Recovery Factor Bbl. Pound Loss

Run by **T. B. Grant** Calibration No. 30862 Calculated by

Calculations & Remarks

Calculated BHP = 1016 psia

Company EPNG

Field Blanco NE Sec. 34-31-10

Lease Atlantic 7-B

Date 2-27-62 Shut-in 8 days

Pay MV 4672 5398 5455

Tubing 2.375 Depth 5405

Casing 7 Depth 4637 open

Lube	863	
1000	893	.030
2000	921	.028
3000	948	.027
5200	996	.022
5298	1002	.061

854
865
none

5298 165

.694

Last Cumulative Production

Instrument Humble No. 1222

Run by T. B. Grant 30862

Calculations and Remarks

Calculated BHP = 1011 psia

Company EPNG

Field Blanco SW Sec. 28-30-6

Lease Barron Kidd Well No. 1-F-X

Date 2-27-62 Status of Well Shut-in 16 days

Pay MV 5074 5540 5667

Tubing 2.375 Depth 5555

Casing 5-1/2 Depth 5667 5074 - 5540

Lube	903			913
1000	932	.029		907
2000	957	.025		none
3000	984	.027		5550
5480	1041	.023		
5500	1043	.100	5555	172
5520	1044	.050		
5540	1044	----		
5555	1053	.600		

.643

Instrument Humble No. 1222

T. B. Grant 30862

Calculated BHP = 1057 psia

Company EPNG

Field Blanco — NE Sec. 29-29-8

Lease Hughes — No. 8

Date 2-26-62 — Shut-in 10 days

Pay MV — Top 4608 — 5342 — 5365

Tubing 2.375 — Depth 5348

Casing 7 — Depth 4575 — open hole

Depth	Pressure	
Lube	914	
1000	949	.035
2000	983	.034
3000	1013	.030
5000	1071	.029
5100	1074	.030
5200	1075	.010
5250	1077	.040
5279	1080	.105

921

907

none

5279 150

.690

PRODUCTIVITY INDEX

Last Cumulative Production

Instrument Humble — Number 1222

Run by T. B. Grant — Calibration No. 30862

Calculated BHP = 1078

Company EPNG

Field Blanco SW Sec. 22-27-6

Lease Rincon 33

Date 3-2-62 Shut-in 176 days

Pay MV 4793 5485 5520

Tubing 2.375 Depth 5495

Casing 7 Depth 4745 open

Lube	551	
1000	572	.021
2000	588	.016
3000	610	.022
4202	650	.033
5000	858	.261
5200	905	.235
5400	962	.285
5450	982	.400
5495	999	.378

855
556
4120
5450

5495 153

Last Cumulative Production

Instrument Humble 1222

Run by T. B. Grant 30862

Calculations and Remarks:

Calculated BHP = 1001 psia

Company EPNG

Field Blanco NE Sec. 30-28-5

Lease San Juan Unit 28-5 32

Date 3-2-62 Shut-in 43 days

Pay MV Top 5546 5718 5810

Tubing 2.375 Depth 5711 5-1/2"

Casing 7.625 Depth 3634 5546 - 5718 3569-5807

Lube	841	
1000	874	.033
2000	902	.028
3000	935	.033
5200	1000	.030
5400	1004	.020
5600	1007	.015
5628	1007	----

855

846

None

5628 158

.711

Instrument Humble No. 1222

Run by T. B. Grant 30862

Calculations and Remarks:

Calculated BHP = 1015 psia (Piston)

EL PASO NATURAL GAS COMPANY

BOTTOM HOLE PRESSURE REPORT

Company EPNG — W.O. No.

Field Blanco — NE Sec. 31-28-5

Lease San Juan Unit 28-5 — Well No. 51

Date 3-2-62 — Time — Status of Well Shut-in 42 days

Pay MV — Top 5026 ft. Bottom 5502 ft. T.D. 5580 ft. Datum ft.

Tubing 2.375 Depth 5460 ft. B.H.C. ft. Plug or Pin (Liner) 4-1/2" Packer ft.

Casing 7 Depth 3430 ft. Perfs. 5026 - 5502 ft. Liner 3285-5578 Tree Connection

Depth Feet	Pressure lbs. sq. in.	Gradient
Lube	902	
1000	935	.033
2000	968	.033
3000	990	.022
5200	1051	.028
5240	1056	.125

Csg. Press. 908 P.S.I.

Tbg. Press. 902 P.S.I.

Oil Level none ft.

Water Level ft.

Hours Shut-In

Temp. 5240 ft. 152 °F.

Last Test Date

Press. Last Test Psi.

Gas Sp. Gr. .702

GOR

PRODUCTIVITY INDEX - BBLS. DAY LBS. DROP

Last Cumulative Production — Present Cumulative Production — Production Between Tests

Instrument Humble — No. 1222 — Recovery Factor / Bbls. per Lbs. Loss

Run by T. B. Grant — Calibration No. 30862 — Calculated by

Calculations and Remarks:

Calculated BHP = 1065 psia

Form 23-858 (1-59)

EL PASO NATURAL GAS COMPANY

BOTTOM HOLE PRESSURE REPORT

Company EPNG W.O. No.

Field Blanco SW Sec. 2-29-6

Lease San Juan Unit 29-6 Well No. 15

Date 3-1-62 Time Status of Well Shut-in 3 days

Pay MV Top 5213 ft. Bottom 5730 ft. T.D. 5730 ft. Datum ft.

Tubing 2.375 Depth 5663 ft. B.H.C. ft. Pressure Pin Packer ft.

Casing 7 Depth 5214 ft. Perfs. 5213 - 5730 ft. Liner Tree Connection

Depth Feet	Pressure	Pressure	Gradient
Lube	874		
1000	900	.026	
2000	929	.029	
3000	955	.026	
5300	1010	.024	
5500	1017	.035	
5610	1018	.009	
5630	1019	.050	
5650	1021	.100	
5663	1022	.077	

Casing Press. 882 p.s.i.
Tubing Press. 879 p.s.i.
Oil Level none ft.
Water Level ft.
Base Static Flowing
Temp. 5663 ft. 166 °F.
Elevation K.B. Elevation G.L. ft.
Last Test Date
Press. Last Test Psig
B.H.P. Change Days
Loss
Choke Size
Oil Bbls. day
Water Bbls. day
Total Bbls. day
Orifice Line Size
Static Differential
Gas Sp. Gr. .667
Gas Cu. Ft. day
GOR
Gas

PRODUCTIVITY INDEX BBLS. DAY LBS. DROP

Last Cumulative Production | Present Cumulative Production | Production Between Tests

Instrument Humble Number 1222 Recovery Factor Bbls. pound Loss

Run by T. B. Grant Calibration No. 30862 Calculated by

Calculations and Remarks:

Calculated BHP = 1031 psia

Form 23-855 (10-58)

EL PASO NATURAL GAS COMPANY

BOTTOM HOLE PRESSURE REPORT

Company EPNG W.O. No.

Field Blanco NE Sec. 31-29-6

Lease San Juan Unit 29-6 Well No. 53-31

Date 2-26-62 Time Status of Well Shut-in 31 days

Pay MV Top 5034 ft. Bottom 5600 ft. T.D. 5649 ft. Datum ft.

Tubing 2.375 Depth 5567 ft. S.B.H.C. ft. Plug or Pin Packer ft.

Casing 5-1/2 Depth 5645 ft. Perfs. 5034 - 5600 ft. Liner Tree Connection

Depth Feet	Pressure lbs. sq. in.	Press. Gradient	
Lube	837		
1000	867	.030	
2000	898	.031	
5450	988	.026	
5500	991	.060	
5584	993	.024	

Casing Press. 858 D.A.L.
Tubing Press. 844 D.A.L.
Oil Level none ft.
Water Level ft.
Bomb Shut In 5584 152
Gas Sp. Gr. .649

PRODUCTIVITY INDEX - BBLS. DAY LBS. DROP

Last Cumulative Production | Present Cumulative Production | Production Between Tests

Instrument Humble Number 1222 | Recovery Factor Bbls. pound Loss

Run by T. B. Grant Calibration No. 30862 | Calculated by

Calculations and Remarks:

Calculated BHP = 999 psia

EL PASO NATURAL GAS COMPANY

BOTTOM HOLE PRESSURE REPORT

Company EPNG   W.O. No.

Field Blanco   SW Sec. 21-21-9

Lease Sunray   Well No. 1-G

Date 2-28-62   Time   Status of Well Shut-in 21 days

Pay MV   Top 4800 ft. Bottom 5330 ft. T.D. ft. Datum ft.

Tubing 2.375 Depth 5356 ft. B.H.C. ft. Plug or Pin Packer ft.

Casing 7 Depth 4751 ft. Perfs. open ft. Liner Free Connection

Depth Feet	Pressure Psi.	Gradient
Lube	932	
1000	970	.380
2000	993	.023
5200	1043	.016
5300	1045	.020
5320	1046	.050
5340	1049	.150
5349	1057	.889

Casing Press. 922 p.s.i.
Tubing Press. 917 p.s.i.
Oil Level none
Water Level
5349 ft. 171
Gas Gravity .658

PRODUCTIVITY INDEX - BBLS. DAY LBS. DROP

Last Cumulative Production | Present Cumulative Production | Production Between Tests

Instrument Humble   Number 1222   Recovery Factor Bbls. pound Loss

Run by T. B. Grant   Calibration No. 30862   Calculated by

Calculations and Remarks:

Calculated BHP = 1066 psia

EL PASO NATURAL GAS COMPANY

BOTTOM HOLE PRESSURE REPORT

Company EPNG W.O. No.

Field Blanco SW Sec. 32-31-9

Lease Walker Well No. 2

Date 2-28-62 Time Status of Well Shut-in 21 days

Pay MV Top 4780 ft. Bottom 5435 ft. T.D. 5435 ft. Datum ft.

Tubing 2.375 Depth 5380 ft. CHLC ft. Plug or Pin Packer ft.

Casing 7 Depth 4755 ft. Perfs. open ft. Liner Tree Connection

Depth Feet	Pressure Psi, sq. in.	Pressure	Gradient
Lube	893		
1000	924		.031
2000	952		.028
3000	979		.027
5200	1035		.025
5250	1036		.020
5280	1038		.067
5300	1038		----
5320	1038		---
5340	1038		---
5360	1039		.050
5380	1043		.200

Casing Press. 896 D.W.T.
Tubing Press. 880 D.W.T.
Oil Level none ft.
Water Level ft.
Temp. 5380 165
Last Test Date
Press. Last Test Psi.
Gas Spec. Gr. .673

PRODUCTIVITY INDEX

Last Cumulative Production | Present Cumulative Production | Production Between Tests

Instrument Humble Number 1222 Recovery Factor Bbls. pound Loss

Run by T. B. Grant Calibration No. 30862 Calculated by

Calculations and Remarks:

Calculated BHP = 1043 psia

[illegible]

EL PASO NATURAL GAS COMPANY

BOTTOM HOLE PRESSURE REPORT

Company EPNG W.O. No.

Field Blanco NE Sec. 9-30-8

Lease Woodriver Well No. 2

Date 2-28-62 Time Status of Well Shut-in 21 days

Pay MV Top 4865 ft. Bottom 5424 ft. T.D. 5482 ft. Datum ft.

Tubing 2.375 Depth 5398 ft. 'BHLC ft. Plug or Pin Packer ft.

Casing 5.500 Depth 5482 ft. Perfs. 4865 - 5424 ft. Tree Connection

Depth Feet	Pressure Psi.	Gradient	
Lube	803		
1000	830	.027	
2000	852	.022	
3000	875	.023	
5200	918	.020	
5300	920	.020	
5320	921	.050	
5340	921	----	
5360	921	----	
5409	921	----	

Casing Press. 807 D.A.T.

Tubing Press. 805 D.A.T.

none

Fluid Level

Hours Shut In Elem.

5409 158

Last Test Date

Press. Last Test Psig

B.H.P. Change Days

Oil Bbls. day

Water Bbls. day

Total Bbls. day

Gas Sp. Gr. .646

PRODUCTIVITY INDEX - BBLS. DAY LBS. DROP

Last Cumulative Production | Present Cumulative Production | Production Between Tests

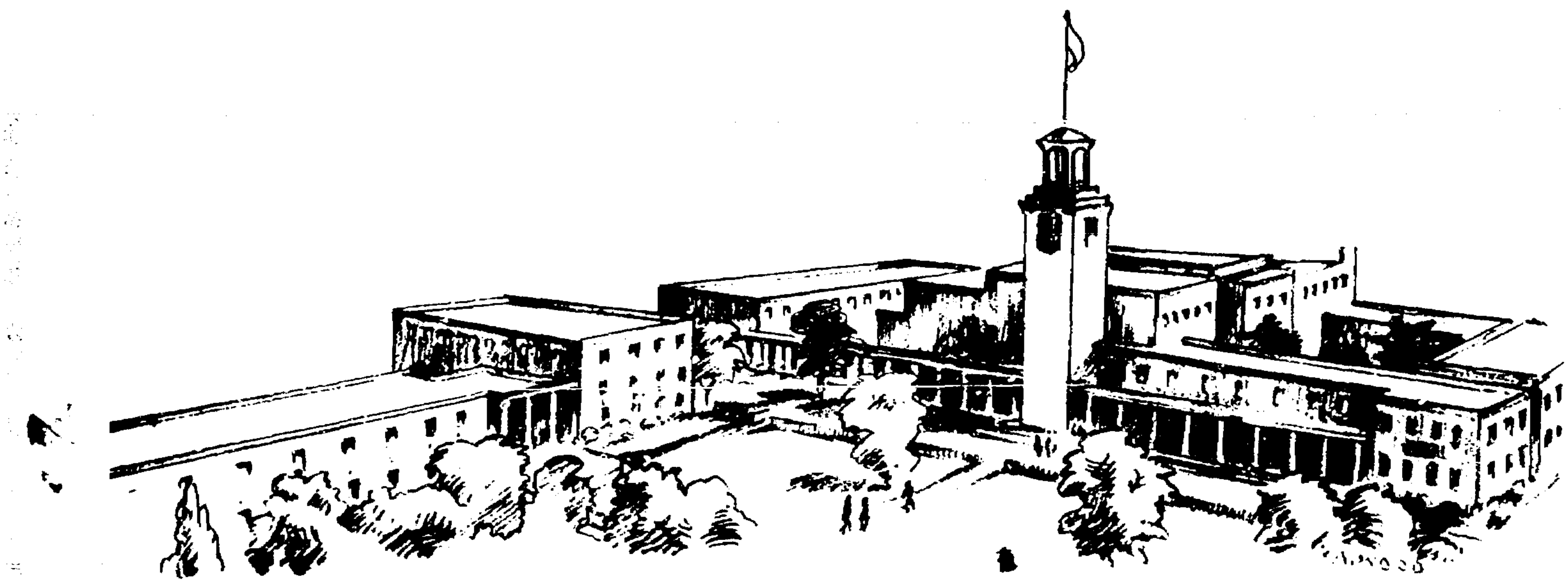
Recovery Factor Bbls. pound Loss

Instrument Humble Number 1222

Run by T. B. Grant Calibration No. 30862 Calculated by

Calculations and Remarks:

Calculated BHP = 934 psia



NEW MEXICO OIL CONSERVATION COMMISSION

MANUAL FOR

BACK PRESSURE TEST FOR NATURAL GAS WELLS

STATE OF NEW MEXICO

MANUAL FOR

BACK PRESSURE TEST FOR NATURAL GAS WELLS

STATE OF NEW MEXICO

Compiled

by

Elvis A. Utz

Gas Engineer

February 1, 1956

I N D E X

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We wish to express our appreciation to Mr. M. H. Cullender and Mr. C. W. Binkley, Phillips Petroleum Company, for contributing the basic data and tables for calculating pressure loss due to friction and the method of calculating Static Column Pressures as well as their invaluable counsel and advice.

We also express appreciation to Mr. F. Norman Woodruff, Chairman of the Industry Committee appointed by the Commission to study gas well testing in Southeastern New Mexico, and the following committee members for their invaluable counsel and advice, as well as their willing and effective work in making special well tests and analyzing various material used in this manual:

Mr. W. G. Abott, Amerada Petroleum Corporation
Mr. J. W. Cole, Jr., Gulf Oil Corporation
Mr. H. M. Purkaple, Shell Oil Company
Mr. M. H. Cullender, Phillips Petroleum Company
Mr. C. L. Quast, Sinclair Oil and Gas Company
Mr. Dave Nichols, Southern Union Gas Company
Mr. Max Curry, Buffalo Oil Company
Mr. D. L. Henry, Gulf Oil Corporation
Mr. William Randolph, Continental Oil Company
Mr. Robert E. Cook, Continental Oil Company
Mr. G. L. Tribble, Permian Basin Pipeline Company
Mr. A. M. Wiederkehr, Southern Union Gas Company
Mr. Charlie Cole, El Paso Natural Gas Company
Mr. Fred G. Bernard, El Paso Natural Gas Company
Mr. W. L. Smith, Gulf Oil Corporation
Mr. L. S. Muennink, Southern Union Gas Company
Mr. L. E. Mabe, El Paso Natural Gas Company
Mr. C. W. Binkley, Phillips Petroleum Company
Mr. H. E. Barrett, Permian Basin Pipeline Company
Mr. J. A. Moore, Continental Oil Company

W. B. MACEY, Secretary-Director

ELVIS A. UTZ, Gas Engineer

FOREWORD

The staff of the New Mexico Oil Conservation Commission has prepared this manual as a result of considerable study in cooperation with a committee composed of engineers from the industry.

The purpose of this manual is to assist the gas operators of the State to comply with the Commission's Rules and Regulations, and to standardize gas testing procedure.

W. B. MACEY
Secretary-Director

INTRODUCTION

This manual is written in compliance with Rule 401 of the Commission's Rules and Regulations of January 1, 1953 and Orders R-368-A through R-376-A, inclusive. Rule 401 requires back pressure tests on all gas wells in the State to be filed once each year. Orders R-368-A through R-376-A, inclusive, are proration orders for the designated dry gas pools of Southeast New Mexico. Reference is made to Paragraph (7) of the findings of each of the above-mentioned orders which states:

> (7) That an adequate gas well testing procedure should be adopted as soon as possible so that operators, purchasers and the Commission can determine the fairness and feasibility of an allocation factor for the pool which employs the factors of deliverability, pressure, or any other factor relating to gas well productivity.

RULES OF PROCEDURES
MULTI-POINT BACK PRESSURE TEST FOR
NATURAL GAS WELLS IN STATE
OF NEW MEXICO

The New Mexico Oil Conservation Commission has adopted the following procedure for taking of Back Pressure Tests on gas wells in the State, except those wells in pools where special testing orders are applicable. This procedure has been adopted to standardize back pressure testing and should be followed closely so that the test be acceptable to the Commission's engineering department.

1. If the well being tested has a pipeline connection it should be flowed for at least 24 hours prior to the shut-in period at a rate high enough to clear the well of liquids.

   If the well cannot be cleared of liquids by producing into the pipeline or if the well has no pipeline connection an attempt shall be made to clear the well by blowing to the atmosphere prior to the shut-in period.

2. The well shall be shut-in for 72 hours plus or minus 6 hours. This shut-in pressure shall be considered stabilized unless deadweight readings taken at a lessor period are higher, in which event the highest recorded pressure shall be used as the shut-in pressure.

   In the event liquid accumulation in the wellbore during the shut-in period appreciably effects the surface pressure, appropriate correction of the surface pressure shall be made in order to account for the pressure due to the liquid column. This correction shall be made in the manner shown in examples No. 6 and No. 7 pages 28 and 34.

3. All shut-in and flowing pressure readings shall be taken with a deadweight gauge. The use of spring gauges is not acceptable because of their inaccuracy.

4. The lowest rate of flow on the test shall be at a rate high enough to keep the well clear of liquids.

5. The test shall be run in the increasing flow rate sequence except in the case of high liquid ratio wells where a decreasing flow rate sequence may be used after the increasing sequence method will not give point alignment. When the decreasing sequence method is used, a statement giving the reasons why the use of such method is necessary shall be furnished with the Form C-122.

6. If possible the working wellhead pressure on the low rate of flow should be drawn down at least 5% of the well's shut-in pressure and at least 30% of the well's shut-in pressure on the highest rate of flow. One criterian as to the acceptability of the test shall be a good spread of data points. If data cannot be obtained in accordance with the above provisions an explanation shall be furnished with Form C-122.

7. An orifice meter, critical flow prover, or a positive choke are the only acceptable metering devices. Gas shall not be vented however, except where absolutely necessary.

8. The diameter of the orifice plate in the meter run and the inside diameter of the run should be checked.

9. The meter pens should be checked and verified correct.

10. a. The absolute potential herein referred to shall be the potential as determined from the 24-hour back pressure curve. The 24-hour back pressure curve shall be determined by either of the following means.

(1) The data obtained from at least four flow rates of 20 to 28-hour duration each or;

(2) By the application of the slope of the back pressure curve, as determined from data obtained from at least four flow rates of lesser duration, to the data obtained from a one-point test of 20 to 28 hours duration. Each flow rate of a test taken for the purpose of establishing only the slope of the back pressure curve shall be of approximately the same duration and not less than three hours unless stabilization is obtained in a lesser time. A constant working pressure for a period of one hour shall constitute stabilization. The one-point test referred to above may be a separate one-point test after shut-in or a continuation after the fourth rate of flow of the multi-point test.

This later procedure shall be used when gas is being vented to the atmosphere except that in the case of information tests taken in the process of completing the well, the operator may utilize such method as is necessary to evaluate the well.

b. The slope herein referred to is the exponent (n) in the back pressure equation $Q = C (P_c^2 - P_w^2)^n$ and shall be determined as outlined in example No. 1 page 7.

c. When the back pressure curve cannot be drawn through at least three of the plotted points, the well shall be re-tested. If upon retest a curve cannot be drawn through at least three of the plotted points, an average curve shall be drawn through the points of such test provided, however, that the slope of said curve will not be more than 1.0 nor less than 0.5.

d. If the curve drawn through at least 3 points of the back pressure test has a slope greater than 1.0 or less than 0.5, the well should be retested.

(1) If upon retest the slope of the curve is greater than 1.0, a curve with a slope of 1.0 shall be drawn through the data point corresponding to the highest rate of flow.

(2) If upon retest the slope of the curve is less than 0.5, a curve with a slope of 0.5 shall be drawn through the data point corresponding to the lowest rate of flow.

11. Correction for the compressibility of flowing gas shall be made in accordance with the Simplified Supercompressibility (F_{pv}) tables published by the Commission.

In the event the gas contains carbon dioxide or nitrogen in excess of 2% by volume, the F_{pv} factor shall be determined through use of the appropriate California Natural Gasoline Association (510 W. Sixth Street, Los Angeles 14, California) bulletins TS402 or TS461.

12. Where the static wellhead working pressure reading cannot be obtained due to packer or dual completion said pressure shall be calculated by using the tables in this manual and as shown in example No. 5 page 25.

13. The average Barometric Pressure shall be assumed to be 13.2 psia in Southeastern New Mexico and 12.0 psia in Northwestern New Mexico.

