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 Pressure (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 (Commission designated value or Agreed SIP)

OR: PC = CSGSIP OR: ~~Avg. Offset SIP~~ (3)

PD = PC x Pool Percentage (4)

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

OR:

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

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

* 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	=	CORPRES	+	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~~ Deliverability, 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.

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

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

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 VALUE OF DFACT1 FOUND IN POOL TABLE (UNDER Item 9) & the SMALLER VALUE OF DFACT1 IS TO BE used. IF TABLE VALUE is used - Put out message "MAXIMUM MULTIPLIER used". However the CALCULATED DFACT will BE REFLECTED ON the CIGA Test Sheet.

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 <u>ANY</u> 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 i) 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).

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