14. Upon completion of the test, all the calculations shall be shown on New Mexico Oil Conservation Commission Form No. C-122 and shall be accompanied by a back pressure curve neatly plotted on equal scale log-log paper of at least 3 inch cycles. Three copies of both the data sheet and back pressure curve shall be mailed to the Commission office in Santa Fe, New Mexico.

CALCULATION EXAMPLE NO. 1

BACK PRESSURE TEST ON A GAS WELL PRODUCING THROUGH THE TUBING WITH CASING PRESSURES AVAILABLE.

Step (1) After filling in the General Data at the top of Form C-122 and Observed Data for each rate of flow on Form C-122, the calculation may begin.

Step (2) Flow Rate Calculations

Formula for calculating orifice meter flow:

$$Q = C \sqrt{(h_w)\ (p_f)} \times F_t \times F_g \times F_{pv}$$

Where:

Q = rate of flow, MCFD @ 15.025 psia. 60°F.

C = basic orifice factor (Flange Taps)

h_w = Differential meter pressure. (inches of water)

p_f = static meter pressure. psia

F_t = flowing temperature factor

F_g = specific gravity factor

F_{pv} = supercompressibility factor

Calculating first rate of flow:

General and observed data.

Barometric Pressure	-	13.2 psia
Gas Gravity	-	.675
Testing Device	-	Meter Run
Type Taps	-	Flange
Meter Run	-	4"
Orifice size	-	1.500"

Observed Field Data and Table Factors

C = 13.99 (Table I Page 38)

h_w = 12.00 in wtr. (Field Data)

p_f = 767.2 psia (Field Data)

F_t = .9868 (Table V Page 42)

F_g = .9427 (Table VI Page 43)

F_{pv} = 1.084 (NMOCC Simplified Supercompressibility Tables)

Substituting above data into formula

$$Q = 13.99 \sqrt{(12.0)\ (767.2)} \times .9868 \times .9427 \times 1.084$$

Q_1 = 1353 MCFD

In like manner the other three flow rates are found to be: (see Form C-122, page 13)

2nd rate - Q_2 = 1838 MCFD

3rd rate - Q_3 = 2031 MCFD

4th rate - Q_4 = 2421 MCFD

Step (3) PRESSURE CALCULATIONS

Since this is a dry gas well and the static wellhead working pressures are measured the liquid column or pressure loss due to friction calculations (P_W) are not necessary.

Data for plotting back pressure curve.

Q vs. $(P_c^2 - P_w^2)$

Where:

Q = rate of flow, MCFD @ 15.025 psia 60°F.

P_c = wellhead shut-in pressure, casing or tubing whichever is higher.

P_w = static wellhead working pressure at the termination of each flow period. (casing if flowing through tubing, tubing if flowing through casing) All squared pressures in thousands.

Then:

	Q MCFD	P_c (Psia)	P_c^2 (Thsnds)	P_w (Psia)	P_w^2 (Thsnds)	$P_c^2 - P_w^2$ (Thsnds)
(1)	1353	999.2	998.4	855.2	731.4	267.0
(2)	1838	999.2	998.4	795.2	632.3	366.1
(3)	2031	999.2	998.4	767.2	588.6	409.8
(4)	2421	999.2	998.4	711.2	505.8	492.6

The above data shall then be plotted on log log paper of at least three inch cycles in accordance with item 10 of the Rules of Procedures. Q shall be plotted on the horizontal axis and ($P_c^2 - P_w^2$) on the vertical axis as shown in the example on page 13.

Enter values of P_c, P_c^2, P_w, P_w^2 and ($P_c^2 - P_w^2$) on Form C-122.

Step (5) Determining the value of slope n of the back pressure curve.

The numerical value of the slope n is the cotangent of the angle formed by the back pressure curve and the horizontal axis of the log log plot.

However, a more convenient and accurate method shall be used to determine the value of n. The difference of the logarithm of two values of Q which are exactly one vertical cycle apart shall be determined in the following manner. (see example on page 13)

Value of Q where curve intersects the ($P_c^2 - P_w^2$) scale exactly one cycle higher than the ($P_c^2 - P_w^2$) value used for Q_1. In this example this value is 2000 (thousands) — Q_2 = 8910; Log Q_2 = 3.949878

Value of Q where curve intersects the lowest convenient value of ($P_c^2 - P_w^2$). In this example this value is 200 (thousands) — Q_1 = 1045; Log Q_1 = 3.019116

Slope n .930762

Rounded off to two decimals the slope n is then .93. This value shall be entered on Form C-122.

Step (6) Determining Absolute Potential

The absolute potential is defined as the calculated rate of flow at the wellhead after flowing for a 24 hour flow period against atmospheric pressure if there were no pressure loss due to friction in the flow string. The rate of flow shall be expressed at New Mexico Oil Conservation Commission base conditions of 15.025 psia and 60° Farenheit. This is sometimes called a wellhead absolute potential.

The error caused in the value of the absolute potential, when atmospheric pressure is ignored in the determination of absolute potential, is insignificant when shut-in pressure is below 100 psia. Because of this fact, atmospheric pressure will not be considered in the following explanations.

The absolute potential shall be determined by plotting the value of $(P_c^2 - P_w^2)$ on the back pressure curve when P_w equals 0 absolute. The absolute potential is read on the Q or horizontal scale of the log log plot directly under the plotted point where the $(P_c^2 - P_w^2)$ value intersects the back pressure curve.

In this example P_c^2 equals 998.4 (thousands). When plotted on the back pressure curve, the value of (AP) the absolute potential is 4670 MCFD. Record this value on Form C-122.

The values of AP and slope n should be checked by substituting test data in the following formula. If a data point does not fall on the curve as drawn, then any convenient value of Q and $(P_c^2 - P_w^2)$ from the curve should be used in the following formula.

$$AP = Q \left[\frac{P_c^2}{(P_c^2 - P_w^2)}\right]^n$$

where:

AP = absolute potential

Q = rate of flow from test data point, or from B. P. curve.

P_c = shut-in pressure psia.

P_w = static wellhead working pressure psia.

Note: Where data is taken from curve $(P_c^2 - P_w^2)$ is read from the Back Pressure Plot.

Substituting values in equation:

$$AP = 2421 \left[\frac{998.4}{(998.4 - 505.8)}\right]^{.93}$$

$$AP = 2421 \ (2.02679)^{.93}$$
$$AP = 2421 \ (1.9288)$$

AP = 4669.6

The Calculation checks the value of 4670 as read from the Back Pressure Curve and is correct.

Form C-122 should be checked for accuracy and to be sure that all necessary data has been filled in. The Form should then be signed and filed in triplicate with the Commission Office, Box 871, Santa Fe, New Mexico.

INSTRUCTIONS

This form is to be used for reporting multi-point back pressure tests on gas wells in the State, except those on which special orders are applicable. Three copies of this form and the back pressure curve shall be filed with the Commission at Box 871, Santa Fe.

The log log paper used for plotting the back pressure curve shall be of at least three inch cycles.

NOMENCLATURE

Q = Actual rate of flow at end of flow period at W. H. working pressure (P_w). MCF/da. @ 15.025 psia and 60° F.

P_c = 72 hour wellhead shut-in casing (or tubing) pressure whichever is greater. psia

P_w = Static wellhead working pressure as determined at the end of flow period. (Casing if flowing thru tubing, tubing if flowing thru casing.) psia

P_t = Flowing wellhead pressure (tubing if flowing through tubing, casing if flowing through casing.) psia

P_f = Meter pressure, psia.

h_w = Differential meter pressure, inches water.

F_g = Gravity correction factor.

F_t = Flowing temperature correction factor.

F_{pv} = Supercompressability factor.

n = Slope of back pressure curve.

Note: If P_w cannot be taken because of manner of completion or condition of well, then P_w must be calculated by adding the pressure drop due to friction within the flow string to P_t.

[illegible] 1

NEW MEXICO OIL CONSERVATION COMMISSION

Form C-122
Revised 12-1-55

MULTI-POINT BACK PRESSURE TEST FOR GAS WELLS

Pool: Eumont | Formation: Queen | County: Lea

Initial: X | Annual: ____ | Special: ____ | Date of Test: 12-1-55

Company: Blowe Gas Company | Lease: H.I. Test | Well No.: 6

Unit: A | Sec.: 36 | Twp.: 22S | Rge.: 35E | Purchaser: Blowe Gas Company

Casing: 5.5 | Wt.: 15.5 | I.D.: 4.950 | Set at: 3573 | Perf.: 3550 | To: 3560

Tubing: 2.375 | Wt.: 4.7 | I.D.: 1.995 | Set at: 3573 | Perf.: None | To: ____

Gas Pay: From 3550 | To 3580 | L 3573 | xG .675 | -GL 2412 | Bar.Press. 13.2

Producing Thru: Casing ____ | Tubing x | Type Well: Single
Single-Bradenhead-G. G. or G.O. Dual

Date of Completion: 6-4-50 | Packer: None | Reservoir Temp.: 130 F.

OBSERVED DATA

Tested Through ~~(Prover)~~ ~~(Choke)~~ (Meter) | Type Taps: Flange

	Flow Data					Tubing Data		Casing Data		
No.	~~(Prover)~~ (Line) Size	~~(Choke)~~ (Orifice) Size	Press. psig	Diff. h_w	Temp. °F.	Press. psig	Temp. °F.	Press. psig	Temp. °F.	Duration of Flow Hr.
SI	4 in.	1.5 in.				986	75	984	75	72 hr. S. I.
1.	"	"	754	12.0	74	754	74	842	75	24
2.	"	"	652	26.0	71	652	72	782	75	24
3.	"	"	598	35.0	71	598	71	754	75	24
4.	"	"	401	77.0	71	401	71	698	75	24
5.	"	"								

FLOW CALCULATIONS

No.	Coefficient (24-Hour)	$\sqrt{h_w p_f}$	Pressure psia	Flow Temp. Factor F_t	Gravity Factor F_g	Compress. Factor F_{pv}	Rate of Flow Q-MCFPD @ 15.025 psia
1.	13.99	95.94	767.2	.9868	.9427	1.084	1353
2.	"	131.49	665.2	.9896	"	1.071	1838
3.	"	146.23	611.2	.9896	"	1.064	2031
4.	"	177.89	414.2	.9896	"	1.043	2421
5.							

PRESSURE CALCULATIONS

Gas Liquid Hydrocarbon Ratio: Dry Gas cf/bbl.
Gravity of Liquid Hydrocarbons ____ deg.
F_c ____ P_w measured ____ $(1-e^{-s})$ ____

Specific Gravity Separator Gas ____
Specific Gravity Flowing Fluid ____
P_c 999.2 P_c^2 998.4

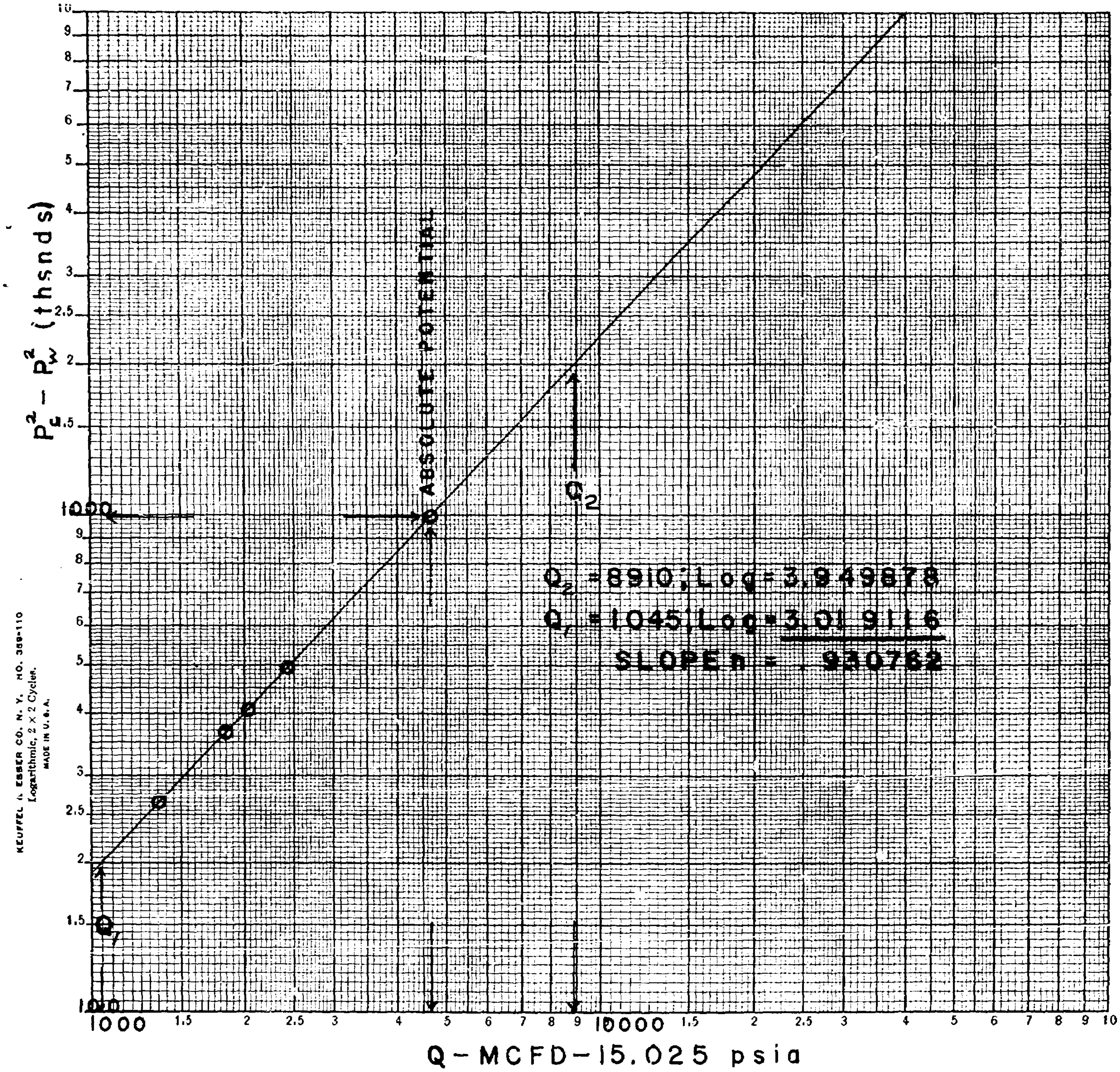
No.	P_w / P_t (psia)	P_t^2	F_cQ	$(F_cQ)^2$	$(F_cQ)^2 (1-e^{-s})$	P_w^2	$P_c^2-P_w^2$	Cal. P_w	$\frac{P_w}{P_c}$
1.	855.2					731.4	267.0		85.6
2.	795.2					632.3	366.1		79.6
3.	767.2					588.6	409.8		76.6
4.	711.2					505.8	492.6		71.2
5.									

Absolute Potential: 4670 MCFPD; n .93

COMPANY: Blowe Gas Company
ADDRESS: 4600 Broadway, Jal, New Mexico
AGENT and TITLE: John Doe, Gas Engineer
WITNESSED: I. M. Goode
COMPANY: North Gas Company

REMARKS

COMPANY	Blowe Gas Company
WELL	H. I. Test No. 6
LOCATION	A 36-22S-35E
COUNTY	Lea
DATE	12-1-55



CALCULATION EXAMPLE NO. 2

BACK PRESSURE TEST ON A HIGH PRESSURE DUALLY COMPLETED GAS WELL PRODUCING THROUGH THE ANNULUS.

This Example will show the method of calculating G_{mix} and static wellhead working pressure when they cannot be measured.

Step (1) After filling in the General Data at the top of Form C-122 and the Observed Data on same Form, the calculations may begin.

Step (2) Flow Rate Calculations

Since this well was tested through an Orifice Meter refer to the procedure for calculating the flow rates in Example 1.

The rates of flow are calculated to be:

1st rate	-	2584 MCFD	or	2.584 M^2CFD
2nd rate	-	3570 MCFD	or	3.570 M^2CFD
3rd rate	-	4859 MCFD	or	4.859 M^2CFD
4th rate	-	6493 MCFD	or	6.493 M^2CFD

Step (3) Pressure Calculations

Since this well is a dual completion the static wellhead working pressure must be calculated. In order to accurately calculate this pressure it is first necessary to determine the gravity of the flowing fluid or the G_{mix}:

G_{mix} calculation.

Formula:

$$G_{mix} = \frac{G_1 + \frac{4591\ (G_2)}{R}}{1 + \frac{1123}{R}}$$

Where:

G_{mix} = specific gravity of flowing fluid (Air = 1.0)

G_1 = specific gravity of separator gas. (Air = 1.0)

G_2 = specific gravity of separator liquid hydrocarbons (water = 1.0)

R = gas-liquid ratio (cu. ft. per bbl.)

Then:

G_1 = .680 from data on Form C-122

G_2 = .6988 from Table IX page 52 .

R = 76,859 from data on Form C-122

Substituting data into formula:

$$G_{mix} = \frac{.680 + \frac{(4591)\ (.6988)}{76,859}}{1 + \frac{1123}{76,859}}$$

G_{mix} = .711

Static Wellhead Working Pressure Calculation: *

Formula:

$$P_w^2 = P_t^2 + (F_c Q)^2 \ (1-e^{-s})$$

Where:

P_w^2 = Static wellhead working pressure, psia squared, expressed in thousands.

P_t^2 = flowing wellhead pressure psia. squared, expressed in thousands.

F_c = Flow string factor Table VII C page 50.

Q = Rate of flow M^2CFD from Form C-122

$(1-e^{-s})$ = GL factor. Table VIII page 48 .

In order to determine the value of F_c and $(1-e^{-s})$ we must first determine:

O.D. of Tubing = 2.375 in.
I.D. of Casing = 4.392 in.
GL = G_{mix} gravity x length of flow string from top of perforations = 3831 ft.

* Tables VII A (Southeast), VII B (Southeast), VII C (Southeast) and VIII (Southeast) are based on average conditions existing in Southeastern New Mexico. For friction loss calculations in San Juan Basin (Northwestern New Mexico) the appropriate tables for that area should be obtained from the Commission.

Taken from Data on Form C-122 for 1st. rate of flow:

P_{t1} = 1691.2 psia

Q_1 = 2.584 M^2CFD

F_c = 1.812 (2.375" OD tubing and 4.892" ID casing from Table VII C page 47.)

$(1-e^{-s})$ = .232 (GL of 3831 from Table VIII page 48.)

Substituting in formula:

$$P_{w1}^2 = (1691.2)^2 + \left[(1.812 \times 2.584)^2 \quad (.232)\right]$$

$$P_{w1}^2 = 2865.08$$

$$P_{w1} = 1692.6$$

Second rate of flow:

P_{t2} = 1610.2

Q_2 = 3.570 M^2CFD

$$P_{w2}^2 = (1610.2)^2 + \left[(1.812 \times 3.570)^2 \quad (.232)\right]$$

$$P_{w2}^2 = 2602.4$$

$$P_w = 1613.2$$

Third rate of flow:

P_{t3} = 1509.2

Q_3 = 4.859 M^2CFD

$$P_{w3}^2 = (1509.2)^2 + \left[(1.812 \times 4.859)^2 \quad (.232)\right]$$

$$P_{w3}^2 = 2296$$

$$P_{w3} = 1515$$

Fourth rate of flow:

P_{t4} = 1340.2

Q_4 = 6.493 M^2CFD

$$P_{w4}^2 = (1340.2)^2 + \left[(1.812 \times 6.493)^2 \quad (.232)\right]$$

$$P_{w4}^2 = 1828.2$$

$$P_{w4} = 1352.1$$

Step (4) Data for Plotting Back Pressure Curve

	Q (MCFD)	P_c (psia)	P_c^2 (Thsnds)	P_w (psia)	P_w^2 (Thsnds)	$P_c^2 - P_w^2$ (Thsnds)
1	2584	1876	3519.0	1692.6	2865.0	654.0
2	3570	1876	3519.0	1613.2	2602.4	916.6
3	4859	1876	3519.0	1515.1	2295.6	1223.4
4	6493	1876	3519.0	1352.1	1828.2	1690.8

The above plotting data should be plotted on log log paper, then the slope of the back pressure curve and the absolute potential determined as explained in Example No. 1 under "Determining the value of slope n" and "Determining absolute potential" respectively.

The slope "n" is determined to be .97.

The absolute potential is read from the log log plot as 13,200 MCFD.

When checking the accuracy of the absolute potential of 13,200 MCFD, as determined from the plot, we calculate this to be 13,219 when using data for the first plotting point and 13,225 when using data for the fourth plotting point. The absolute potential of 13,200 MCFD is therefore considered correct.

The above data should be recorded on Form C-122 under "Pressure Calculations".

The Form C-122 should be checked carefully for accuracy, signed and filed in triplicate with the Commission Office, Box 871, Santa Fe.

INSTRUCTIONS

This form is to be used for reporting multi-point back pressure tests on gas wells in the State, except those on which special orders are applicable. Three copies of this form and the back pressure curve shall be filed with the Commission at Box 871, Santa Fe.

The log log paper used for plotting the back pressure curve shall be of at least three inch cycles.

NOMENCLATURE

Q = Actual rate of flow at end of flow period at W. H. working pressure (P_w). MCF/da. @ 15.025 psia and 60° F.

P_c = 72 hour wellhead shut-in casing (or tubing) pressure whichever is greater. psia

P_w = Static wellhead working pressure as determined at the end of flow period. (Casing if flowing thru tubing, tubing if flowing thru casing.) psia

P_t = Flowing wellhead pressure (tubing if flowing through tubing, casing if flowing through casing.) psia

P_f = Meter pressure, psia.

h_w = Differential meter pressure, inches water.

F_g = Gravity correction factor.

F_t = Flowing temperature correction factor.

F_{pv} = Supercompressability factor.

n = Slope of back pressure curve.

Note: If P_w cannot be taken because of manner of completion or condition of well, then P_w must be calculated by adding the pressure drop due to friction within the flow string to P_t.

EXAMPLE NO. 2

NEW MEXICO OIL CONSERVATION COMMISSION

Form C-122
Revised 12-1-55

MULTI-POINT BACK PRESSURE TEST FOR GAS WELLS

Pool Undesignated Formation Blinebry County Lea

Initial X Annual ______ Special ______ Date of Test 1-31-56

Company Doe Gas Company Lease Deer Well No. 1

Unit C Sec. 10 Twp. 24S Rge. 36E Purchaser American Pipeline Company

Casing O.D. 5½ Wt. 17# I.D. 4.892 Set at 6484 Perf. 5388 To 5494

Tubing 2 3/8 Wt. 4.7# I.D. 1.995 Set at 6469 Perf. 6460 To 6463

Gas Pay: From 5388 To 5494 L 5388 xG mix .711 -GL 3831 Bar.Press. 13.2

Producing Thru: Casing X Tubing ______ Type Well G. O. Dual

Single-Bradenhead-G. G. or G.O. Dual

Date of Completion: 12-15-55 Packer 6410 Reservoir Temp. 110°F

OBSERVED DATA

Tested Through ~~(Prover)~~ ~~(Choke)~~ (Meter) Type Taps Pipe Taps

No.	Flow Data: (Prover) (Line) Size	(Choke) (Orifice) Size	Press. psig	Diff. h_w	Temp. °F.	Tubing Data: Press. psig	Temp. °F.	Casing Data: Press. psig	Temp. °F.	Duration of Flow Hr.
SI	4"	2.50						1863	60	72 hrs.
1.	"	"	459	5.0	70			1678	72	24
2.	"	"	464.8	9.2	63			1597	65	24
3.	"	"	461.4	17.3	66			1496	66	24
4.	"	"	473	29.5	58			1327	60	24
5.										

FLOW CALCULATIONS

No.	Coefficient (24-Hour)	$\sqrt{h_w P_f}$	Pressure psia	Flow Temp. Factor F_t	Gravity Factor F_g	Compress. Factor F_{pv}	Rate of Flow Q-MCFPD @ 15.025 psia
1.	54.44	48.58		.9905	.9393	1.050	2584
2.	"	66.31		.9971	"	1.056	3570
3.	"	90.65		.9943	"	1.054	4859
4.	"	119.78		1.0019	"	1.058	6493
5.							

PRESSURE CALCULATIONS

Gas Liquid Hydrocarbon Ratio 76,859 cf/bbl.
Gravity of Liquid Hydrocarbons 71° deg.
F_c 1.812 $(1-e^{-s})$ .232

Specific Gravity Separator Gas .680
Specific Gravity Flowing Fluid .711
P_c 1876 P_c^2 3519

No.	P_w P_t (psia)	P_t^2	F_cQ	$(F_cQ)^2$	$(F_cQ)^2 (1-e^{-s})$	P_w^2	$P_c^2-P_w^2$	Cal. P_w	$\frac{P_w}{P_c}$
1.	1691.2	2860	4.682	21.92	5.09	2865	654	1692.6	90.2
2.	1610.2	2593	6.468	41.83	9.71	2602.4	916.6	1613.2	85.9
3.	1509.2	2277	8.804	77.51	17.98	2295.6	1223.4	1515.1	80.7
4.	1340.2	1796	11.77	138.53	32.11	1828.2	1690.8	1352.1	72.0
5.									

Absolute Potential: 13,200 MCFPD; n .97

COMPANY Doe Gas Company

ADDRESS 9670 Main Street, Hobbs, New Mexico

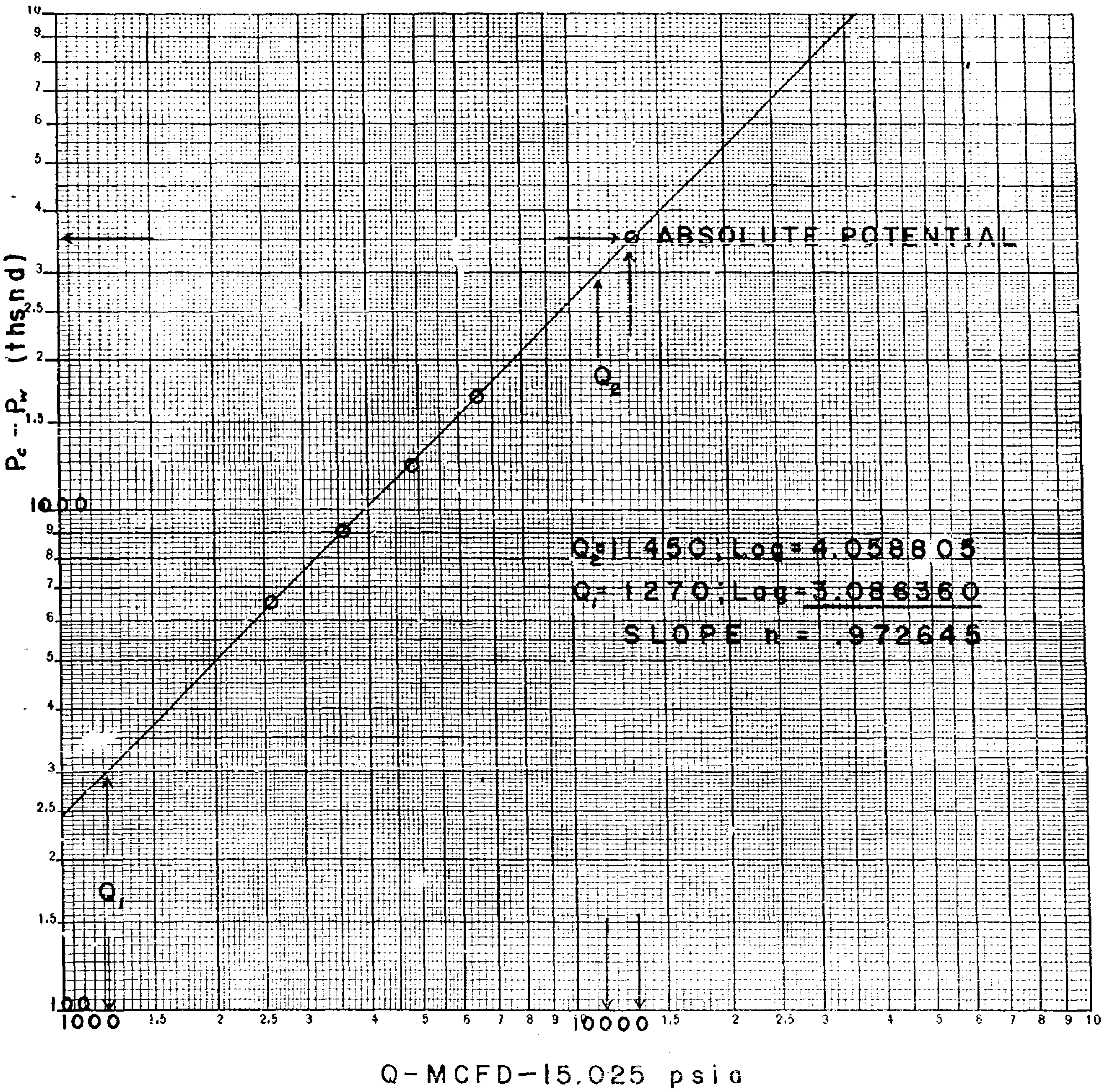
AGENT and TITLE I. M. Lowe, Gas Engineer

WITNESSED J. R. Neal

COMPANY Best Oil Company

REMARKS

COMPANY	Doe Gas Company
WELL	Deer No. 1
LOCATION	C-10-24S-36E
COUNTY	Lea
DATE	1-31-56



PROCEDURES TO FOLLOW FOR WELLS COMPLETED IN MANNERS OTHER THAN THOSE CONSIDERED IN EXAMPLE NO. 1 AND 2.

I. A single completion producing through the tubing but where P_w cannot be measured due to packer, no pressure connection on casing, etc.

Follow the procedures of Example No. 1, steps 1, 2, 5 and 6.

Since P_w cannot be measured we will use the procedure of step 3, Example No. 2 to complete the calculation. The value of F_c used will be for the proper size tubing from Table VII A page 44 .

If the well produced dry gas the G_{mix} calculation shown in this example shall be eliminated and the actual measured gravity of the flowing gas used in its place.

II. A single Completion with no tubing in well.

Follow the procedures of Example 2, steps 1 through 4. The procedure of step 4 is changed only in that the F_c factor is determined for the proper size casing from Table VII B.

If the well produces dry gas the G_{mix} calculation shown in step 3 of this Example shall be eliminated and the actual measured gravity of the flowing gas used in its place.

III. Bradenhead well (a well producing gas from exposed zones in the annular area between the outside of the production casing and the well-bore or outside of the production string and inside the intermediate or surface casing.)

The wells where flow is for the most part between the outside of the production casing and the well bore (i.e., no intermediate casing in well), no attempt shall be made to calculate the pressure drop due to friction. The value of P_t shall be used in place of P_w in plotting the Back Pressure curve.

The wells where flow is mostly from the annular area between the outside of the production string and the inside of the intermediate string, the procedure shall be the same as used in Example No. 2, step 3. The friction loss shall be calculated only for flow between the two strings of casing and any loss due to flow between the production casing and the well bore shall be ignored.

IV. Dual Completions with two paralled tubing strings.

(a) Where P_w can be measured use procedures in Example No. 1.

(b) Where P_w cannot be measured use the procedures outlined in I above for that particular tubing size.

EXAMPLE NO. 3

VOLUME CALCULATIONS FOR FLOW THROUGH ORIFICE METER, CRITICAL FLOW PROVER AND POSITIVE CHOKES.

Orifice Meter

Refer to flow calculations in Example No. 1, Page 7.

CRITICAL FLOW PROVER
(Two and Four Inch)

Formula:

$Q = C \times P_t \times F_t \times F_g \times F_{pv}$

where:

Q = Rate of flow MCFD, 15.025 psia 60° F.

C = Coefficient of orifice plate.

P_t = Flowing gas pressure on prover psia.

F_t = Flowing gas temperature factor.

F_g = Flowing gas gravity factor

F_{pv} = Supercompressibility factor

Observed data:

2" critical flow prover - 1/2" plate
Pressure of flowing gas on prover - 915 psig
Temperature of flowing gas - 70°F
Gravity of flowing gas - .675
Barometric pressure - 13.2 psia

Determining values of factors for formula:

C = 5.523 Table III, page 40.

P_t = 928.2 psia from observed data.

F_t = .9905 Table V, page 42.

F_g = .9427 Table VI, page 43.

F_{pv} = 1.104 New Mexico Oil Conservation Commission. Simplified Supercompressibility Tables. (915 psig, .675 gravity and 70°F.)

P_f = Bottom Pressure psia

P_c = Adjusted wellhead pressure psia

G = Specific gravity of gas column (air = 1.00)

H = Length of gas column to datum point.

I_1 = Value of I where H = 6000 ft.

I_2 = Value of I where H = 3000 ft.

I_3 = Value of I where H = 0 ft.

Then:

$$P_c = 1955 - \frac{3\ (163.122)}{.241227 + 4\ (.237020) + .234578}$$

$$P_c = 1955 - 343.7$$

$$P_c = 1611.3 \text{ or } 1611 \text{ psia}$$

$$\frac{163.122 - 81.561}{.478035} = 170.6$$

14. Since this value is more than .5 psia different than the first trial value of M we must enter this value on Line 6, Column 10 and repeat steps 8, the $\frac{TZ}{P_n}$ part of 10, 11, 12 and 13.

then:

$P_n = 1784.4$

$\frac{TZ}{P_n} = .237020$

$N = .478247$

$(M \times N) = 81.589$

$\Sigma(M \times N) = 81.533$

and:

Check value of M = 170.5

Since the check value of M is different than the trial value of M by only .1 psia the second trial value of M (170.5) and the second trial value of P_n (1784.4) is considered correct.

15. Enter depth at which next pressure is to be calculated (zero wellhead) on Line 7, Column 1.

16. The value of .0375 GH is now 0. Enter on Line 7, Column 14.

17. Determine the first trial value of the pressure due to the weight of the gas column from 3000 to wellhead (0).

$$\frac{\Sigma(M \times N) \text{ @ 3000 ft.} - .0375 \text{ GH @ 0 ft}}{N \text{ @ 3000 ft.}} = \text{First Trial M @ 0 ft.}$$

$$\frac{81.533 - 0}{.478247} = 170.5 \text{ psia}$$

Enter on Line 7, Column 10.

18. Determine first trial value of pressure at wellhead.

P_n @ 3000 ft. - M @ 0 ft. = P_n @ 0 ft.

1784.4 - 170.5 = 1613.9 psia

19. Enter wellhead absolute temperature on Line 7, Column 4.

20. Determine P_r, T_r, F_{pv}, Z, TZ, and $\frac{TZ}{P}$ for 0 ft.

$P_r = 2.42$; $T_r = 1.36$; $F_{pv} = 1.195$; $Z = .700$;

$TZ = 378.00$; $\frac{TZ}{P} = .234215$

Enter on Line 7, Column 3, 5, 6, 7, 8 and 9 respectively.

21. Determine value of N @ 0 ft.

I @ 3000 ft. + trial I @ 0 ft. = trial N @ 0 ft.

.237020 + .234215 = .471235

Enter on Line 7, Column 11.

22. Determine M x N @ 0 ft.

Trial M @ 0 ft. x Trial N @ 0 ft. = Trial M x N @ 0 ft.

170.5 x .471235 = 80.346

Enter on Line 7, Column 12.

23. Determine $\Sigma(M \times N)$ @ 0 ft.

$\Sigma(M \times N)$ @ 3000 ft. - trial M x N @ 0 ft. = Trial $\Sigma(M \times N)$ @ 0 ft.

81.533 - 80.346 = 1.187

Column 13 is not equal to Column 14 so a check must be made to determine how close we are to the proper value of M @ 0 ft. The check is made as in step 13 above.

$$\frac{81.533 - 0}{.471235} = \text{Check value of M} = 173.0$$

24. Since the check value of M is different than the first trial value of M by 2.5 psia we must enter this value on Line 8, Column 10 and repeat steps 18, the $\frac{TZ}{P}$ part of 20, 21, 22, and 23 until Column 13 is as close to Column 14 as possible.

$\frac{TZ}{P}$ = .234578

N = .471598

M x N = 81.586

$\Sigma(M \times N)$ = .053

Check value of M = 172.8

Since the check value of M is different from the second trial value by only .2 psia the second trial value of M (173.0) and the second trial value of P_n (1611.4) is considered correct.

25. Now that the proper values of P_n for 6000, 3000 and 0 ft. have been determined we can calculate the adjusted wellhead pressure by using the following formula:

$$P_c = P_f - 2\Delta P$$

where:

$$2\Delta P = \frac{3\ (.0375\ GH)\ @\ 6000\ ft.}{I_1 + 4I_2 + I_3}$$

8. Determine first trial value of pressure at mid-point of gas column.

P_n @ 6000 ft - Trial M = Trial P_n @ 3000 ft.
1955 - 169 = 1786 psia.

Enter on Line 5, Column 2.

9. Determine the average absolute temperature at mid-column.

$$\frac{540 + 600}{2} = 570\ ^oR$$

Enter on Line 5, Column 4.

10. Determine values of P_r, T_r, F_{pv}, Z, TZ and $\frac{TZ}{P_n}$ for 3000 ft. and enter on line 5, Columns 3, 5, 6, 7, 8 and 9 as shown in step 3 above.

P_r = 2.67; T_r = 1.43; F_{pv} = 1.161; Z = .742; TZ = 422.94;

$$\frac{TZ}{P_n} = .236808$$

11. Determine value of N @ 3000 ft.

I @ 6000 ft + trial I @ 3000 ft. = trial N @ 3000 ft.

.241227 + .236808 = .478035

Enter on Line 5, Column 11.

12. Determine trial value of M x N @ 3000 ft.

169.0 x .478035 = 80.788

Enter on Line 5, Column 12.

13. Determine trial value of Σ(M x N) @ 3000 ft.

Σ(M x N) @ 6000 ft. - Trial (M x N) @ 3000 ft. =

Trial (M x N) @ 3000 ft.

163.122 - 80.788 = 82.334

Enter on Line 5, Column 13.

When column 13 is equal to Column 14 the proper value of P_n @ 3000 has been determined. A check must be made by determining the value of the pressure due to the weight of the column of gas from 3000 ft. to 6000 ft. as follows:

Σ(M x N) @ 6000 ft. - .0375 GH @ 3000 ft. = Check value of M @ 3000 ft.

Using "Calculation Sheet for static column pressures" shown with Example of Appendix C, Case II.

1. The values of G, P_{cr}, and T_{cr} will be the same as shown for Case I, (Appendix C).

2. Enter length of column (H), Formation Pressure (P_n) and absolute formation temperature T on Line 4, Columns 1, 2 and 4, respectively.

3. Determine P_r, T_r, F_{pv}, Z, TZ and $\frac{TZ}{P_n}$ or I and enter on line 4, Columns 3, 5, 6, 7, 8 and 9 respectively.

$$P_r = \frac{P_n}{P_{cr}} = \frac{1955}{668} = 2.93$$

$$T_r = \frac{T}{T_{cr}} = \frac{600}{398} = 1.51$$

$$F_{pv} = 1.128 \text{ CNGA TS - 461, Table V.}$$

$$Z = \frac{1}{(F_{pv})^2} = \frac{1}{1.272} = .786$$

$$TZ = 600 \times .786 = 471.600$$

$$\frac{TZ}{P_n} = \frac{471.600}{1955} = .241227$$

4. Determine value of .0375 GH. for 6000 ft.

$$.0375 \times .725 \times 6000 = 163.122$$

Enter on Line 4, Columns 13 and 14.

5. Enter H (1/2 of total depth) on Line 5, Column 1.

$$\frac{6000}{2} = 3000 \text{ ft.} = H$$

6. Determine value of .0375 GH @ 3000 ft.

$$.0375 \text{ GH} \times .725 \times 3000 = 81.561$$

Enter on Line 5, Column 14.

7. Determine first trial value of the weight of the lower half of the gas column (from 3000 to 6000 ft.)

$$\frac{\frac{.0375 \text{ GH @ 3000 ft.}}{2}}{\frac{TZ}{P_n}} = \frac{40.780}{.241227} = 169.0$$

Enter on Line 5, Column 10.

APPENDIX D

DETERMINING THE ADJUSTED WELLHEAD SHUT-IN PRESSURE ON GAS WELLS WITH LIQUID COLUMNS IN WELLBORE UNDER STATIC CONDITIONS.

In some cases, the observed wellhead shut-in pressure of a gas well is effected by accumulated liquids in the wellbore and will not reflect the true conditions of the well. When the height of the liquid column and the specific gravity of the liquids are known, the formation (Bottom Hole) pressure may be determined by calculating the pressure at the gas-liquid interface as explained in Example No. 6 and adding to this figure the weight of the liquid column above the desired datum plane.

When it is necessary to determine the wellhead pressure which would exist if the liquid column were not present, the formation pressure determined as explained above may be used to calculate an adjusted wellhead pressure based on the assumption that no liquid column exists. The following example explains the same method and procedure as shown in Appendix C, except that it is used to determine wellhead pressure from a known bottom hole pressure while Appendix C shows the procedure for determining bottom hole pressure when the wellhead pressure is known.

Observed data:

H = 6000 ft. (Length of wellbore to datum point. Datum Point used shall be that determined by the Commission)

G_1 = .725 (Gravity of Gas, Air = 1.00)

G_2 = .7389 (Specific gravity (water = 1.00)60° API, Table IX, Page 52 .)

h = 1200 ft. (Length of Liquid Column in wellbore above Datum)

Wellhead Temperature = 540 °R

Formation Temperature = 600 °R

1 ft. of water = .4333 psia.

Weight of liquid column expressed as psia.

$$\text{psia} = h \times G_2 \times .4333$$

$$\text{psia} = 1200 \times .7389 \times .4333 = 384.2$$

Pressure at gas-liquid interface as determined in Appendix C	= 1571 psia
Pressure of liquid column	= 384 "
Formation Pressure (P_f @ 6000 ft.)	1955 psia

Since we desire the adjusted wellhead pressure and we have the Formation pressure at the well datum point we must calculate the pressure due to the weight of the column of gas by beginning with datum point conditions.

CALCULATION SHEET FOR STATIC COLUMN PRESSURES

COMPANY ______________ LEASE ______________ WELL NO. ______________ DATE ______________

G= .725 %CO_2= 0 %N= 0 Cr. Pressure (P_{cr})= 668 Cr. Temp. (T_{cr})= 398 .0375G = .027187

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
			P_r		T_r		Z		I	M	N			
	H	P_n	$\frac{P_n}{P_{cr}}$	T	$\frac{T}{T_{cr}}$	F_{pv}	$\frac{1}{(F_{pv})^2}$	TZ	$\frac{TZ}{P_n}$	$P_n P_{n-1}$	$I_n - I_{n-1}$	M x N	$\Sigma(MxN)$	.0375GH
							CASE I (Wellhead to Gas-Liquid Interface)							
1	0	1350	2.02	540	1.36	1.165	.737	397.98	.294800				0	0
2	2400	1460.7	2.18	564	1.42	1.143	.765	431.46	.295318	110.7	.590118	65.348	65.348	65.249
3	4800	1571.1	2.35	588	1.48	1.124	.791	465.11	.296040	110.4	.591358	65.285	130.633	130.497
							CASE II (Datum Point to Wellhead)							
4	6000	1955	2.93	600	1.51	1.128	.786	471.60	.241227				163.122	163.122
5	3000	1786	2.67	570	1.43	1.161	.742	422.93	.236808	169.0	.478035	80.788	82.334	81.561
6	3000	1784.4	"	"	"	"	"	"	.237020	170.6	.478247	41.589	81.533	"
7	0	1613.9	2.42	540	1.36	1.195	.700	378.00	.234215	170.5	.471235	80.346	1.187	0
8	0	1611.4	"	"	"	"	"	"	.234578	173.0	.471598	81.586	.053	

CASE I

$$2\ \Delta P = \frac{3\ (.0375\ GH)}{I_1 + 4I_2 + I_3} = \frac{3\ (130.487)}{.294800 + 4\ (.295318) + .296040}$$

$= 220.9$

$P_f = 1350 + 220.9 = 1570.9$

CASE II

$$2\ \Delta P = \frac{3\ (.0375\ GH)}{I_1 + 4I_2 + I_3} = \frac{3\ (163.122)}{.241227 + 4\ (.237020) + .234578}$$

$= 343.7$

$P_c = 1955 - 343.7 = 1611.3$

until Column 13 is as near equal to Column 14 as possible.

29. Determine Pressure at Total Depth (4800 ft.)

Now that the proper values of P_n for 2400 and 4800 ft. have been determined we can calculate the pressure at 4800 ft. by the following formula.

$$P_f = P_c + 2 \Delta P$$

where: $$2 \Delta P = \frac{3\ (.0375\ GH)\ @\ 4800\ ft.}{I_1 + 4I_2 + I_3}$$

P_f = Bottom Hole Pressure psia.

P_c = Wellhead shut-in pressure. psia.

G = Specific gravity of gas. (Air = 1.0)

H = Length of gas column to gas liquid inter-face.

I_1 = Value of I where H = 0 ft.

I_2 = Value of I where H = 2400 ft.

I_3 = Value of I where H = 4800 ft.

then:

$$P_f = 1350 + \frac{3\ (130.497)}{.294800 + 4\ (.295318) + .296040}$$

$$P_f = 1350 + 220.92$$

$$P_f = 1570.92 \text{ or } 1571 \text{ psia}$$

$1460.7 + 110.4 = 1571.1$ psia

Enter on Line 3, Column 2.

24. Enter absolute bottom hole temperature at 4800 ft.

$128 + 460\ R^{o} = 588\ R^{o}$

Enter on Line 3, Column 4.

25. Determine values of P_r, T_r, F_{pv}, Z, TZ and $\frac{TZ}{P_n}$ at 4800 ft. as shown in steps 5, 7, 8, 9, 10 and 11.

$P_r = 2.35$, $T_r = 1.48$, $F_{pv} = 1.124$, $Z = .791$, TZ -465.11, $\frac{TZ}{P_n}$ or I= .296040.

Enter on Line 3, Columns 3, 5, 6, 7, 8 and 9, respectively.

26. Determine trial value of N for 4800 ft.

I @ 2400 + trial I @ 4800 ft. = trial N @ 4800 ft.

$.295318 + .296040 = .591358$

Enter on Line 3, Column 11.

27. Determine Trial M x N @ 4800 ft.

Trial M @ 4800 ft. x trial N @ 4800 = trial M x N @ 4800 ft.

$110.4 \times .591358 = 65.285$

28. Determine trial value of Σ(M x N) 4800 ft.

Σ(M x N) @ 2400 ft. + Trial M x N @ 4800 ft. =Trial Σ(M x N) at 4800 ft. $65.348 + 65.285 = 130.633$

Enter on Line 3, Column 13.

When column 13 is equal to column 14 the proper value of P_n @ 4800 ft. has been determined. A check must be made by determining again the value of the weight of the column of gas @ 4800 ft. as in step 22, except that the value of N is the trial value @ 4800 ft.

$$\frac{.0375\ GH\ @\ 4800\ ft. - \Sigma(M \times N)\ @\ 2400\ ft.}{Trial\ N\ @\ 4800\ ft.} = 110.16$$

Since this value is only .24 psi less than the trial M @ 4800 ft. of 110.4 we shall consider 110.4 as correct and the value of P_{n1} (1571.1) on line 3, column 2, as correct. If the value of M in this check had been different than 110.4 by more than .5 psi., then we would have entered this value on line 4, column 10 and repeat steps 22, 23, the $\frac{TZ}{P_n}$ of 25, 26, 27, and 28

P_r = 2.18, T_r = 1.42, F_{pv} = 1.143, Z = .765.

$$TZ = 431.46 \text{ and } \frac{TZ}{P_n} \text{ or } I = .295318$$

Enter on Line 2, Columns 3, 5, 6, 7, 8 and 9, respectively.

18. Determine value of N.

I @ 0 ft. + trial I @ 2400 ft. = Trial N @ 2400 ft.

.29480 + .295318 = .590118

Enter on Line 2, Column 11.

19. Determine value of M x N.

M x N = MN

110.7 x .590118 = 65.348

Enter on Line 2, Column 12 and 13.

When Column 13 is equal to Column 14 then the proper value of P_n @ 2400 ft. has been determined. A check should be made by dividing column 14 by column 11, as follows:

$$\frac{.0375\ GH}{N} = \frac{65.249}{.590118} = 110.57$$

Since this value is only .13 psi less 110.7 we shall consider 110.7 as correct. If the value of M in this check had been different than 110.7 by more than .5 psi. then we would have entered this value on line 3, column 10 and repeated steps 15 through 19 until column 13 was as close to column 14 as possible.

20. Enter total depth for which pressure is being calculated on line 3, column 1.

21. Determine value of .0375 GH as in step 13.

.0375 GH = 130.497

22. Determine trial value of the weight of the gas column (M) at this depth. (4800 ft.)

$$\frac{.0375\ GH - \Sigma(MxN) \ @\ 2400 \text{ ft.}}{N \ @\ 2400 \text{ ft.}} = \text{Trial (M) @ 4800 ft.}$$

$$\frac{130.497 - 65.348}{.590118} = 110.40$$

Enter on Line 3, Column 10.

23. Determine trial value of pressure at desired depth of 4800 ft.

(P_n) at 2400 ft. + trial (M) @ 4800 ft. = trial ($P_{n'}$) @ 4800 ft.

9. From F_{pv} determine Z factor.

$$\frac{1}{(F_{pv})^2} = \frac{1}{(1.165)^2} = .737$$

Enter on Line 1, Column 7.

10. Determine value of TZ.

$$540 \times .737 = 397.98$$

Enter on Line 1, Column 8.

11. Determine value of $\frac{TZ}{P_n}$.

$$\frac{TZ}{P_n} = \frac{397.98}{1350} = .29480$$

Enter on Line 1, Column 9.

12. H is the length of the static gas column being evaluated in each step of the calculation (see page 71).

Enter H (1/2 of total depth) for which the pressure is being determined on Line 2, Column 1.

13. Determine value of .0375 GH.

$$.0375 \times .725 \times 2400 = 65.249$$

Enter on Line 2, Column 14.

14. Determine first trial value of weight of gas column at midpoint of gas column.

$$\frac{\frac{.0375GH}{2}}{\frac{TZ}{P_n}} = \frac{\frac{65.249}{2}}{.29480} = 110.66 \text{ or } 110.7$$

Enter on Line 2, Column 10.

15. Determine first trial value of pressure at midpoint of gas column.

$$1350 + 110.7 = 1460.7 \text{ psia}$$

Enter on Line 2, Column 2.

16. Determine the average absolute temperature between the wellhead and Bottom Hole.

$$\frac{80 + 128}{2} + 460\ R^{o} = 564\ {}^{o}R \text{ (Rankine)}$$

Enter on Line 2, Column 4.

17. Determine values of P_r, T_r, F_{pv}, Z, TZ and $\frac{TZ}{P_n}$ as shown in steps 5, 7, 8, 9, 10 and 11.

APPENDIX C

DETERMINING STATIC COLUMN PRESSURES IN GAS WELLS

The determination of subsurface static column pressures by the "Two Step" Simpson's Rule may be accomplished through the use of the following procedure and the "Calculation Sheet for Static Column Pressures".

Observed data:

Specific Gravity of Gas	.725 (Air= 1.00)
Measured Wellhead Pressure	1350 psia
% CO_2	0
% N	0
Wellhead Temperature	80°F
Reservoir Temperature	128°F

Using "Calculation Sheet for Static Column Pressures", Case I.

1. Enter specific gravity (G) and composition of gas at top of calculation sheet.

2. Determine critical pressure (P_{cr}) and critical temperature (T_{cr}).

   P_{cr} = 668 — CNGA TS-461, Table I.

   T_{cr} = 398 — CNGA TS-461, Table I.

If gas contains carbon dioxide or nitrogen P_{cr} and T_{cr} should be corrected at this time by using Table II of CNGA TS 461. Enter these values at top of Calculation Sheet.

3. Enter initial depth (zero wellhead) on Line 1, Column 1.

4. Enter wellhead pressure (P_n) on Line 1, Column 2. (1350 psia)

5. Determine reduced pressure. (P_r)

   $$\frac{P_n}{P_{cr}} = \frac{1350}{668} = 2.02 = P_r$$

   Enter on Line 1, Column 3.

6. Enter Wellhead Temperature (absolute) on Line 1, Column 4.

7. Determine reduced temperature. (T_r)

   $$\frac{T}{T_{cr}} = \frac{540}{398} = 1.36$$

   Enter on Line 1, Column 5.

8. Using P_r and T_r determined supercompressibility factor (F_{pv})

   F_{pv} = 1.165 (AGA-TS-461 Table V)

   Enter on Line 1, Column 6.

CALCULATION SHEET FOR STATIC COLUMN PRESSURES

COMPANY________ LEASE________ WELL NO.________ DATE________

G 0.850 %CO_2 28 %N________ Cr. Press. 788 Cr. Temp. 393

H	P_n	P_r	T	T_r	Z	TZ	I TZ/P	M P_n-P_{n-1}	N I_n+I_{n-1}	MxN	(MxN)	0.0375 x GH
0	4465	5.67	564	1.44	0.821	463.044	.103705				0	0
6574	5478	6.95	608	1.55	0.930	565.44	.103220	1013	.206925	209.615	209.615	209.546
13148	6495	8.24	652	1.66	1.024	667.648	.102794	1017	.206014	209.516	419.131	419.093

By Simpson's Rule

$$\frac{2\ P}{3}(0.103705 + 4(0.103220) + 0.102794) = 419.093$$

$$2\ P = 2030$$

$$P_s = P_w + 2\ P$$

$$P_s = 6495$$

Note: Although in this particular case there is no difference in the values determined for P_s before and after the application of Simpson's Rule; there is usually some difference between the two values and the final value is considered to be more nearly correct.

CASE III

Numerical Evaluation of the Definite Integral $\int_{P_c}^{P_f} \frac{TZ}{P} d(P)$ by Two Equal Intervals and Simpson's Rule

Then:

$Q = 5.523 \times 928.2 \times .9905 \times .9427 \times 1.104$

$Q = 5285,$ MCFD

Positive Chokes

(Including Thornhill-Craver positive flow-beans)

Formula:

$Q = C \times P_t \times F_t \times F_g \times F_{pv}$

where:

Q = Rate of flow MCFD, 15.025 psia, 60°F.

C = Positive choke coefficient.

P_t = Pressure of flowing gas on choke, psia.

F_t = Flowing gas temperature factor.

F_g = Flowing gas gravity factor.

F_{pv} = Supercompressibility factor of flowing gas.

Observed data:

Positive choke size - 13/64 in.
Pressure of flowing gas on prover - 915 psig.
Temperature of flowing gas - 70°F
Gravity of flowing gas - .675 (Air = 1.0)
Barometric Pressure - 13.2 psia

Determining factors for formula:

C = .8731 Table IV page 41.
Column (1) for Thornhill-Craver chokes.

P_t = 928.2 psia from observed data.

F_t = .9905 Table V page 42.

F_g = .9427 Table VI, page 43.

F_{pv} = 1.104 New Mexico Oil Conservation Commission Simplified Supercompressibility tables. .675 gravity, 915 psig, 70°F.

Then:

$Q = .8731 \times 928.2 \times .9905 \times .9427 \times 1.104$

$Q = 835$ MCFD

EXAMPLE NO. 4

PROCEDURE FOR DETERMINING THE GRAVITY OF FLOWING WET GAS IN THE FLOW STRING.

In cases where the gravity of flowing wet gas is not known this procedure may be used to determine the gravity.

When this method is used we must know the

(1) Specific gravity of the separator gas,

(2) The specific, or A.P.I. gravity of the separator Hydrocarbon Liquids, and

(3) The Gas-Liquid ratio.

If only the A.P.I. gravity of the separator liquids is known we must determine the specific gravity by referring to Table IX, Page 52, or by calculating using the following equation:

$$\text{Specific gravity} = \frac{141.5}{131.5 + \text{Degrees A.P.I.}}$$

The specific gravity may then be calculated as follows:

Formula:

$$\text{Flowing wet gas gravity} = \frac{G_1 + \frac{4591\ G_2}{R}}{1 + \frac{1123}{R}}$$

Where:

G_1 = Separator gas specific gravity. (Air = 1.00)

G_2 = Separator Hydrocarbon Liquid Specific gravity. (Water = 1.0)

R = Gas - Liquid Ratio. (cu. ft./bbl.)

and

G_1 = .680

G_2 = .6988 for 71° A.P.I.

R = 76,859 cu. ft./bbl.

Substituting values in formula:

$$\text{Flowing Gravity of wet gas } (G_{mix}) = \frac{.680 + \frac{(4591)(.6988)}{76,859}}{1 + \frac{1123}{76,859}}$$

EXAMPLE NO. 5

METHOD OF DETERMINING PRESSURE LOSS DUE TO FRICTION IN FLOW STRINGS FOR GAS WELLS.

Nomenclature

Q	=	M^2cfd @ 15.025 psia and 60°F.
P_c	=	Shut-in wellhead pressure, psia.
P_w	=	Static wellhead working pressure, psia
P_t	=	Flowing wellhead pressure, psia
F_c	=	Factor dependent upon size of flow string, pressure base, temperature and compressibility factor. (See Tables VII A, B and C of F_c values)
$(1-e^{-s})$	=	Factor dependent upon GL, temperature and compressibility factor. (See Table VIII of $(1-e^{-s})$. values)
G	=	Specific gravity (Air = 1.00)
L	=	Length of flowing gas column, ft.

Procedure

1. From the Table VII A, B or C, obtain the value of F_c corresponding to the internal diameter of the pipe.
2. From the Table VIII, obtain the value of $(1-e^{-s})$ corresponding to the value of GL.
3. From the test data, obtain the rate of flow (Q) and the corresponding flowing pressure. (P_t)
4. Multiply F_c (Table VII A, B or C value) times Q.
5. Square the term F_cQ.
6. Multiply $(F_cQ)^2$ by $(1-e^{-s})$ (Table VIII value)
7. Add the value of $(F_cQ)^2$ $(1-e^{-s})$ to P_t^2 to obtain P_w^2.
8. Extract square root of P_w^2 to obtain P_w.

Calculations

Test data from Form C-122 (revised 12-1-55) necessary for P_w calculation.

1. 1.995" = Size of Flow String I.D. (If not known I. D. may be determined from Table VII A by referring to O.D. and #/ft. columns.)

2. L = 4000'= Length of Flowing String (If lower sections of tubing is perforated, the top of the perforations shall determine L. Where the flow is through the casing and casing is set above the producing formation the casing shoe shall determine L. Where flow is through casing and casing is set through the producing formation and slotted or perforated the top of the perforations shall determine L.)

3. G = .651 = Specific Gravity of Flowing Gas (Air = 1.0.)

4. P_t = 835 psia = Wellhead flowing tubing or casing pressure.

5. Q = 2.500 M^2CF = Rate of Flow (Volume shown under "Flow Calculations" expressed in million cu. ft. per day.)

Begin calculation as follows:

6. Determine Table VII A Value (F_c) for 1.995 Tubing. This is 9.936. Show this value in space provided for friction calculations on Form C-122.

7. Multiply G x L; GL = 2604, shown at top of Form C-122.

8. Determine Table VIII value ($1-e^{-s}$) for GL of 2604. This is .164. Show this value in space provided for "Pressure Calculations" Form C-122.

9. Multiply Table VII A value 9.936 (F_c) by 2.500 (Q) and square the product. $(9.936 \times 2.500)^2 = 617.0$ (thousands).

10. Multiply 617.0 by Table VIII value of .164 ($1-e^{-s}$). $617.0 \times .164 = 101.2$ (thousands).

11. Square 835 (P_t); $(835)^2 = 697.2$ (thousands). Item 4 above from Form C-122.

12. Add 697.2 $(P_t)^2$ to 101.2 $(F_cQ^2)(1-e^{-s})$ and extract the square root of the sum.
$697.2 + 101.2 = 798.4$ (thousands).

$(798.4)^{.5} = 893.5 = P_w$ (Calculated static wellhead working pressure).

13. This is the P_w to be used in the $(P_c^2 - P_w^2)$ calculation when P_w cannot be measured accurately because of dual completion, liquids in well-bore and etc.

14. The above data should be entered in the space provided under Pressure Calculations on Form C-122.

15. The simplified formula for the above calculation is:

$$P_w = \left(P_t^2 + \left[(F_c Q)^2 \quad (1-e^{-s})\right]\right)^{.5}$$

EXAMPLE NO. 6

DETERMINING STATIC COLUMN PRESSURES IN GAS WELLS

The determination of subsurface static column pressures shall be accomplished through the use of the following procedure and the "Calculation Sheet for Static Column Pressures". *

Observed data:

Specific gravity of gas	.725 (Air = 1.0)
Measured Wellhead Pressure	1350 Psia
% CO_2	0
% N	0
Wellhead temperature	80° F (540° Rankine)
Reservoir Temperature	128° F (588° Rankine)

Using the "Calculation Sheet for Static Column Pressures", Case I.

1. Enter specific gravity of gas (G) and the composition of gas at top of calculation sheet.

2. Determine critical pressure and temperature of gas from CNGA Bulletin No. TS 461.

$$P_{cr} = 688; \; T_{cr} = 398$$

If the gas contains carbon dioxide or Nitrogen the P_{cr} and T_{cr} should be corrected at this time by using Table II of CNGA TS 461.

Enter values of T_{cr} and P_{cr} at top of calculation sheet.

* In cases where extremely accurate calculated pressures are required the Procedures outlined on page 66 of appendix C should be used.

3. Enter initial depth (zero wellhead) on line 1, column 1.

4. Enter wellhead pressure (P_n) on Line 1, Column 2. (1350 psia)

5. Determine reduced pressure. (P_r)

$$\frac{P_n}{P_{cr}} = \frac{1350}{668} = 2.02 = P_r$$

Enter on Line 1, Column 3.

6. Enter wellhead temperature (absolute) on Line 1, Column 4. (540° R.)

7. Determine reduced temperature (T_r)

$$\frac{T}{T_{cr}} = \frac{540}{398} = 1.36 = T_r$$

Enter on Line 1, Column 5.

8. Using P_r and T_r determine supercompressibility factor (F_{pv}) from Table V, CNGA Bulletin TS 461.

$$F_{pv} = 1.165$$

Enter on Line 1, Column 6.

9. From F_{pv} determine Z factor.

$$\frac{1}{(F_{pv})^2} = \frac{1}{(1.165)^2} = .737 = Z$$

Enter on Line 1, Column 7.

10. Determine value of TZ.

$$540 \times .737 = 397.98 = TZ$$

Enter on Line 1, Column 8.

11. Determine value of $\frac{TZ}{P_n}$

$$\frac{397.98}{1350} = .29480 = \frac{TZ}{P_n}$$

Enter on Line 1, Column 9.

12. H is the length of the static gas column being evaluated in each step of the calculation (see page 33 .)

Enter H (Total Depth) for which pressure is being determined on Line 2, Column 1.

$$H = 4800 \text{ ft.}$$

13. Determine value of .0375 GH

$$.0375 \times .725 \times 4800 = 130.497$$

Enter on Line 2, Column 14.

14. Determine first trial value of weight of gas column (0-4800 ft.)

$$\frac{\frac{1}{2}(.0375\ GH)}{\frac{TZ}{P_n}} = \frac{\frac{1}{2}(130.479)}{.29480} = 221.3$$

where:

$$H = 4800 \text{ ft.}$$

$$\frac{TZ}{P_n} = \frac{TZ}{P_n} \text{ where } H = 0 \text{ ft.}$$

Enter on Line 2, Column 10.

15. Determine first trial value P_n of pressure at total depth. (4800 ft.)

$$1350 + 221.3 = 1571.3 \text{ psia} = P_n$$

Enter on Line 2, Column 2.

16. Determine absolute bottom hole temperature (T)

$$128^oF + 460\ ^oR = 588\ ^oR. = T$$

Enter on Line 2, Column 4.

17. Determine values of P_r, T_r, F_{pv}, Z, TZ, and $\frac{TZ}{P_n}$ as shown in steps 5, 7, 8, 9, 10 and 11.

$P_r = 2.35$; $T_r = 1.48$; $F_{pv} = 1.124$; $Z = .792$;

$TZ = 465.696$; and $\frac{TZ}{P_n}$ or $I = .296376$

Enter on Line 2, Columns 3, 5, 6, 7, 8, and 9 respectively.

18. Determine value of N.

I where H = 0 ft. + Trial I where H = 4800 ft. =

Trial N where H = 4800 ft.

.294800 + .296376 = .591176 = N

Enter on Line 2, Column 11.

19. Determine value of M x N where H = 4800 ft.

221.3 x .591176 = 130.827

Enter on Line 2, Column 12 and 13.

When Column 13 is equal to Column 14 then the proper value of M, where H = 4800 ft., has been determined. A check should be made by dividing Column 14 by Column 11 as follows:

$$\frac{.0375\ GH}{N} = \frac{130.497}{.591176} = 220.7$$

Since the check value of M (220.7) is only .4 psia more than the first trial value of M (221.3 psia) we shall consider the check value of 220.7 to be correct.

Since the check value of M is considered correct it follows that the value of P_f is:

$$P_f = P_c + \frac{.0375\ GH}{N}$$

where:

P_f = Bottom Hole Pressure psia

P_c = Wellhead shut-in pressure, psia

G = Specific gravity of the gas (Air = 1.0)

H = Total length of gas column

and

$$P_f = 1350 + \frac{130.497}{.591176}$$

$$P_f = 1350 + 220.7$$

$$P_f = 1571 \text{ psia}$$

If the check value of M had been different than trial value of M by more than 1 psia we would have entered this value on Line 3, Column 10 and repeated steps 15 through 19 until Column 13 was as close to column 14 as possible.

CALCULATION SHEET FOR STATIC COLUMN PRESSURES

COMPANY__________ LEASE__________ WELL NO.__________ DATE__________

G= .725 %CO_2= 0 %N= 0 Cr. Pressure (P_{cr})= 668 Cr. Temp. (T_{cr})= 398 .0375G = .027187

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
			Pr		Tr		Z		I	M	N			
	H	P_n	$\frac{P_n}{P_{cr}}$	T	$\frac{T}{T_{cr}}$	F_{pv}	$\frac{1}{(F_{pv})^2}$	TZ	$\frac{TZ}{P_n}$	P_n-P_{n-1}	I_n-I_{n-1}	M x N	Σ(MxN)	.0375GH
							CASE I							
1	0	1350	2.02	540	1.36	1.165	.737	397.98	.294800				0	0
2	4800	1571.3	2.35	588	1.48	1.124	.792	465.696	.296376	221.3	.591176	130.827	130.827	130.497
		1671								221				
							CASE II							
3	6000	1955	2.93	600	1.51	1.128	.786	471.600	.241227				163.122	163.122
4	0	1616.9	2.42	540	1.36	1.195	.700	378.0	.233780	338.1	.475007	160.599	2.523	0
5	0	1611.6	"	"	"	"	"	"	.234570	343.4	.475797	163.388	-.266	0
6		1612								343				

EXAMPLE NO. 7

DETERMINING THE ADJUSTED WELLHEAD SHUT-IN PRESSURE ON GAS WELLS, WITH LIQUID COLUMNS IN WELLBORE, UNDER STATIC CONDITIONS.

In some cases the observed wellhead shut-in pressures of a gas well is effected by accumulated liquids in the wellbore and will not reflect the true conditions of the well. When the height of liquid column and specific gravity of the liquids are known, the formation (Bottom Hole) pressure may be determined by calculating the pressure at the gas-liquid interface as explained in Example No. 6 and adding to this figure the weight of the liquid column above the desired datum plane.

When it is necessary to determine the wellhead pressure which would exist if the liquid column were not present, the formation pressure determined as explained above may be used to calculate an adjusted wellhead pressure based on the assumption that no liquid column exists.

Observed data:

H = 6000 ft. (Length of wellbore to datum point. Datum point used shall be that determined by the Commission).

G_1 = .725 (Gravity of Gas, Air = 1.00)

G_2 = .7389 (Specific gravity of liquids, water = 1.00, 60°API, Table IX, page 52.)

h 1200 ft. (Length of the liquid column above the datum)

Wellhead Temperature = 540°R.

Formation Temperature = 600°R.

1 ft. column of water = .4333 psia

Weight of liquid column above datum expressed as psia.

$$\text{psia} = h \times G_2 \times .4333$$

$$\text{psia} = 1200 \times .7389 \times .4333 = 384.2$$

Pressure at Gas-Liquid Interface as determined in Example No. 6 =	1571 psia
Pressure of Liquid Column =	384 psia
Formation pressure (P_f @ 6000 ft.)	1955 "

Since we desire the adjusted wellhead pressure and we now have the formation pressure at the well's datum point we must calculate the pressure due to the weight of column of gas by beginning with datum point conditions.

Using the "Calculation sheet for Static Column Pressures" shown with Example No. 6, Case II.

1. The values of G, P_{cr} and T_{cr} will be the same as shown for Case I, Example No. 6.

2. Enter length of column (H), formation pressure (P_n) and absolute formation temperature (T) on Line 3, Columns 1, 2 and 4, respectively.

3. Determine P_r, T_r, F_{pv}, Z, TZ and $\frac{TZ}{P_n}$ or I

   and enter on Line 3, Columns 3, 5, 6, 7, 8 and 9 respectively.

$$P_r = \frac{P_n}{P_{cr}} = \frac{1955}{668} = 2.93$$

$$T_r = \frac{T}{T_{cr}} = \frac{600}{398} = 1.51$$

$$F_{pv} = 1.128 \text{ (CNGA TS-461, Table V)}$$

$$Z = \frac{1}{(F_{pv})^2} = \frac{1}{1.272} = .786$$

$$TZ = 600 \times .786 = 471.600$$

$$\frac{TZ}{P_n} = \frac{471.600}{1955} = .241227$$

4. Determine value of .0375 GH where H = 6000 ft.

$$.0375 \times .725 \times 6000 = 163.122$$

   Enter on Line 3, Column 13 and 14.

5. Enter (H) where H = 0 (wellhead) on Line 4, Column 1.

6. Enter value of .0375 GH where H = 0 on Line 4, Column 14.

$$.0375 \text{ GH} = 0$$

7. Determine the first trial value of the weight of the column from 6000 to wellhead.

$$\frac{\frac{1}{2}(.0375 \text{ GH})}{\frac{TZ}{P_n}} = \frac{\frac{1}{2}(163.122)}{.241227} = 338.1$$

Where:

$H = 6000$ ft. and $\frac{TZ}{P_n} = \frac{TZ}{P_n}$ where H = 6000 ft.

Enter on Line 4, Column 10.

8. Determine first trial value of the pressure at the wellhead.

   P_n (where H = 6000 ft.) - Trial M (where H = 0) =

   Trial P_n (where H = 0)

   1955 - 338.1 = 1616.9 psia.

   Enter on Line 4, Column 2.

9. Enter absolute wellhead temperature (T) on Line 4, Column 4.

   $T = 540°R.$

10. Determine values of P_r, T_r, F_{pv}, Z, TZ and $\frac{TZ}{P_n}$ and enter on Line 4, Columns 3, 5, 6, 7, 8 and 9.

    $P_r = 2.42$; $T_r = 1.36$; $F_{pv} = 1.195$; $Z = .700$;

    $TZ = 378.0$; $\frac{TZ}{P_n}$ or $I = .233780$

11. Determine Trial N where H = 0.

    I where H = 6000 ft. + I where H = 0 =

    Trial N where H = 0 ft.

    .241227 + .233780 = .475007

    Enter on Line 4, Column 11.

12. Determine trial value of M x N where H = 0 ft.

    M x N = 338.1 x .475007 = 160.599

    Enter on Line 4, Column 12.

13. Determine trial value of $\Sigma(M \times N)$ where H = 0

    Trial $\Sigma(M \times N)$ where H = 6000 - Trial M x N where H = 0 = Trial $\Sigma(M \times N)$ where H = 0.

    163.122 - 160.599 = 2.523

    Enter on Line 4, Column 13.

When Column 13 is equal to Column 14 the proper value of M, where H = 0, has been determined. A check should be made by determining again the weight of the column of gas as follows:

$$\frac{(M \times N) \text{ where } H = 6000}{\text{Trial } (N) \text{ where } H = 0} = \text{check value of M where H = 0.}$$

$$\frac{163.122}{.475007} = 343.4$$

Since this check value is 5.3 psia higher than the first trial value of M we must enter this value on Line 5, Column 10 and repeat steps 8, 9, $\frac{TZ}{P_n}$ part of 10, 11, 12 and 13.

then:

$$P_n = 1611.6; \frac{TZ}{P_n} = .234570; N = .475797;$$

$$M \times N = 163.388; \sum(M \times N) = -.266$$

and

$$\text{Check value of } M = 342.8$$

Since the check value of M is only .6 psia lower than the second trial value of 343.4 the check value of 343 psia is considered correct. Also the adjusted wellhead pressure is:

$$1955 - 343 = 1612 \text{ psia}$$

TABLE I

NEW MEXICO OIL CONSERVATION COMMISSION

BASIC ORIFICE FACTORS - MCF 24/ HOURS F_b

FLANGE TAPS

Base Temperature	60°F	Base Flowing Temp. 60°F.
Base Pressure	15.025 Psia	Specific Gravity .600

Orifice Diameter Inches	Pipe Sizes - Nominal and Actual Diameters 2" Std. 2.067	3" Std. 3.068	4" Std. 4.026	6" Std. 6.065
.250	.3860	.3858	.3852	- - -
.375	.8634	.8618	.8607	- - -
.500	1.535	1.528	1.525	1.524
.625	2.409	2.388	2.382	2.378
.750	3.497	3.449	3.435	3.424
.875	4.814	4.713	4.686	4.664
1.000	6.386	6.182	6.135	6.100
1.125	8.253	7.868	7.786	7.732
1.250	10.48	9.781	9.643	9.559
1.375	13.16	11.94	11.71	11.58
1.500	16.47	14.36	13.99	13.80
1.625		17.08	16.51	16.23
1.750		20.15	19.27	18.86
1.875		23.60	22.28	21.69
2.000		27.52	25.58	24.74
2.125		31.97	29.17	27.99
2.250		37.15	33.10	31.47
2.375			37.41	35.18
2.500			42.13	39.13
2.625			47.33	43.31
2.750			53.05	47.75
2.875			59.39	52.47
3.000			66.67	57.46
3.125				62.75
3.250				68.36
3.375				74.32
3.500				80.64
3.625				87.35
3.750				94.50
3.875				102.1

TABLE II

NEW MEXICO OIL CONSERVATION COMMISSION

BASIC ORIFICE FACTORS - MCF 24/HOURS - F_b

PIPE TAPS

Base Temperature 60°F
Base Pressure 15.025 psia

Base Flowing Temp. 60°F
Specific Gravity .600

Pipe Sizes - Nominal and Actual Diameters

Orifice Diameter Inches	2" Std. 2.067	3" Std. 3.068	4" Std. 4.026	6" Std. 6.065
.250	.3887	.3872	.3864	---
.375	.8810	.8712	.8682	---
.500	1.594	1.557	1.546	1.538
.625	2.554	2.455	2.425	2.405
.750	3.797	3.584	3.515	3.469
.875	5.379	4.961	4.828	4.735
1.000	7.390	6.607	6.375	6.209
1.125	9.963	8.556	8.174	7.897
1.250	13.30	10.85	10.24	9.807
1.375	17.74	13.54	12.59	11.94
1.500		16.70	15.26	14.32
1.625		20.44	18.28	16.95
1.750		24.88	21.69	19.84
1.875		30.19	25.55	23.00
2.000		36.62	29.92	26.45
2.125		44.50	34.88	30.21
2.250			40.53	34.29
2.375			47.00	38.72
2.500			54.44	43.52
2.625			63.05	48.73
2.750			73.11	54.38
2.875				60.51
3.000				67.17
3.125				74.42
3.250				82.31
3.375				90.92
3.500				100.33
3.675				110.63
3.750				121.95
3.875				134.41

TABLE III

CRITICAL FLOW COEFFICIENTS FOR TWO AND FOUR INCH CRITICAL FLOW PROVERS

MCF Per day; Pressure Base: 15.025 psia; Specific Gravity: 0.60; Base and Flowing Temperature: 60 Degrees Fahrenheit.

TWO INCH PROVER		FOUR INCH PROVER	
Orifice Dia., Inches	Coefficient	Orifice Dia, Inches	Coefficients
1/16	.0827	1/4	1.352
3/32	.1820		
1/8	.3418	3/8	3.039
3/16	.7851		
7/32	1.0834		
1/4	1.4030	1/2	5.436
3/16	2.1577	5/8	8.469
3/8	3.0691	3/4	12.137
7/16	4.3997	7/8	16.504
1/2	5.5233	1	21.501
5/8	8.3555	1 1/8	27.085
3/4	12.2023	1 1/4	33.444
7/8	16.7816	1 3/8	40.264
1	22.0662	1 1/2	47.979
1 1/8	28.2569	1 3/4	65.542
1 1/4	35.6738	2	86.594
1 3/8	43.8286	2 1/4	111.009
1 1/2	54.3653	2 1/2	139.223
		2 3/4	172.374
		3	211.818

TABLE IV

SIX INCH POSITIVE CHOKE NIPPLE COEFFICIENTS

MCF/da./ Psia: Pressure Base: 15.025; Specific Gravity: .60; Base and Flowing Temperature: 60° Fahrenhiet.

Nominal Choke Size. Inches	Inside Diameter inches	(1)	Coefficient (2)
1/8	.1250	.3261	.3393
9/64	.1406	.4140	.4329
5/32	.1563	.5133	.5392
11/64	.1719	.6224	.6572
3/16	.1875	.7425	.7839
13/64	.2031	.8731	.9321
7/32	.2188	1.0155	1.0881
15/64	.2344	1.1678	1.2558
1/4	.2500	1.3309	1.4382
17/64	.2656	1.5049	1.6254
9/32	.2813	1.6907	1.8379
19/64	.2969	1.8865	2.0573
5/16	.3125	2.0930	2.3674
21/64	.3281	2.3105	2.5361
11/32	.3438	2.5404	2.7945
23/64	.3594	2.7796	3.0655
3/8	.3750	3.0300	3.3210
25/64	.3906	3.2911	3.6467
13/32	.4063	3.5650	3.9616
27/64	.4219	3.8481	4.2843
7/16	.4531	4.1423	4.6188
29/64	.4531	4.4476	4.9737
15/32	.4688	4.7659	5.3374
31/64	.4844	5.0931	5.7157
1/2	.5000	5.4315	6.1155
9/16	.5625	6.8979	7.8101
5/8	.6250	8.5417	9.7524
11/16	.6875	10.3640	11.8721
3/4	.7500	12.3650	14.1605

(1) For standard six inch Thornhill-Craver positive flow-beans. Calculated from test data of Texas College of Arts and Industries.

(2) Calculated from data appearing in United States Bureau of Mines Monograph 7, for choke nipples as illustrated below.

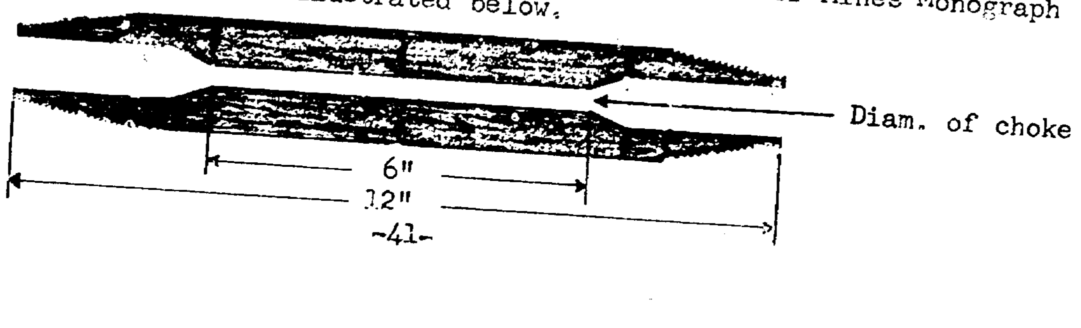


TABLE V

FLOWING TEMPERATURE FACTORS

$$\text{Factor} = \frac{520}{460^{\circ} + T}$$

°F	Factor	°F	Factor	°F	Factor	°F	Factor	°F	Factor	°F	Factor
0	1.0632	35	1.0249	70	0.9905	105	0.9592	140	0.9309	175	0.9048
1	1.0620	36	1.0239	71	0.9896	106	0.9585	141	0.9301	176	0.9042
2	1.0609	37	1.0229	72	0.9887	107	0.9576	142	0.9293	177	0.9035
3	1.0598	38	1.0219	73	0.9877	108	0.9568	143	0.9284	178	0.9028
4	1.0586	39	1.0208	74	0.9868	109	0.9559	144	0.9279	179	0.9020
5	1.0574	40	1.0198	75	0.9859	110	0.9551	145	0.9271	180	0.9014
6	1.0563	41	1.0188	76	0.9850	111	0.9543	146	0.9263	181	0.9007
7	1.0552	42	1.0178	77	0.9840	112	0.9534	147	0.9255	182	0.9000
8	1.0540	43	1.0168	78	0.9831	113	0.9526	148	0.9247	183	0.8992
9	1.0529	44	1.0157	79	0.9822	114	0.9518	149	0.9240	184	0.8985
10	1.0518	45	1.0147	80	0.9813	115	0.9510	150	0.9233	185	0.8979
11	1.0507	46	1.0137	81	0.9804	116	0.9501	151	0.9225	186	0.8972
12	1.0496	47	1.0127	82	0.9795	117	0.9493	152	0.9217	187	0.8965
13	1.0485	48	1.0117	83	0.9786	118	0.9485	153	0.9210	188	0.8958
14	1.0474	49	1.0107	84	0.9777	119	0.9477	154	0.9202	189	0.8951
15	1.0463	50	1.0098	85	0.9768	120	0.9469	155	0.9195	190	0.8944
16	1.0452	51	1.0088	86	0.9759	121	0.9460	156	0.9187	191	0.8937
17	1.0441	52	1.0078	87	0.9750	122	0.9452	157	0.9180	192	0.8931
18	1.0430	53	1.0068	88	0.9741	123	0.9444	158	0.9173	193	0.8923
19	1.0419	54	1.0058	89	0.9732	124	0.9436	159	0.9165	194	0.8916
20	1.0408	55	1.0048	90	0.9723	125	0.9428	160	0.9158	195	0.8910
21	1.0398	56	1.0039	91	0.9715	126	0.9420	161	0.9150	196	0.8903
22	1.0387	57	1.0029	92	0.9706	127	0.9412	162	0.9143	197	0.8896
23	1.0376	58	1.0019	93	0.9697	128	0.9404	163	0.9135	198	0.8889
24	1.0365	59	1.0010	94	0.9688	129	0.9396	164	0.9128	199	0.8882
25	1.0355	60	1.0000	95	0.9680	130	0.9388	165	0.9121		
26	1.0344	61	0.9990	96	0.9671	131	0.9380	166	0.9112		
27	1.0333	62	0.9981	97	0.9662	132	0.9372	167	0.9106		
28	1.0323	63	0.9971	98	0.9653	133	0.9364	168	0.9099		
29	1.0312	64	0.9962	99	0.9645	134	0.9356	169	0.9092		
30	1.0302	65	0.9952	100	0.9636	135	0.9348	170	0.9085		
31	1.0291	66	9.9943	101	0.9627	136	0.9341	171	0.9077		
32	1.0281	67	0.9933	102	0.9618	137	0.9333	172	0.9069		
33	1.0270	68	0.9924	103	0.9610	138	0.9325	173	0.9063		
34	1.0260	69	0.9915	104	0.9602	139	0.9317	174	0.9055		

TABLE VI

SPECIFIC GRAVITY FACTORS

$$\text{Factor} = \frac{0.60}{\text{Sp. Gr.}}$$

Sp. Gr.	Factor	Sp. Gr.	Factor	Sp. Gr.	Factor
0.500	1.0954	0.650	0.9608	0.800	0.8660
0.505	1.0900	0.655	0.9571	0.805	0.8635
0.510	1.0847	0.660	0.9535	0.810	0.8607
0.515	1.0794	0.665	0.9498	0.815	0.8580
0.520	1.0742	0.670	0.9463	0.820	0.8554
0.525	1.0690	0.675	0.9427	0.825	0.8528
0.530	1.0640	0.680	0.9393	0.830	0.8502
0.535	1.0590	0.685	0.9359	0.835	0.8476
0.540	1.0541	0.690	0.9325	0.840	0.8452
0.545	1.0492	0.695	0.9292	0.860	0.8353
0.550	1.0445	0.700	0.9258	0.880	0.8257
0.555	1.0398	0.705	0.9225	0.900	0.8165
0.560	1.0351	0.710	0.9193	0.920	0.8076
0.565	1.0304	0.715	0.9161	0.940	0.7989
0.570	1.0260	0.720	0.9129	0.960	0.7906
0.575	1.0215	0.725	0.9097	0.980	0.7825
0.580	1.0171	0.730	0.9066	1.000	0.7746
0.585	1.0127	0.735	0.9035	1.020	0.7669
0.590	1.0084	0.740	0.9005	1.040	0.7595
0.595	1.0041	0.745	0.8974	1.060	0.7523
0.600	1.0000	0.750	0.8944	1.080	0.7453
0.605	0.9958	0.755	0.8914	1.100	0.7385
0.610	0.9918	0.760	0.8885	1.120	0.7319
0.615	0.9877	0.765	0.8856	1.140	0.7255
0.620	0.9837	0.770	0.8827	1.160	0.7192
0.625	0.9798	0.775	0.8793	1.180	0.7131
0.630	0.9759	0.780	0.8771	1.200	0.7071
0.635	0.9721	0.785	0.8743	1.220	0.7013
0.640	0.9682	0.790	0.8715	1.240	0.6956
0.645	0.9645	0.795	0.8687	1.260	0.6901

TABLE VII A
(SOUTHEASTERN NEW MEXICO)

Values of F_c for Various Tubing Sizes

(Use only for internal diameters less than 4.277 in.)

Note: $$F_c = \frac{0.10797}{d^{2.612}} \quad \frac{P_b}{14.65} \quad (T) \quad (Z)$$

Values shown based on P_b = 15.025

T = 545

Z = 1.00

Nominal Size, In.	O.D. In.	#/Ft.	I.D. In.	F_c
1	1.315	1.80	1.049	53.26
1 1/4	1.660	2.40	1.380	26.02
1 1/2	1.990	2.75	1.610	17.40
2	2.375	4.70	1.995	9.936
2 1/2	2.875	6.50	2.441	5.866
	3.500	9.30	2.992	3.447
	4.000	11.00	3.476	2.330
	4.500	12.70	3.958	1.660
	4.750	16.25	4.082	1.532
	4.750	18.00	4.000	1.615
	5.000	18.00	4.276	1.357
	5.000	21.00	4.154	1.463

TABLE VII B
(SOUTHEASTERN NEW MEXICO)

Values of F_c for Various Casing Sizes

(Use only for internal diameters greater than 4.277 in.)

Note: $F_c = \left(\frac{0.10337}{d^{2.582}}\right) \left(\frac{P_b}{14.65}\right) (T) \quad (Z)$

Values shown based on P_b = 15.025
T = 545
Z = 1.00

O.D. In.	#/Ft.	I.D. In.	F_c
5.000	13.00	4.494	1.193
5.000	15.00	4.408	1.254
5.500	14.00	5.012	0.9002
5.500	15.00	4.976	0.9171
5.500	17.00	4.892	0.9583
5.500	20.00	4.778	1.018
5.500	23.00	4.670	1.080
5.500	25.00	4.580	1.136
6.000	15.00	5.524	0.7003
6.000	17.00	5.450	0.7251
6.000	20.00	5.352	0.7599
6.000	23.00	5.240	0.8025
6.000	26.00	5.140	0.8435
6.625	20.00	6.049	0.5539
6.625	22.00	5.989	0.5684
6.625	24.00	5.921	0.5854
6.625	26.00	5.855	0.6026
6.625	28.00	5.791	0.6199
6.625	31.80	5.675	0.6532
6.625	34.00	5.595	0.6776
7.000	20.00	6.456	0.4682
7.000	22.00	6.398	0.4792
7.000	24.00	6.336	0.4915
7.000	26.00	6.276	0.5037
7.000	28.00	6.214	0.5168
7.000	30.00	6.154	0.5299
7.000	40.00	5.836	0.6076
7.625	26.40	6.969	0.3843
7.625	29.70	6.875	0.3980
7.625	33.70	6.765	0.4150
7.625	38.70	6.625	0.4380
7.625	45.00	6.445	0.4703
8.000	26.00	7.336	0.3308
8.125	28.00	7.485	0.3196
8.125	32.00	7.385	0.3309

TABLE VII B (continued)
(SOUTHEASTERN NEW MEXICO)

Values of F_c for Various Casing Sizes

O.D. IN.	#/FT.	I.D. In.	F_c
8.125	35.50	7.285	0.3427
8.125	39.50	7.185	0.3552
8.625	17.50	8.249	0.2487
8.625	20.00	8.191	0.2532
8.625	24.00	8.097	0.2609
8.625	28.00	8.003	0.2689
8.625	32.00	7.907	0.2774
8.625	36.00	7.825	0.2850
8.625	38.00	7.775	0.2897
8.625	43.00	7.651	0.3020
9.000	34.00	8.290	0.2455
9.000	38.00	8.196	0.2528
9.000	40.00	8.150	0.2565
9.000	45.00	8.032	0.2664
9.625	36.00	8.921	0.2031
9.625	40.00	8.835	0.2083
9.625	43.50	8.755	0.2132
9.625	47.00	8.681	0.2180
9.625	53.50	8.535	0.2277
9.625	58.00	8.435	0.2348
10.000	33.00	9.384	0.2329
10.000	55.50	8.908	0.2039
10.000	61.20	8.790	0.2111
10.750	32.75	10.192	0.1440
10.750	35.75	10.136	0.1461
10.750	40.00	10.050	0.1493
10.750	45.50	9.950	0.1532
10.750	48.00	9.902	0.1552
10.750	54.00	9.784	0.1600

TABLE VII C
(SOUTHEASTERN NEW MEXICO)

Values of F_c for various casing-tubing combinations. (Annular Flow)

CASING			TUBING			
O.D. In.	I.D. In.	#/Ft.	O.D. In.	I.D. In.	#/Ft.	F_c
7.625	6.625	39	2.375	1.995	4.7	.651
7.000	6.366	23	2.375	1.995	4.7	.740
7.000	6.276	26	2.375	1.995	4.7	.744
7.000	6.366	23	2.875	2.441	6.5	.865
6.625	6.049	20	2.375	1.995	4.7	.875
7.000	6.276	26	2.875	2.441	6.5	.910
6.625	6.049	20	2.875	2.441	6.5	1.041
6.625	5.921	24	3.500	2.992	9.3	1.540
5.500	4.892	17	2.375	1.995	4.7	1.812
5.500	4.892	17	3.000			2.735
5.500	4.976	15.5	2.375	1.995	4.7	1.758
5.500	5.012	14.0	2.375	1.995	4.7	1.712
6.625	6.049	20.0	4.000	3.476	11.0	1.889
6.625	6.049	20.0	3.500	2.992	9.3	1.399
5.500	4.950	15.5	2.375	1.995	4.7	1.793
7.000	6.456	20.0	2.375	1.995	4.7	0.707
5.5	4.892	17.0	2.875	2.441	6.5	2.507
5.0	4.408	15.0	2.375	1.995	4.7	2.834
5.50	4.892	17.0	3.500	2.992	9.3	4.220
4.50	4.090	9.5	2.375	1.995	4.7	3.912

Formula 1.

$$F_c \text{ (for Annulus)} = \left(\frac{0.10797}{\left[(d_1 + d_2)(d_1 - d_2)\right]^{1.612}} \right) \left(\frac{P_b}{14.65} \right) (T) \quad (Z)$$

d_1 = I.D. of casing-in.
d_2 = O.D. of tubing-in.

Formula 2.

$$F_c \text{ (for Annulus)} = \left(\frac{0.10337}{\left[(d_1 + d_2)(d_1 - d_2)\right]^{1.582}} \right) \left(\frac{P_b}{14.65} \right) (T) \quad (Z)$$

d_1 = I.D. of casing-in.
d_2 = O.D. of tubing-in.

NOTE: When calculating F_c factors for d_1, d_2, T, or Z values not listed in these tables use above formula 1, for annular flow. If the answer is less than 1.357 then the above formula 2 for annular flow is the proper formula to use to calculate F_c.

TABLE VIII
(SOUTHEASTERN NEW MEXICO)

Values of $(1-e^{-s})$ for Various Vaules of GL

Note: $S = \frac{0.0375\ GL}{TZ}$

Values shown based on T = 545
Z = 1.00

From	To	$(1-e^{-s})$	From	To	$(1-e^{-s})$
1000	1015	0.067	1559	1571	0.102
1016	1031	0.068	1572	1587	0.103
1032	1046	0.069	1588	1604	0.104
1047	1062	0.070	1605	1620	0.105
1063	1078	0.071	1621	1636	0.106
1079	1093	0.072	1637	1653	0.107
1094	1109	0.073	1654	1669	0.108
1110	1124	0.074	1670	1684	0.109
1125	1141	0.075	1685	1700	0.110
1142	1156	0.076	1701	1716	0.111
1157	1172	0.077	1717	1734	0.112
1173	1188	0.078	1735	1751	0.113
1189	1203	0.079	1752	1767	0.114
1204	1218	0.080	1768	1783	0.115
1219	1235	0.081	1784	1800	0.116
1236	1251	0.082	1801	1816	0.117
1252	1267	0.083	1817	1832	0.118
1268	1283	0.084	1833	1849	0.119
1284	1298	0.085	1850	1876	0.120
1299	1314	0.086	1877	1882	0.121
1315	1329	0.087	1883	1899	0.122
1330	1346	0.088	1900	1915	0.123
1347	1362	0.089	1916	1932	0.124
1363	1378	0.090	1933	1949	0.125
1379	1394	0.091	1950	1965	0.126
1395	1410	0.092	1966	1982	0.127
1411	1426	0.093	1983	1998	0.128
1427	1441	0.094	1999	2015	0.129
1442	1458	0.095	2016	2032	0.130
1459	1474	0.096	2033	2049	0.131
1475	1490	0.097	2050	2065	0.132
1491	1507	0.098	2066	2082	0.133
1508	1523	0.099	2083	2099	0.134
1524	1539	0.100	2100	2116	0.135
1540	1558	0.101	2117	2132	0.136

Values of $(1-e^{-s})$ for Various Values of GL

GL From	GL To	$(1-e^{-s})$	GL From	GL To	$(1-e^{-s})$
2133	2149	0.137	2876	2893	0.180
2150	2166	0.138	2894	2910	0.180
2167	2183	0.139	2911	2928	0.182
2184	2200	0.140	2929	2946	0.183
2201	2217	0.141	2947	2964	0.184
2218	2234	0.142	2965	2982	0.185
2235	2251	0.143	2983	2999	0.186
2252	2268	0.144	3000	3017	0.187
2269	2285	0.145	3018	3035	0.188
2286	2302	0.146	3036	3053	0.189
2303	2319	0.147	3054	3071	0.190
2320	2336	0.148	3072	3089	0.191
2337	2353	0.149	3090	3107	0.192
2354	2370	0.150	3108	3125	0.193
2371	2387	0.151	3126	3144	0.194
2388	2404	0.152	3145	3161	0.195
2405	2422	0.153	3162	3179	0.196
2423	2439	0.154	3180	3197	0.197
2440	2456	0.155	3198	3215	0.198
2457	2473	0.156	3216	3234	0.199
2474	2490	0.157	3235	3252	0.200
2491	2508	0.158	3253	3270	0.201
2509	2525	0.159	3271	3288	0.202
2526	2542	0.160	3289	3306	0.203
2543	2560	0.161	3307	3325	0.204
25[illegible]	2577	0.162	3326	3343	0.205
2578	2594	0.163	3344	3361	0.206
2595	2611	0.164	3362	3379	0.207
2612	2629	0.165	3380	3398	0.208
2630	2646	0.166	3399	3416	0.209
2647	2664	0.167	3417	3435	0.210
2665	2681	0.168	3436	3453	0.211
2682	2699	0.169	3454	3471	0.212
2700	2716	0.170	3472	3490	0.213
2717	2734	0.171	3491	3507	0.214
2735	2751	0.172	3508	3526	0.215
2752	2769	0.173	3527	3545	0.216
2770	2787	0.174	3546	3564	0.217
2788	2804	0.175	3565	3582	0.218
2805	2822	0.176	3583	3601	0.219
2823	2840	0.177	3602	3620	0.220
2841	2857	0.178	3621	3638	0.221
2858	2875	0.179	3639	3657	0.222

Values of $(1-e^{-s})$ for Various Values of GL

GL From	GL To	$(1-e^{-s})$	GL From	GL To	$(1-e^{-s})$
3658	3676	0.223	4505	4524	0.267
3677	3695	0.224	4525	4544	0.268
3696	3713	0.225	4545	4563	0.269
3714	3732	0.226	4564	4583	0.270
3733	3751	0.227	4584	4603	0.271
3752	3770	0.228	4604	4623	0.272
3771	3789	0.229	4624	4643	0.273
3790	3807	0.230	4644	4663	0.274
3808	3826	0.231	4664	4683	0.275
3827	3845	0.232	4684	4703	0.276
3846	3864	0.233	4704	4723	0.277
3865	3883	0.234	4724	4743	0.278
3884	3902	0.235	4744	4764	0.279
3903	3921	0.236	4765	4784	0.280
3922	3940	0.237	4785	4804	0.281
3941	3960	0.238	4805	4824	0.282
3961	3979	0.239	4825	4845	0.283
3980	3998	0.240	4846	4865	0.284
3999	4017	0.241	4866	4885	0.285
4018	4036	0.242	4886	4906	0.286
4037	4055	0.243	4907	4926	0.287
4056	4074	0.244	4927	4946	0.288
4075	4094	0.245	4947	4967	0.289
4095	4113	0.246	4968	4987	0.290
4114	4132	0.247	4988	5008	0.291
4133	4151	0.248	5009	5028	0.292
4152	4171	0.249	5029	5049	0.293
4172	4190	0.250	5050	5070	0.294
4191	4210	0.251	5071	5090	0.295
4211	4229	0.252	5091	5111	0.296
4230	4249	0.253	5112	5131	0.297
4250	4268	0.254	5132	5152	0.298
4269	4288	0.255	5153	5173	0.299
4289	4307	0.256	5174	5194	0.300
4308	4327	0.257	5195	5214	0.301
4328	4346	0.258	5215	5235	0.302
4347	4366	0.259	5236	5256	0.303
4367	4386	0.260	5257	5277	0.304
4387	4405	0.261	5278	5298	0.305
4406	4425	0.262	5299	5319	0.306
4426	4444	0.263	5320	5340	0.307
4445	4464	0.264	5341	5361	0.308
4465	4484	0.265	5362	5382	0.309
4485	4504	0.266	5383	5403	0.310

Values of $(1-e^{-s})$ for Various Values of GL

GL			GL		
From	To	$(1-e^{-s})$	From	To	$(1-e^{-s})$
5404	5424	0.311	5832	5852	0.331
5425	5445	0.312	5853	5874	0.331
5446	5466	0.313	5875	5896	0.333
5467	5488	0.314	5897	5918	0.334
5489	5509	0.315	5919	5940	0.335
5510	5530	0.316	5941	5962	0.336
5531	5551	0.317	5963	5984	0.337
5552	5573	0.318	5985	6005	0.338
5574	5594	0.319	6006	6028	0.339
5595	5615	0.320	6029	6049	0.340
5616	5637	0.321	6050	6071	0.341
5638	5658	0.322	6072	6093	0.342
5659	5679	0.323	6094	6116	0.343
5680	5701	0.324	6117	6138	0.344
5702	5723	0.325	6139	6160	0.345
5724	5744	0.326	6161	6182	0.346
5745	5766	0.327	6183	6205	0.347
5767	5787	0.328	6206	6227	0.348
5788	5809	0.329	6228	6249	0.349
5810	5831	0.330	6250	6272	0.350

TABLE IX

CONVERSION OF °A. P. I. TO SPECIFIC GRAVITY

Degrees API at 60°F	Specific Gravity	Degrees API at 60°F	Specific Gravity	Degrees API at 60°F	Specific Gravity
0	1.076	34	.8550	68	.7093
1	1.068	35	.8498	69	.7057
2	1.060	36	.8448	70	.7022
3	1.052	37	.8398	71	.6988
4	1.044	38	.8348	72	.6953
5	1.037	39	.8299	73	.6919
6	1.029	40	.8251	74	.6886
7	1.022	41	.8203	75	.6852
8	1.014	42	.8155	76	.6819
9	1.007	43	.8109	77	.6787
10	1.000	44	.8063	78	.6754
11	.9930	45	.8017	79	.6722
12	.9861	46	.7972	80	.6690
13	.9792	47	.7927	81	.6659
14	.9725	48	.7883	82	.6628
15	.9659	49	.7839	83	.6597
16	.9593	50	.7796	84	.6566
17	.9529	51	.7753	85	.6536
18	.9465	52	.7711	86	.6506
19	.9402	53	.7669	87	.6476
20	.9340	54	.7628	88	.6446
21	.9279	55	.7587	89	.6417
22	.9218	56	.7547	90	.6388
23	.9159	57	.7507	91	.6360
24	.9100	58	.7467	92	.6331
25	.9042	59	.7428	93	.6303
26	.8984	60	.7389	94	.6275
27	.8927	61	.7351	95	.6247
28	.8871	62	.7313	96	.6220
29	.8816	63	.7275	97	.6193
30	.8762	64	.7238	98	.6166
31	.8708	65	.7201	99	.6139
32	.8654	66	.7165	100	.6112
33	.8602	67	.7128		

$$\text{SP. GR.} = \frac{141.5}{131.5 + {}^\circ\text{A. P. I.}}$$

TABLE X

METER FACTORS, M, FOR L-10 CHARTS

Defferential Range of (R_h) Meter, Inches	Maximum Pressure Range of Meter in Pounds absolute; for gas or air at varying pressure (R_s) 24.7	50	100	250	500	1000	1500
2 1/2	0.0786						
10	0.1572	0.2236					
20	0.2223	0.3162	0.4472	0.7071	1.0000		
50	0.3514	0.5000	0.7071	1.1180	1.5810	2.2360	2.7390
100		0.7071	1.0000	1.5810	2.2360	3.1620	3.8730

$$M = 0.01 \quad (R_h \times R_s)^{1/2}$$

R_h = is maximum differential range, inches

R_s = is maximum static range, pounds

TABLE OF SQUARE ROOTS

N	√N	N	√N	N	√N	N	√N	N	√N
		50	7.071	100	10.000	150	12.247	200	14.142
1	1.000	51	7.141	101	10.050	151	12.288	201	14.177
2	1.414	52	7.211	102	10.100	152	12.329	202	14.213
3	1.732	53	7.280	103	10.149	153	12.369	203	14.248
4	2.000	54	7.348	104	10.198	154	12.410	204	14.283
5	2.236	55	7.416	105	10.247	155	12.450	205	14.318
6	2.449	56	7.483	106	10.296	156	12.490	206	14.353
7	2.646	57	7.550	107	10.344	157	12.530	207	14.387
8	2.828	58	7.616	108	10.392	158	12.570	208	14.422
9	3.000	59	7.681	109	10.440	159	12.610	209	14.457
10	3.162	60	7.746	110	10.488	160	12.649	210	14.491
11	3.317	61	7.810	111	10.536	161	12.689	211	14.526
12	3.464	62	7.874	112	10.583	162	12.728	212	14.560
13	3.606	63	7.937	113	10.630	163	12.767	213	14.595
14	3.742	64	8.000	114	10.677	164	12.806	214	14.629
15	3.873	65	8.062	115	10.724	165	12.845	215	14.663
16	4.000	66	8.124	116	10.770	166	12.884	216	14.697
17	4.123	67	8.185	117	10.817	167	12.923	217	14.731
18	4.243	68	8.246	118	10.863	168	12.961	218	14.765
19	4.359	69	8.307	119	10.909	169	13.000	219	14.799
20	4.472	70	8.367	120	10.954	170	13.038	220	14.832
21	4.583	71	8.426	121	11.000	171	13.077	221	14.866
22	4.690	72	8.485	122	11.045	172	13.115	222	14.900
23	4.796	73	8.544	123	11.091	173	13.153	223	14.933
24	4.899	74	8.602	124	11.136	174	13.191	224	14.967
25	5.000	75	8.660	125	11.180	175	13.229	225	15.000
26	5.099	76	8.718	126	11.225	176	13.266	226	15.033
27	5.196	77	8.775	127	11.269	177	13.304	227	15.067
28	5.292	78	8.832	128	11.314	178	13.342	228	15.100
29	5.385	79	8.888	129	11.358	179	13.379	229	15.133
30	5.477	80	8.944	130	11.402	180	13.416	230	15.166
31	5.568	81	9.000.	131	11.446	181	13.454	231	15.199
32	5.657	82	9.055	132	11.489	182	13.491	232	15.232
33	5.745	83	9.110	133	11.533	183	13.528	233	15.264
34	5.831	84	9.165	134	11.576	184	13.565	234	15.297
35	5.916	85	9.220	135	11.619	185	13.601	235	15.330
36	6.000	86	9.274	136	11.662	186	13.638	236	15.362
37	6.083	87	9.327	137	11.705	187	13.675	237	15.395
38	6.164	88	9.381	138	11.747	188	13.711	238	15.427
39	6.245	89	9.434	139	11.790	189	13.748	239	15.460
40	6.325	90	9.487	140	11.832	190	13.784	240	15.492
41	6.403	91	9.539	141	11.874	191	13.820	241	15.524
42	6.481	92	9.592	142	11.916	192	13.856	242	15.556
43	6.557	93	9.644	143	11.958	193	13.892	243	15.588
44	6.633	94	9.695	144	12.000	194	13.928	244	15.620
45	6.708	95	9.747	145	12.042	195	13.964	245	15.652
46	6.782	96	9.798	146	12.083	196	14.000	246	15.684
47	6.856	97	9.849	147	12.124	197	14.036	247	15.716
48	6.928	98	9.899	148	12.166	198	14.071	248	15.748
49	7.000	99	9.950	149	12.207	199	14.107	249	15.780

TABLE OF SQUARE ROOTS

N	√N	N	√N	N	√N	N	√N	N	√N
250	15.811	300	17.321	350	18.708	400	20.000	450	21.213
251	15.843	301	17.349	351	18.735	401	20.025	451	21.237
252	15.875	302	17.378	352	18.762	402	20.050	452	21.260
253	15.906	303	17.407	353	18.788	403	20.075	453	21.284
254	15.937	304	17.436	354	18.815	404	20.100	454	21.307
255	15.969	305	17.464	355	18.841	405	20.125	455	21.331
256	16.000	306	17.493	356	18.868	406	20.149	456	21.354
257	16.031	307	17.521	357	18.894	407	20.174	457	21.378
258	16.062	308	17.550	358	18.921	408	20.199	458	21.401
259	16.093	309	17.578	359	18.947	409	20.224	459	21.424
260	16.125	310	17.607	360	18.974	410	20.248	460	21.448
261	16.155	311	17.635	361	19.000	411	20.273	461	21.471
262	16.186	312	17.664	362	19.026	412	20.298	462	21.494
263	16.217	313	17.692	363	19.053	413	20.322	463	21.517
264	16.248	314	17.720	364	19.079	414	20.347	464	21.541
265	16.279	315	17.748	365	19.105	415	20.372	465	21.564
266	16.310	316	17.776	366	19.131	416	20.396	466	21.587
267	16.340	317	17.804	367	19.157	417	20.421	467	21.610
268	16.371	318	17.833	368	19.183	418	20.445	468	21.633
269	16.401	319	17.861	369	19.209	419	20.469	469	21.656
270	16.432	320	17.889	370	19.235	420	20.494	470	21.679
271	16.462	321	17.916	371	19.261	421	20.518	471	21.703
272	16.492	322	17.944	372	19.287	422	20.543	472	21.726
273	16.523	323	17.972	373	19.313	423	20.567	473	21.749
274	16.553	324	18.000	374	19.339	424	20.591	474	21.772
275	16.583	325	18.028	375	19.365	425	20.616	475	21.794
276	16.613	326	18.055	376	19.391	426	20.640	476	21.817
277	16.643	327	18.083	377	19.416	427	20.664	477	21.840
278	16.673	328	18.111	378	19.442	428	20.688	478	21.863
279	16.703	329	18.138	379	19.468	429	20.712	479	21.886
280	16.733	330		380	19.494	430	20.736	480	21.909
281	16.763	331	18.193	381	19.519	431	20.761	481	21.932
282	16.793	332	18.221	382	19.545	432	20.785	482	21.954
283	16.823	333	18.248	383	19.570	433	20.809	483	21.977
284	16.852	334	18.276	384	19.596	434	20.833	484	22.000
285	16.882	335	18.303	385	19.621	435	20.621	485	22.023
286	16.912	336	18.330	386	19.647	436	20.881	486	22.045
287	16.941	337	18.358	387	19.672	437	20.905	487	22.068
288	16.971	338	18.385	388	19.698	438	20.928	488	22.091
289	17.000	339	18.412	389	19.723	439	20.952	489	22.113
290	17.029	340	18.439	390	19.748	440	20.976	490	22.136
291	17.059	341	18.466	391	19.774	441	21.000	491	22.159
292	17.088	342	18.498	392	19.799	442	21.024	492	22.181
293	17.117	343	18.520	393	19.824	443	21.048	493	22.204
294	17.146	344	18.547	394	19.849	444	21.071	494	22.226
295	17.176	345	18.574	395	19.875	445	21.095	495	22.249
296	17.205	346	18.601	396	19.900	446	21.119	496	22.271
297	17.234	347	18.628	397	19.925	447	21.142	497	22.293
298	17.263	348	18.655	398	19.950	448	21.166	498	22.316
299	17.292	349	18.682	399	19.975	449	21.190	499	22.338

TABLE OF SQUARE ROOTS

N	√N	N	√N	N	√N	N	√N	N	√N
500	22.361	550	23.452	600	24.495	650	25.495	700	26.458
501	22.383	551	23.473	601	24.515	651	25.515	701	26.476
502	22.405	552	23.495	602	24.536	652	25.534	702	26.495
503	22.428	553	23.516	603	24.556	653	25.554	703	26.514
504	22.450	554	23.537	604	24.576	654	25.573	704	26.533
505	22.472	555	23.558	605	24.597	655	25.593	705	26.552
506	22.494	556	23.580	606	24.617	656	25.612	706	26.571
507	22.517	557	23.601	607	24.637	657	25.632	707	26.589
508	22.539	558	23.622	608	24.658	658	25.652	708	26.608
509	22.561	559	23.643	609	24.678	659	25.671	709	26.627
510	22.583	560	23.664	610	24.698	660	25.690	710	26.646
511	22.605	561	23.685	611	24.718	661	25.710	711	26.665
512	22.627	562	23.707	612	24.739	662	25.729	712	26.683
513	22.650	563	23.728	613	24.759	663	25.749	713	26.702
514	22.672	564	23.749	614	24.779	664	25.768	714	26.721
515	22.694	565	23.770	615	24.799	665	25.788	715	26.739
516	22.716	566	23.791	616	24.819	666	25.807	716	26.758
517	22.738	567	23.812	617	24.839	667	25.826	717	26.777
518	22.760	568	23.833	618	24.800	668	25.846	718	26.796
519	22.782	569	23.854	619	24.880	669	25.865	719	26.814
520	22.804	570	23.875	620	24.900	670	25.884	720	26.833
521	22.825	571	23.896	621	24.920	671	25.904	721	26.851
522	22.847	572	23.917	622	24.940	672	25.923	722	26.870
523	22.869	573	23.937	623	24.960	673	25.942	723	26.889
524	22.891	574	23.958	624	24.980	674	25.962	724	26.907
525	22.913	575	23.979	625	25.000	675	25.981	725	26.926
526	22.935	576	24.000	626	25.020	676	26.000	726	26.944
527	22.956	577	24.021	627	25.040	677	26.019	727	26.963
528	22.978	578	23.042	628	25.060	678	26.038	278	26.981
529	23.000	579	24.062	629	25.080	679	26.058	729	27.000
530	23.022	580	24.083	630	25.100	680	26.077	730	27.019
531	23.043	581	24.104	631	25.120	681	26.096	731	27.037
532	23.065	582	24.125	632	25.140	682	26.115	732	27.055
533	23.087	583	24.145	633	25.159	683	26.134	733	27.074
534	23.108	584	24.166	634	25.179	684	26.153	734	27.092
535	23.130	585	24.187	635	25.199	685	26.173	735	27.111
536	23.152	586	24.207	636	25.219	686	26.192	736	27.129
537	23.173	587	24.228	637	25.239	687	26.211	737	27.148
538	23.195	588	23.249	638	25.259	688	26.230	738	27.166
539	23.216	589	23.269	639	25.278	689	26.249	739	27.185
540	23.238	590	24.290	640	25.298	690	26.268	740	27.203
541	23.259	591	24.310	641	25.318	691	26.287	741	27.221
542	23.281	592	24.331	642	25.338	692	26.306	742	27.240
543	23.302	593	24.352	643	25.357	693	26.325	743	27.258
544	23.324	594	24.372	644	25.377	694	26.344	744	27.276
545	23.345	595	24.393	645	25.397	695	26.363	745	27.295
546	23.367	596	24.413	646	25.417	696	26.382	746	27.313
547	23.388	597	24.434	647	25.436	697	26.401	747	27.331
548	23.409	598	24.454	648	25.456	698	26.420	748	27.350
549	23.431	599	24.474	649	25.475	699	26.439	749	27.368

TABLE OF SQUARE ROOTS

N	√N	N	√N	N	√N	N	√N	N	√N
750	27.386	800	28.284	850	29.155	900	30.000	950	30.822
751	27.404	801	28.302	851	29.172	901	30.017	951	30.838
752	27.423	802	28.320	852	29.189	902	30.033	952	30.854
753	27.441	803	28.337	853	29.206	903	30.050	953	30.871
754	27.459	804	28.355	854	29.223	904	30.067	954	30.887
755	27.477	805	28.373	855	29.240	905	30.083	955	30.903
756	27.495	806	28.390	856	29.257	906	30.100	956	30.919
757	27.514	807	28.408	857	29.275	907	30.116	957	30.935
758	27.532	808	28.425	858	29.292	908	30.133	958	30.952
759	27.550	809	28.443	859	29.309	909	30.150	959	30.968
760	27.568	810	28.460	860	29.326	910	30.166	960	30.984
761	27.586	811	28.478	861	29.343	911	30.183	961	31.000
762	27.604	812	28.496	862	29.360	912	30.199	962	31.016
763	27.622	813	28.513	863	29.377	913	30.216	963	31.032
764	27.641	814	28.531	864	29.394	914	30.232	964	31.048
765	27.659	815	28.548	865	29.411	915	30.249	965	31.064
766	27.677	816	28.566	866	29.428	916	30.265	966	31.081
767	27.695	817	28.583	867	29.445	917	30.282	967	31.097
768	27.713	818	28.601	868	29.462	918	30.299	968	31.113
769	27.731	819	28.618	869	29.479	919	30.315	969	31.129
770	27.749	820	28.636	870	29.496	920	30.332	970	31.145
771	27.767	821	28.653	871	29.513	921	30.348	971	31.161
772	27.785	822	28.671	872	29.530	922	30.364	972	31.177
773	27.803	823	28.688	873	29.547	923	30.381	973	31.193
774	27.821	824	28.705	874	29.563	924	30.397	974	31.209
775	27.839	825	28.723	875	29.580	925	30.414	975	31.225
776	27.857	826	28.740	876	29.597	926	30.430	976	31.241
777	27.875	827	28.758	877	29.614	927	30.447	977	31.257
778	27.893	828	28.775	878	29.631	928	30.463	978	31.273
779	27.911	829	28.792	879	29.648	929	30.480	979	31.289
780	27.928	830	28.810	880	29.665	930	30.496	980	31.305
781	27.946	831	28.827	881	29.682	931	30.512	981	31.321
782	27.964	832	28.844	882	29.698	932	30.529	982	31.337
783	27.982	833	28.862	883	29.715	933	30.545	983	31.353
784	28.000	834	28.879	884	29.732	934	30.561	984	31.369
785	28.018	835	28.896	885	29.749	935	30.578	985	31.385
786	28.036	836	28.914	886	29.766	936	30.594	986	31.401
787	28.054	837	28.931	887	29.783	937	30.610	987	31.417
788	28.071	838	28.948	888	29.799	938	30.627	988	31.432
789	28.089	839	28.965	889	29.816	939	30.643	989	31.448
790	28.107	840	28.983	890	29.833	940	30.659	990	31.464
791	28.125	841	29.000	891	29.850	941	30.676	991	31.480
792	28.142	842	29.017	892	29.866	942	30.692	992	31.496
793	28.160	843	29.034	893	29.883	943	30.708	993	31.512
794	28.178	844	29.052	894	29.900	944	30.725	994	31.528
795	28.196	845	29.069	895	29.917	945	30.741	995	31.544
796	28.213	846	29.086	896	29.933	946	30.757	996	31.559
797	28.231	847	29.103	897	29.950	947	30.773	997	31.575
798	28.249	848	29.120	898	29.967	948	30.790	998	31.591
799	28.267	849	29.138	899	29.983	949	30.806	999	31.607

A P P E N D I C E S

APPENDIX A

SOURCE OF THE TERM F_c USED IN THE CALCULATION OF EQUIVALENT STATIC COLUMN WELLHEAD PRESSURES

The calculation of the equivalent static column wellhead pressure corresponding to a flowing wellhead pressure is carried out through use of the following equation:

$$P_w^2 = P_t^2 + F^2T^2Z^2 \; (1-e^{-s}) \quad \text{------------------------}(1)$$

where:

$$F^2 = \frac{2.6665 \; f \; Q^2}{d^5}$$

$$S = \frac{0.0375 \; GL}{TZ}$$

G = Specific gravity (air = 1.00)

L = Length of flow string, ft.

P = Pressure, psia (P^2 in thousands)

Q = Rate of flow, M^2cfd @ 14.65 psia, and 60°F.

T = Effective absolute temperature, °R.

Z = Effective compressibility factor.

d = Internal diameter of flow string, in.

f = Coefficient of friction, dimensionless.

Through use of the complete turbulence portion of the curves published by Lewis F. Moody in November 1944, Transactions of the A.S.M.E., it is possible to determine the value of (f) for various sizes of pipe at a constant absolute roughness of 0.0006 in., which value is considered valid for clean pipe.

Using the values of (f) so determined, it is possible to arrive at a correlation of friction coefficient (f) vs. internal diameter (d) which is reasonably correct. It was found for an absolute roughness of 0.0006 in. that the value of (f) could be expressed as follows:

$$f = \frac{4.372 \times 10^{-3}}{d^{0.224}} \quad \text{for diameters less than 4.277 in.}$$

and

$$f = \frac{4.007 \times 10^{-3}}{d^{0.164}} \quad \text{for diameters greater than 4.277 in.}$$

If the expression $(F_cQ)^2$ is allowed to represent the expression $(F^2T^2Z^2)$ in equation (1), then the value of F_c can be shown to be those given in Table VII, A, B and C.

APPENDIX B

THE GENERAL FLOW EQUATION AND THE DEVELOPMENT OF VARIOUS FORMULAS FOR THE FLOW OF GAS IN PIPES

If it is assumed that the change in kinetic energy due to the flow of gas is negligable, the general equation for the flow of gas in pipes may be expressed as follows:

General Flow Equation

$$\frac{1000\ GL}{53.33} = \int_{P_2}^{P_1} \frac{P/TZ \quad d\,(P)}{\frac{2.6665\ fQ^2}{d^5} + \frac{H}{L}\,(\bar{P}/TZ)^2} \text{ ------------------- (1).}$$

G = Specific gravity (Air = 1.00)

H = Difference in elevation, ft.

L = Length, ft.

P = Pressure, psia ($\bar{p}^2$ in thousands)

Q = Rate of flow, M^2cfd @ 14.65 psia and 60°F.

T = Absolute temperature, °R.

Z = Compressability factor, dimensionless.

d = Internal diameter, inches.

f = Coefficient of friction, dimensionless.

If we let

$$F^2 = \frac{2.6665\ fQ^2}{d^5} \text{ ----------------------------- (2).}$$

then

$$\frac{1000\ GL}{53.33} = \int_{P_2}^{P_1} \frac{P/TZ \quad d\,(P)}{F^2 + \frac{H}{L}\,(P/TZ)^2} \text{ ---------------------- (3).}$$

INCLINED STATIC COLUMN

In a static column of gas Q = 0, consequently F^2 = 0, then EQ. (3) may be expressed as follows:

$$\frac{GH}{53.33} = \int_{P_c}^{P_f} \frac{TZ}{P}\, d\,(P) \text{ ------------------------------(4)}$$

where,

P_c = Shut-in wellhead pressure, psia.

P_f = Formation pressure, psia

Without making certain assumptions with respect to T and Z, EQ. (4) does not lend itself to mathmatical integration; however, an evaluation of the integral over definite limits can be accomplished by numerical means.

In order to evaluate the expression

$$\int_{P_o}^{P_n} \frac{TZ}{P}\, d\,(P) \text{ ------------------------------(5)}$$

it is necessary to calculate the value of $\frac{TZ}{P}$ for P_o and appropriate values of P_i where i = (0, 1, 2, 3 -------n)

If we let,

$$I = \frac{TZ}{P} \text{ ---(6)}$$

then

$$\int_{P_o}^{P_n} \frac{TZ}{P}\, d\,(P) = 1/2 \quad (P_1-P_o)\,(I_1-I_o) + (P_2-P_1)\,(I_2+I_1) + \text{----}$$
$$\text{---------} + (P_n-P_{n-1})\,(I_n+I_{n-1}) \text{ --------(7)}$$

Where the variation of temperature with depth is known, it is necessary to assume appropriate values for the depth; determine the temperature (T) and determine P_1 by trial and error so that

$$\frac{2\ GH_1}{53.33} = \left[(P_1-P_0)\ (I_1+I_0) + (P_2-P_1)\ (I_2+I_1)\right],$$

$$\frac{2\ GH_2}{53.33} = \left[(P_1-P_0)\ (I_1+I_0) + (P_2-I_1) + (P_3-P_2)\ (I_3+I_2)\right],$$

and

$$\frac{2GH}{53.33} = \left[(P_1-P_0)(I_1+I_0) + (P_2-P_1)\ (I_2+I_1) + \text{-------} + (P_n-P_{n-1})(I_n+I_{n-1})\right]$$

The method is rather tedious if a large number of increments are chosen for (H); however, in many cases the total depth may be considered in one increment without causing appreciable error.

A two increment calculation may also be made with Simpson's Rule being applied to the result obtained to minimize the error in the final result.

An example of each method is shown in the attached tables.

CALCULATION SHEET FOR STATIC COLUMN PRESSURES

COMPANY__________ LEASE__________ WELL NO.__________ DATE__________

G 0.850 % CO_2 28 % N__________ Cr. Press. 788 Cr. Temp. 393

							I	M	N			
H	P_n	P_r	T	T_r	Z	TZ	TZ/P	P_n-P_{n-1}	I_n-I_{n-1}	MxN	Σ(MxN)	0.0375 x GH
0	4465	5.67	564	1.44	0.821	463.044	.103705					
1000	4619	5.86	571	1.45	0.837	477.927	.103470	154	.207175	31.905	31.905	31.875
2000	4773	6.06	577	1.47	0.856	493.912	.103480	154	.206950	31.870	63.775	63.750
3000	4927	6.25	584	1.49	0.873	509.832	.103477	154	.206957	31.871	95.646	95.625
4000	5081	6.45	591	1.50	0.889	525.399	.103405	154	.206882	31.860	127.506	127.500
5000	5236	6.64	597	1.52	0.897	535.509	.102274	155	.205679	31.880	159.386	159.375
6000	5391	6.84	604	1.54	0.921	556.284	.103188	155	.205462	31.847	191.233	191.250
7000	5546	7.04	611	1.55	0.935	571.285	.103008	155	.206196	31.960	223.193	223.125
8000	5700	7.23	618	1.57	0.952	588.336	.103217	154	.206225	31.759	254.952	255.000
9000	5855	7.43	624	1.59	0.967	603.408	.103058	155	.206275	31.973	286.925	286.875
10000	6010	7.63	631	1.60	0.980	618.380	.102892	155	.205950	31.922	318.847	318.750
11000	6164	7.82	638	1.62	0.994	634.172	.102883	154	.205775	31.689	350.536	350.625
12000	6319	8.02	644	1.64	1.009	649.796	.102832	155	.205715	31.886	382.422	382.500
13148	6497	8.24	652	1.66	1.024	667.648	.102762	178	.205594	36.596	419.018	419.093

T @ H = 0 = 104°F = 564°R
T @ H = 13148 = 192° F = 652°R

$\frac{88}{13148} \times 1000 = 6.69^\circ/1000$ ft

CASE I

Numerical Evaluation of the Definite Integral

$$\int_{P_c}^{P_f} \frac{TZ}{P} d(P)$$ using 1000 ft. intervals

CALCULATION SHEET FOR STATIC COLUMN PRESSURES

COMPANY__________ LEASE__________ WELL NO.__________ DATE__________

G 0.850 % CO_2 28 %N __________ Cr. Press. 788 Cr.Temp. 393

							I	M	N			
H	P_n	P_r	T	T_r	Z	TZ	TZ/P	$P_n - P_{n-1}$	$I_n + I_{n-1}$	MxN	(MxN)	0.0375 xGH
0	4465	5.67	564	1.44	0.821	463.044	.103705				0	0
13148	6494	8.24	652	1.66	1.024	667.648	.102810	2029	.206515	419.019	419.019	419.09

T @ H = 0 = 104°F = 564° R
T @ H = 13148 = 192°F = 652 °R

CASE II

Numerical Evaluation of the Definite Integral

$$\int_{P_s}^{P_f} \frac{TZ}{P} d(P)$$ by One Interval

PROPOSED REVISION OF ORDERS R-333-C&D AND R-333-E

The following is a copy of the proposed Special Rules and Regulations governing gas well testing in the San Juan Basin which will be considered at a hearing to be held in the Oil Conservation Commission Conference Room, State Land Office Building, Santa Fe, New Mexico, at 9:00 a.m., November 8, 1962.

These rules would supersede Commission Orders R-333-C and D and R-333-E and would govern gas well testing in the Counties of San Juan, Rio Arriba, McKinley, and Sandoval. 1-56

GAS WELL TESTING RULES AND PROCEDURES FOR SAN JUAN BASIN AREA

SECTION A. TYPE OF GAS WELL TESTS REQUIRED:

I. THE INITIAL DELIVERABILITY AND SHUT-IN PRESSURE TESTS FOR NEWLY COMPLETED GAS WELLS.

(A) Immediately upon completion of each gas well in San Juan Basin, a shut-in pressure test of at least 7 days duration shall be made.

(B) Within 60 days after a well is connected to a gas transportation facility the well shall be tested in accordance with Section B, Subsection I, Paragraph (A) of this order, and the results of the test reported to the Commission, and to the gas transportation facility to which the well is connected. Failure to file the required test within the time prescribed above will subject the delinquent well to the loss of one day's allowable for each day the test is late.

(C) Any tests accomplished for information purposes prior to pipeline connection shall not be recognized as an official test for the establishment of allowables.

II. ANNUAL DELIVERABILITY AND SHUT-IN PRESSURE TESTS:

Annual Deliverability and Shut-In Pressure Tests of all producing

BEFORE EXAMINER NUTTER
OIL CONSERVATION COMMISSION
OCC EXHIBIT NO. 1
CASE NO. 2685

gas wells are required to be made during the period from January 1, through December 31, of each year.

1. Annual Deliverability and Shut-In Pressure tests shall not be required during the current annual test period for wells connected after October 31 to a gas transportation facility but such tests may be taken at the option of operator.

2. An initial deliverability test accomplished in accordance with annual testing procedures set out in this order shall be used as the annual test of the well for the year in which the test was accomplished.

All Annual Deliverability and Shut-In Pressure Tests required by this order shall be filed with the Commission and with the gas transportation facility to which the wells are connected within thirty (30) days after the end of the month during which the test is completed; provided however, that all tests completed during the period from December 1 through December 31, shall be reported not later than January 10 of the following year. Failure to file the required tests within the time prescribed above may subject the delinquent wells to the loss of one day's allowable for each day the test is late. No extension of time will be allowed after January 10, except after notice and hearing.

III. SCHEDULE OF TESTS:

(A) ANNUAL DELIVERABILITY TESTS

At least 30 days prior to the beginning of the tests the gas transportation facilities receiving gas from wells to be tested shall, in cooperation with respective operators, submit to the Commission's Aztec office a testing schedule for the Annual Deliverability and Shut-in Pressure Tests. Three copies of the schedule shall be furnished to the Commission and one copy shall be furnished to each operator concerned. Such schedule shall indicate the dates of tests, pool, operator, lease, well number and location of each well. The gas transportation facility making the schedule of tests shall be notified immediately by any operator unable to take such tests as scheduled.

When an Initial Deliverability Test accomplished in accordance with annual testing procedures is to be used as an annual test the operator shall notify the Commission, and the gas transportation facility to which the well is connected, in writing during the fourteen day conditioning period for said test.

In the event a well is not tested in accordance with the test schedule, the well shall be re-scheduled for testing, and the Commission shall be notified of such fact in writing not later than the fourteen day conditioning period for said test.

It shall be the responsibility of each operator to determine that its wells are properly scheduled by the transportation facility to which its wells are connected, in order that said wells can be tested within the testing season.

(B) DELIVERABILITY RETESTS

An operator may, in cooperation with the transportation facility, schedule a well for a deliverability retest by notification to the Commission ten (10) days before the retest is to commence. Such notification shall consist of scheduling the well as required for the annual deliverability test in subsection III, Paragraph A, above. Such retest shall be for good and substantial reason and shall be subject to the approval of the Commission, and conducted in conformance with the Annual Deliverability Test procedures of this order. The Commission may at its discretion require the retesting of any well by notification to the operator to schedule such retest.

The requirements for Initial and Annual Deliverability Tests and the notification and scheduling of such tests which apply to newly completed wells shall also apply to reworked or recompleted wells.

IV. WHO MAY WITNESS TESTS:

Any initial or annual deliverability and shut-in pressure test may be witnessed by any or all of the following: an agent of the Commission, an offset operator, a representative of the pipeline company taking gas from an offset operator, or a representative of a pipeline company taking gas from the well under test.

SECTION B. PROCEDURE FOR TESTS:

I. MESAVERDE FORMATION:

(A) INITIAL DELIVERABILITY AND SHUT-IN PRESSURE TEST

1. Within sixty days (60) after a newly completed well is connected to a gas transportation facility the operator shall accomplish a deliverability and shut-in pressure test in conformance with annual test procedures

of this order and results reported as required in Section A, Subsection I, or:

2. In the event that it is impractical to test a newly completed well in accordance with paragraph 1 above, the operator may accomplish a deliverability and shut-in pressure test in the following manner:

(a) A seven or eight day production chart may be used as a basis for determining the well's deliverability, providing the chart so used is preceded by at least fourteen (14) days continuous production. The well shall produce through either the casing or tubing, but not both, into a pipeline during these periods. The production valve and the choke settings shall not be changed during either the conditioning or flow period with the exception of the first week of the conditioning period when maximum production would over-range the meter chart [redacted]or location production equipment.

(b) A shut-in pressure of at least seven days duration shall be taken. This shall be the shut-in test required in Section A, Subsection I, Paragraph (A).

(c) The average daily static meter pressure shall be determined in accordance with Section B, subsection I, Paragraph (B). This pressure shall be used as P_t in calculating P_w for the Deliverability Calculation.

(d) The daily average rate of flow shall be determined in accordance with Section B, Subsection I, Paragraph (B) of this order.

(e) The static wellhead working pressure (P_w) shall be determined in accordance with Section B, Subsection I, Paragraph (B) of this order.

(f) The deliverability of the well shall be determined by using the data determined in Paragraphs (a) through (e) above, in the deliverability formula in accordance with Section B, Subsection I, Paragraph (B) of this order.

(g) The data and calculations for the above Paragraphs (a) through (f) shall be reported as required in Section A, Subsection I, upon the blue colored Form C-122-A.

(B) THE ANNUAL DELIVERABILITY AND SHUT-IN PRESSURE TESTS

This test shall be taken by producing a well into the pipeline through either the casing or tubing, but not both. The production valve and choke settings shall not be changed during either the conditioning or flow periods except during the first seven (7) days of the conditioning period when maximum production would overrange the meter chart and/or the location production equipment. The daily flowing rate shall be determined from an average of seven (7) consecutive producing days, following a minimum conditioning period of fourteen (14) consecutive days production. The first seven (7) days of said conditioning period shall have not more than one (1) interruption, which interruption shall be no longer than 36 continuous hours in duration. The eighth to fourteenth days, inclusive, of said conditioning period shall have no interruptions whatsoever. All such production during the fourteen (14) days conditioning period plus the seven (7) day deliverability test period shall be at static wellhead working pressures not in excess of seventy-five (75) percent of the previous annual seven (7) day shut-in pressure of such well if such previous annual shut-in pressure information is available; otherwise, the seven (7) day initial deliverability shut-in pressure of such well shall be used.

In the event that the existing line pressure does not permit a drawdown as specified above, with the well producing unrestrictedly into the pipeline, the operator shall request an exception to this requirement on the Form C-122-A. The request shall state the reasons for the necessity for the exception.

Instantaneous pressures shall be measured by deadweight gauge during the seven day flow period at the casinghead, tubinghead, and orifice meter and recorded along with the instantaneous meter chart static pressure reading.

When it is necessary to restrict the flow of gas between the wellhead and orifice meter the ratio of the downstream pressure to the upstream pressure shall be determined. When this ratio is 0.57, or less, critical flow conditions shall be considered to exist across the restriction.

When more than one restriction between the wellhead and orifice meter causes the pressures to reflect critical flow between the wellhead and orifice meter the pressures across each of these restrictions shall be measured to determine whether critical flow exists at any restriction. When critical flow does not exist at any restriction the pressures taken to disprove critical flow shall be reported to the Commission on Form C-122-A in the "remarks" section of the form. When critical flow conditions exist, the instantaneous flowing pressures required hereinabove shall be measured during the last forty-eight (48) hours of the seven (7) day flow period.

When critical flow exists between the wellhead and orifice meter, the measured wellhead flowing pressure of the string through which the well flowed during test shall be used as P_t when calculating the static wellhead working pressure (P_w) using the method established below.

When critical flow does not exist at any restriction, P_t shall be the corrected average static pressure from the meter chart plus friction loss from the wellhead to the orifice meter.

The static wellhead working pressure (P_w) of any well under test shall be the calculated seven (7) day average static tubing pressure if the well is flowing through the casing; or the calculated seven (7) day average static casing pressure if the well is flowing through the tubing. The static wellhead working pressure (P_w) shall be calculated by applying the tables and procedures as set out in New Mexico Oil Conservation Commission Manual entitled "Method of Calculating Pressure Loss Due to Friction in Gas Well Flow Strings" for San Juan Basin.

To obtain the shut-in pressure of a well under test the well shall be shut-in immediately after the seven (7) day deliverability test for the full period of seven (7) consecutive days. Such shut-in pressure shall be measured within the next succeeding twenty-four (24) hours following the seven (7) day shut-in period aforesaid. The seven-day (7) shut-in pressure shall be measured on both the tubing and the casing when communication exists between the two strings. The high of such pressures shall be used as P_c in the deliverability calculation. When any such shut-in pressure has been determined by the Commission to be abnormally low, or when only one pressure is available, the shut-in pressure to be used shall be determined by one of the following methods:

1. A Commission designated value.
2. An average shut-in pressure of all offset wells completed in the same zone.
3. A calculated surface pressure based on a measured bottom hole pressure. Such calculation shall be made in accordance with New Mexico Oil Conservation Commission Back Pressure Manual, Example No. 7.

All wellhead pressures as well as the flowing meter pressure tests which are to be taken during the seven (7) day deliverability test period, as required hereinabove, shall be taken with a deadweight gauge. The deadweight reading, the date and time according to the chart shall be recorded and maintained in the companies records with the test information.

Orifice meter charts shall be changed and so arranged as to reflect upon a single chart the flow data for the gas from each well for the full seven-day deliverability test period; except that no tests shall be voided if satisfactory explanation is made as to the necessity for using test volumes through two chart periods. Corrections shall be made for pressure base, measured flowing temperature, specific gravity, and supercompressibility provided however, that if the specific gravity of the gas from any well under test is not available, an estimated specific gravity may be assumed therefor, based upon that of gas from near-by wells, the specific gravity of which has been actually determined by measurement.

The seven (7) day average flowing meter pressure shall be calculated by taking the average of all consecutive 2-hour flowing meter pressure readings as recorded on the seven (7) day flow period chart (test chart #3). The pressure so calculated shall be used in calculating the wellhead working pressure, determining supercompressibility factors and calculating flow volumes.

The seven (7) day flow period volume shall be calculated from the integrated readings as determined from the flow period orifice meter chart, (chart #3). The volume so calculated shall be divided by the number of testing days on the chart to determine the average daily flow period rate of flow. The flow chart shall have legibly recorded a minimum of seven (7) days and a maximum of eight (8) flowing days to be acceptable for test purposes. The volume used in this calculation shall be corrected to New Mexico Oil Conservation Commission standard conditions.

The average flowing meter pressure for the seven (7) day or eight (8) day flow period and the corrected integrated volume shall be determined by the purchasing company that integrates the flow charts and furnished to the operator or testing agency when such operator or testing agency requests such information.

The daily volume of flow as determined from the flow period chart (Test Chart #3) integrator readings shall be calculated by applying the Basic Orifice meter formula.

$$Q = C' \sqrt{h_w \quad p_f}$$

Where:

Q = Metered volume of flow MCFD @ 15.025, 60° F. and .60 specific gravity.

C' = The 24-hour basic orifice meter flow factor corrected for flowing temperature, gravity and supercompressibility.

h_w = Daily average differential meter pressure from flow period chart.

P_f = Daily average flowing meter pressure from flow period chart.

The basic orifice meter flow factors, flowing temperature factor and specific gravity factor shall be determined from New Mexico Oil Conservation Commission Back Pressure Test Manual.

The daily flow period average corrected flowing meter pressure, psig, shall be used to determine the supercompressibility factor. Supercompressibility Tables may be obtained from the New Mexico Oil Conservation Commission.

When supercompressibility correction is made for a gas containing either nitrogen or carbon dioxide in excess of 2 percent, the supercompressibility factors of such gas shall be determined by the use of Table V of the C.N.G.A. Bulletins TS-402 for pressure 100-500 psig or Table II, TS-461 for pressures in excess of 500 psig.

The use of tables for calculating rates of flow from integrator readings, which do not specifically conform to New Mexico Oil Conservation Commission Back Pressure Test Manual may be approved for determining the daily flow period rates of flow upon a showing that such tables are appropriate and necessary.

The daily average integrated rate of flow for the seven-day flow period shall be corrected for meter error by the multiplication by a correction factor determined by dividing the square root of the chart flowing meter pressure psia into the square root of the deadweight flowing meter pressure psia.

Deliverability pressure, as used herein for the Mesaverde formation, is a defined pressure applied to each well and used in the process of comparing the abilities of wells in this formation to produce at static wellhead working pressures equal to a percentage of the seven (7) day shut-in pressure of the respective individual wells. Such percentage shall be determined periodically by the Commission based on the relationship of the average static wellhead working pressures (P_w) divided by the average (P_c) seven-day shut-in pressure of the pool.

The deliverability of gas at the "deliverability pressure" of any well under test shall be calculated from the test data derived from the tests hereinabove required by use of the following deliverability formula:

$$D = Q \left[\frac{\left(P_c^2 - P_d^2\right)}{\left(P_c^2 - P_w^2\right)} \right]^n$$

WHERE:

D	=	Deliverability at the deliverability pressure, (P_d) Mcfd, (at Standard Condition of 15.025 psia and 60° F).
Q	=	Daily flow rate in Mcfd, at wellhead pressure (P_w).
P_c	=	7-day shut-in wellhead pressure, psia, determined in accordance with Section B, Subsection I, Paragraph (B).
P_d	=	Deliverability pressure; psia, as defined above.
P_w	=	Average static wellhead working pressure, as determined from 7-day flow period, psia, and calculated from New Mexico Oil Conservation Commission "Pressure Loss Due to Friction" Tables.
n	=	Average pool slope of back pressure curve (.75) for Mesaverde wells).

The value of the multiplier in the above formula (ratio factor after the application of the pool slope) by which Q is multiplied shall not exceed a limiting value to be determined periodically by the Commission. Such determination shall be made after a study of the test data of the pool obtained during the previous testing season. The limiting value of multiplier may be exceeded only after the operator has conclusively shown to the Commission that the shut-in pressure (P_c) is accurate or that the static wellhead pressure (P_w) cannot be lowered due to existing producing conditions.

Any test hereinabove provided for will be considered unacceptable if the average flow rate for the final 7-day deliverability test is more than 10 percent in excess of any consecutive 7-day average of the preceding two weeks. A deliverability test not meeting this requirement shall be invalid and the well shall be retested.

All charts relative to annual deliverability tests ~~shall be identified by the words "Test Chart No. 1" (2,3,4, etc.)~~, and any or all charts or photostats thereof shall be made available to the Commission upon its request.

II. ALL FORMATIONS OTHER THAN MESAVERDE

(A) Initial ~~and~~/or annual deliverability and shut-in Pressure Tests:

Except as provided in Special Pool Rules these tests shall be made and reported in accordance with the procedure set out in this order for the Mesaverde formation, provided however, that the exponent "n" for the Pictured Cliffs and Fruitland formations shall be point eight five (0.85).

SECTION C. INFORMATION TEST FOR ALL FORMATIONS

I. TYPE OF TEST:

(A) A one-point back pressure test may be taken on newly completed wells before their connection or reconnection to a gas transportation facility. This test shall not be a required official test but may be taken for information purposes at the option of the operator. When taken, this test must be taken and reported as prescribed below:

(B) ONE-POINT BACK PRESSURE POTENTIAL TEST PROCEDURE

1. This test shall be accomplished after a minimum shut-in of seven days. The shut-in pressure shall be measured with a deadweight gauge.

2. The flow rate shall be measured by flowing the well 3 hours through a positive choke, which has a 3/4 inch orifice.

3. A 2-inch nipple which provides a mechanical means of accurately measuring the pressure and temperature of the flowing gas shall be installed immediately upstream from the positive choke.

4. The absolute open flow shall be calculated using the conventional back pressure formula as shown in New Mexico Oil Conservation Commission Back Pressure Test Manual.

5. The observed data and flow calculations shall be reported in duplicate on Form C-122, "Multi-Point Back Pressure Test for Gas Wells."

6. Non-critical flow exists when the choke pressure is 13 psig or less. When this condition exists the flow rate shall be measured with a pitot tube and nipple as specified in the Commission's manual of "Tables and Procedure for Pitot Tests." The pitot test nipple shall be installed immediately downstream from the 3/4 inch positive choke.

7. Any well completed with two-inch nominal size (1.995 inside diameter) or larger shall be tested through the tubing.

<u>IT IS FURTHER ORDERED</u>:

GAS WELL TESTING RULES AND PROCEDURES
FOR SAN JUAN BASIN AREA

SECTION A. TYPE OF GAS WELL TESTS REQUIRED:

I. THE INITIAL DELIVERABILITY AND SHUT-IN PRESSURE TEST FOR NEWLY COMPLETED GAS WELLS.

(A) Immediately upon completion of each gas well in San Juan Basin, a shut-in pressure test of at least 7 days duration shall be made.

(B) Within 60 days after a well is connected to a gas transportation facility the well shall be tested in accordance with Section B, Subsection I, Paragraph (A) of this order, and the results of the test reported to the Commission, and to the gas transportation facility to which the well is connected. Failure to file the required test within the time prescribed above will subject the delinquent well to the loss of one day's allowable for each day the test is late.

(C) Any test accomplished for information purposes prior to pipeline connection shall not be recognized as an official test for the establishment of allowables.

II. ANNUAL DELIVERABILITY AND SHUT-IN PRESSURE TESTS:

Annual Deliverability and Shut-in Pressure Tests of all producing gas wells are required to be made during the period from January 1 through December 31 of each year.

1. Annual Deliverability and Shut-in Pressure Tests shall not be required during ~~that~~ the current annual test period for wells connected after October 31 to a gas transportation facility ~~after October 31~~ but such tests may be taken at the option of the operator.

2. An Initial Deliverability Test accomplished in accordance with Annual testing procedures set out in this order shall be used as an Annual Test for that year.

Chg.

All Annual Deliverability and Shut-in Pressure Tests required by this order shall be filed with the Commission and with the gas transportation facility to which the wells are connected within thirty (30) days after the end of the month during which the tests are completed; provided however, that all tests completed during the period from December 1 through December 31 shall be reported not later than January 10 of the following year. Failure to file the required tests within the time prescribed above may subject the delinquent wells to the loss of 1 day's allowable for each day the test is late. No extension of time will be allowed after January 10 except after notice and hearing.

III. SCHEDULE OF TESTS:

(A) ANNUAL DELIVERABILITY TESTS

At least 30 days prior to the beginning of the tests the gas transportation facilities receiving gas from wells to be tested shall, in cooperation with respective operators, submit to the Commission's Aztec office a testing schedule for the Annual Deliverability and Shut-in Pressure Tests. Three copies of the schedule shall be furnished to the Commission and one copy shall be furnished to each operator concerned. Such schedule shall indicate the dates of test, pool, operator, lease, well number and location of each well. The gas transportation facility making the schedule of tests shall be notified immediately by any operator unable to take such tests as scheduled.

When an Initial Deliverability Test accomplished in accordance with annual testing procedures is to be used as an annual test, the operator shall notify the Commission and the gas transportation facility to which the well is connected, in writing prior to or during the fourteen day conditioning period for said test.

In the event a well is not tested in accordance with the test schedule, the well shall be re-scheduled for testing, and the Commission shall be notified of such fact in writing prior to or during the fourteen days conditioning period for said test.

It shall be the responsibility of each operator to determine that its wells are properly scheduled by the transportation facility to which its wells are connected in order to be tested within the testing season.

(B) DELIVERABILITY RETESTS

An operator may ~~[struck out]~~ in cooperation with the transportation facility, schedule a well for deliverability retest for substantial reason by notification to the Commission ten (10) days before the retest is to commence. Such notification shall consist of scheduling the well as required for the annual deliverability test in subsection III, Paragraph A, above. Such retest shall be subject to the approval of the Commission, and conducted in conformance with the Annual Deliverability Test procedures of this order. The Commission may, at its discretion, require the retesting of any well by notification to the operator to schedule such retest.

The requirements for Initial and Annual Deliverability Tests and the notification and scheduling of such tests which apply to newly completed wells shall also apply to reworked or recompleted wells.

IV. WHO MAY WITNESS TESTS:

Any Initial or Annual Deliverability and Shut-in Pressure test may be witnessed by any or all of the following: an agent of the Commission, an offset operator, a representative of the pipeline company taking gas from an offset operator, or a representative of a pipeline company taking gas from the well under test.

SECTION B. PROCEDURE FOR TESTS:

I. MESA VERDE FORMATION:

(A) INITIAL DELIVERABILITY AND SHUT-IN PRESSURE TEST.

1. Within sixty (60) days after a newly completed well is connected to a gas transportation facility the operator shall accomplish a deliverability and shut-in pressure test in conformance with annual test procedures of this order and results reported as required in Section A, Subsection I, or:

2. In the event that it is impractical to test a newly completed well in accordance with paragraph 1. above, the operator may accomplish a deliverability and shut-in pressure test in the following manner:

(a) A seven or eight day production chart may be used as a basis for determining the well's deliverability providing the chart so used is preceded by at least fourteen (14) days continuous production. The well shall produce ~~unrestrictedly~~ through either the casing or tubing, but not both, into a pipeline during these periods. The production valve and choke settings shall not be changed during the conditioning or flow periods. except during the first week of the conditioning period when maximum production would over-range the meter chart.

(b) A shut-in pressure of at least seven days duration shall be taken. This shall be the shut-in test required in Section A, Subsection I, Paragraph (A).

(c) The average daily static meter pressure shall be determined in accordance with Section B, Subsection I, Paragraph (B). This pressure shall be used as P_t in calculating P_w for the Deliverability Calculation.

(d) The daily average rate of flow shall be determined in accordance with Section B, Subsection I, Paragraph (B) of this order.

(e) The static wellhead working pressure (P_w) shall be determined in accordance with Section B, Subsection I, Paragraph (B) of this order.

(f) The deliverability of the well shall be determined by using the data determined in Paragraphs (a) through (e) above, in the deliverability formula in accordance with Section B, Subsection I, Paragraph (B) of this order.

(g) The data and calculations for the above paragraphs (a) through (f) shall be reported as required in Section A, Subsection I, upon the blue colored Form C-122-A.

(B) <u>THE ANNUAL DELIVERABILITY AND SHUT-IN PRESSURE TESTS.</u>

~~These tests~~ This test shall be taken by producing ~~the well~~ a well into the pipeline through either the casing or tubing, but not both. The production valve and choke settings shall not be changed during either the conditioning or flow periods/ except during the first week of the conditioning period when maximum production would over-range the meter chart. The daily flowing rate shall be determined from an average seven (7) consecutive producing days, following a minimum conditioning period of fourteen (14) consecutive days production. The first seven (7) days of said conditioning period shall have not more than one (1) interruption, which interruption shall be no longer than 36 hours continuous duration. The eighth to fourteenth days, inclusive, of said conditioning period shall have no interruptions whatsoever. All such production during the fourteen (14) days conditioning period plus the seven (7) days deliverability test period shall be at static wellhead working pressures not in excess of seventy-five (75) per cent of the previous annual seven (7) day shut-in pressure of such well if such previous annual shut-in pressure information is available; otherwise, the seven (7) day initial deliverability shut-in pressure of such well shall be used.

In the event that existing line pressure does not permit a drawdown as specified above, with the well producing unrestrictedly into the pipeline, the operator shall request an exception to this requirement on the Form C-122-A. The request shall state the reasons for the necessity for the exception.

Insert No. 1

The static wellhead working pressure (P_W) of any well under test shall be the calculated seven (7) day average static tubing pressure if the well is flowing through the casing; or the calculated seven (7) day average static casing pressure if the well is flowing through the tubing. The static wellhead working pressure (P_W) shall be calculated by applying the tables and procedures as set out in New Mexico Oil Conservation Commission manual entitled "Method of Calculating Pressure Loss Due to Friction in Gas Well Flow Strings for San Juan Basin."

To obtain the shut-in pressure of a well under test, the well shall be shut-in immediately after the seven (7) day deliverability test for a full period of seven (7) consecutive days. Such shut-in pressure shall be measured within the next succeeding twenty-four (24) hours following the seven (7) day shut-in period aforesaid. The seven day shut-in pressure shall be measured on both tubing and casing/ provided communication exists. The higher of such pressures shall be used as P_c in the deliverability calculation. When any such shut-in pressure has been determined by the Commission to be abnormally low, or when only one pressure is available, the shut-in pressure to be used shall be determined by one of the following methods:

1. A Commission designated value.
2. An average shut-in pressure of all offset wells completed in the same zone.
3. A calculated surface pressure based on a measured bottom hole pressure. Such calculation shall be made in accordance with New Mexico Oil Conservation Commission Back Pressure Manual.

All wellhead pressures as well as the flowing meter pressure tests which are to be taken during the seven (7) day deliverability test period, as required hereinabove, shall be taken with a dead-weight gauge. The dead-weight reading, the date and time according to the chart shall be recorded and maintained in the company's records with the test information.

Orifice meter charts shall be changed and so arranged as to reflect upon a single chart the flow data for the gas from each well for the full seven day deliverability test period; except that no tests shall be voided if satisfactory explanation is made as to the necessity for using test volumes through two chart periods. Corrections shall be made for pressure base, measured flowing temperature, specific gravity, and supercompressibility provided however, that if the specific gravity of the gas from any well under test is not available, an estimated specific gravity may be assumed therefore, based upon that of gas from near-by wells, the specific gravity of which has been actually determined by measurement.

The seven (7) day average flowing meter pressure shall be calculated by taking the average of all consecutive 2-hour flowing meter pressure readings as recorded on the seven (7) day flow period chart (test chart No. 3.) The pressure so calculated shall be used in calculating the wellhead working pressure, determining supercompressibility factors and calculating flow volumes.

The seven (7) day flow period volume shall be calculated from the integrated readings as determined from the flow period orifice meter chart, (Chart No. 3.) The volume so calculated shall be divided by the number of testing days on the chart to determine the average daily flow period rate of flow. The flow chart shall have legibly recorded a minimum of seven (7) days and a maximum of eight (8) flowing days to be acceptable for test purposes. The volume used in this calculation shall be corrected to New Mexico Oil Conservation Commission Standard conditions.

The average flowing meter pressure for the seven (7) day or eight (8) day flow period and the corrected integrated volume shall be determined by the purchasing company that integrates the flow charts and furnished to the operator or testing agency when such operator or testing agency requests such information.

The daily volume of flow as determined from the flow period chart (Test Chart No. 3) integrator readings shall be calculated by applying the Basic Orifice meter formula.

$$Q = C' \sqrt{h_w \times P_f}$$ ~~Pm (to be in accord with IOCC Manual)~~

Where:

Q = Metered volume of flow MCFD at 15.025, 60° F. and .60 specific gravity.

C' = The 24-hour basic orifice meter flow factor corrected for flowing temperature, gravity and supercompressibility.

h_w = Daily average differential meter pressure from flow period chart.

P_f = Daily average flowing meter pressure form flow period chart.

The basic orifice meter flow factors, flowing temperature factor and specific gravity factor shall be determined from New Mexico Oil Conservation Commission Back Pressure Test Manual.

The daily flow period average corrected flowing meter pressure, psig, shall be used to determine the supercompressibility factor. Supercompressibility Tables may be obtained from the New Mexico Oil Conservation Commission.

When supercompressibility correction is made for a gas containing either nitrogen or carbon dioxide in excess of 2 per cent, the supercompressibility factors of such gas shall be determined by the use of Table V of the ~~above-mentioned~~ C.M.&.A. TS-402 for pressure 100-500 psig or Table II, TS-461 for pressures in excess of 500 psig.

The use of tables for calculating rates of flow from integrator readings, which do not specifically conform to New Mexico Oil Conservation Commission Back Pressure Test Manual, may be approved for determining the daily flow period rates of flow upon a showing that such tables are appropriate and necessary.

The daily average integrated rate of flow for the seven-day flow period shall be corrected for meter error by the multiplication by a correction factor determined by dividing the square root of the chart flowing meter pressure psia into the square root of the dead-weight flowing meter pressure psia.

Deliverability pressure, as used herein for the Mesa Verde ~~production~~ formation, is a defined pressure applied to each well and used in the process of comparing the abilities of wells in this formation to produce at static wellhead working pressures equal to a percentage of the seven (7) day shut-in pressure of the respective individual wells. Such percentage shall be determined periodically by the Commission based on the relationship of the average static wellhead working pressure (P_W) divided by the average seven-day shut-in pressure (P_C) of the pool.

(9)

The deliverability of gas at the "deliverability pressure" of any well under test shall be calculated from the test data derived from the tests hereinabove required by use of the following deliverability formula:

$$D = Q \left[\frac{(P^2_c - P^2_d)}{(P^2_c - P^2_w)} \right]^n$$

WHERE:

D = Deliverability at the deliverability pressure, (P_d) MCF/D, (at Standard Condition of 15.025 psia and 60°F.)

Q = Daily flow rate in MCF/D, at wellhead pressure (P_w).

P_c = 7-day shut-in wellhead pressure, psia, determined in accordance with Section B, Subsection I, Paragraph (B).

P_d = Deliverability pressure, psia, as defined above.

P_w = Average static wellhead working pressure, as determined from 7-day flow period, psia, and calculated from New Mexico Oil Conservation Commission Pressure Loss Due to Friction Tables for San Juan Basin.

n = Average pool slope of back pressure curve (.75) for Mesa Verde wells.)

The value of the multiplier (ratio factor after the application of the pool slope) by which Q is multiplied shall not exceed a limiting value to be determined periodically by the Commission. Such determination shall be made after a study of the test data of the pool obtained during the previous testing season. The limiting value of the multiplier may be exceeded only after the operator has conclusively shown to the Commission that the shut-in pressure (P_c) is accurate or that the static wellhead pressure (P_w) cannot be lowered due to existing producing conditions.

Any test hereinabove provided for will be considered unacceptable if the average flow rate for the final 7 day deliverability test is more than 10% in excess of any consecutive 7-day average of the preceding two weeks. ~~for any reason other than~~

~~xx reduction to pipeline pressure.~~ "A deliverability test" not meeting this requirement shall be ~~rejected~~ invalid and the well shall be retested.

All charts relative to initial or annual deliverability tests ~~shall be identified by the words "Test Chart No. 1(2), (3), etc." and any or all charts~~ or photostats thereof shall be made available to the Commission upon its request.

II. ALL FORMATIONS OTHER THAN MESA VERDE

(a) Initial and/or Annual Deliverability and Shut-In Pressure Tests:

Except as provided in Special Pool Rules these tests shall be made and reported in accordance with the procedure set out in this order for the Mesa Verde formation, provided however, that the exponent "n" for the Pictured Cliffs, Fruitland and Farmington formations shall be zero point eight five (0.85.)

SECTION C. INFORMATION TEST FOR ALL FORMATIONS.

I. TYPE OF TEST:

(A) A one-point back pressure test may be taken on newly completed wells before their connection or reconnection to a gas transportation facility. This test shall not be a required official test but may be taken for information purposes at the option of the operator. When taken, this test must be taken and reported as prescribed below:

(B) ONE-POINT BACK PRESSURE POTENTIAL TEST PROCEDURE.

1. This test shall be accomplished after a minimum shut-in of seven days. The shut-in pressure shall be measured with a dead weight guage.
2. The flow rate shall be measured by flowing the well 3 hours through a positive choke, which has a 3/4 inch orifice.
3. A 2-inch nipple which provides a mechanical means of accurately measuring the pressure and temperature of the flowing gas shall be installed immediately upstream from the positive choke.

4. The absolute open flow shall be calculated using the conventional back pressure formula as shown in New Mexico Oil Conservation Commission Back Pressure Test Manual.

5. The observed data and flow calculations shall be reported in duplicate on Form C-122, "Multi-Point Back Pressure Test for Gas Wells."

6. Non-critical flow exists when the choke pressure is 13 psig or less. When this condition exists the flow rate shall be measured with a pitot tube and nipple as specified in the Commissions manual of "Tables and Procedure for Pitot Tests." The pitot test nipple shall be installed immediately downstream from the 3/4 inch positive choke.

7. Any well completed with two-inch nominal size (1.995 inside diameter) or larger shall be tested through the tubing. ~~Any well completed with tubing smaller than two-inch nominal shall be tested through the casing.~~

IT IS FURTHER ORDERED:

All forms heretofore mentioned, are hereby adopted for the use in the San Juan Basin Area in open form subject to such modification as experience may indicate.

All testing agencies whether individuals, companies, pipeline companies or operators shall maintain a log of all tests accomplished by them including all field test data.

DONE at Santa Fe, New Mexico, on the day and year hereinabove designated.

STATE OF NEW MEXICO
OIL CONSERVATION COMMISSION

REVISION ORDER - R-333-C,D & E
10-10-62

DENNIS ROSE

CASE RECORD FILE

REVISION Order-
R-333-C,D & E
this FILE has NO PAPERS inside