CHAPTER - 6

COMMINGLING FLOW

CHAPTER - VI

6.1 INTRODUCTION

In this chapter, a new method of commingling production that eliminates the drawbacks of conventional commingling system is presented. This method of commingling allows the production from more than one zone through a single tubing string and involves the use of bottomhole choke in the system. Field trial tests have been conducted in the wells of Gandhar oil field to study the performance of this production system. The data obtained from field trial tests show that the use of this system result in increased oil production with reduced gas oil ratio. A method of choke size selection for this production system is presented. The flow rate and Tubinghead pressure predictions by the above choke size selection procedures are compared with that of measured values.

6.2 THEORETICAL CONSIDERATIONS

6.2.0 COMMINGLING FLOW

The conventional way to produce from a multi-layered reservoir is to produce from each layer separately and monitor them individually by designing a proper well completion technique. The other way of production is the commingling where more than one layer is allowed to flow through a single tubing string. Multi-layered reservoir can be classified into two groups.

1. Layered reservoir with cross flow.
2. Layered reservoir without cross flow.

Figure 6.1 shows a three layer reservoir with cross flow where the layers hydrodynamically communicate. Figure 6.2 illustrates a two layered reservoir where layers are separated by flow barrier. When a perforation is made in such a

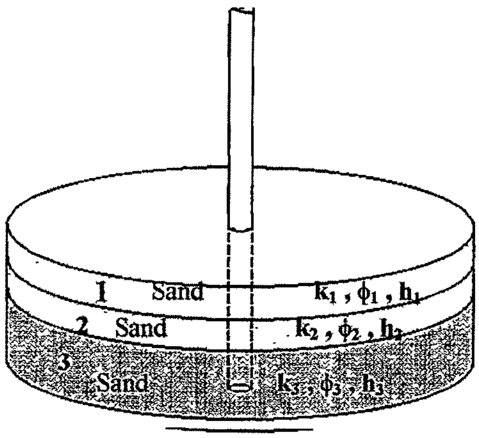

Fig. 6.1 Three-layer reservoir with crossflow

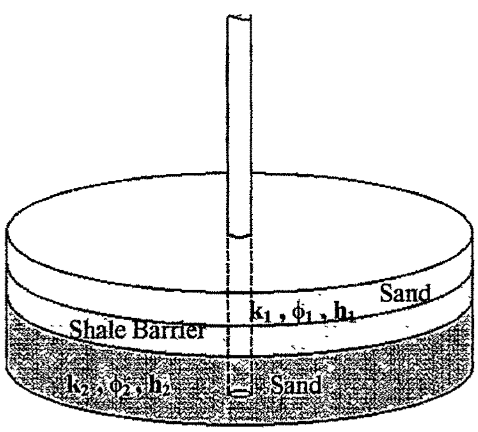

Fig. 6.2 Two-layer reservoir without crossflow

reservoir without cross flow and the layers are allowed to flow through a single tubing string, it is known as *'COMMINGLING PRODUCTION SYSTEM'*.

Woods [68] has developed a simple model for the prediction of flow rate in a two layer system. The following assumptions were made by him in developing the model:--

- **transmissivity, diffusivity and skin factor are constant for all the layers**
- **wellbore pressure is identical for all the layers**
- **no cross flow occurs during production.**
- **the effects of gravity are ignored.**

He derived the following equation for predicting the flow rate from each layer:--

$$q_i / q = \frac{T_i / B_i P_{Di}}{\sum T_i / B_i P_{Di}} \qquad \text{.............(6.1)}$$

where

T_i = **Transmisivity**

B_i = **Formation volume factor**

P_D = **Dimensionless pressure**

$= 1/2 \ \ln(2.2458)\, t_{DA} + s$ ....(6.2)

when $t_{DA} <= 0.1$

$P_D = 2\,\Pi\, t_{DA} + \mathrm{Ln}(0.472\,(r_e/r_w)) + s$ ....(6.3)

when $t_{DA} > 0.1$

t_{DA} = **Dimensionless time**

s = **Skin factor**

r_e = **Drainage radius**

r_w = **Wellbore radius**

The main drawbacks of this system of commingling flow are

- **The production from both the zones cannot be achieved to the maximum potential as the higher porosity layer contributes more in the initial stages and the low porosity layer contributes more in the later stages of production.**

- **When the well is closed, cross flow will take place i.e. the high pressure zone will charge the low pressure zone.**

- **As cross flow takes place when the well is closed, the interpretation of the pressure buildup data becomes more complicated.**

- **There is a possibility of other non-hydrocarbon bearing layer that falls in-between the hydrocarbon producing zones either to be charged or to contribute water thus reducing the life of the producing zones.**

6.2.1 MODIFIED COMMINGLING FLOW

The limitations of the conventional commingling flow can be overcome by regulating the flow from each zone with the help of bottomhole chokes. A schematic of the modification suggested in the present studies is shown in Figure 6.3. The chokes should be chosen depending upon the pressure conditions of each zone and the required tubinghead pressure to assure critical flow in each of the chokes.

It can be seen from the Figure 6.3 that the configuration of the upper choke resembles that of an ejector. The fluids from both the layers will be mixed in the downstream side of the upper choke. Complete mixing of both the streams is normally achieved within a distance equal to 6-8 diameters of the tubing string from the tip of the upper choke.

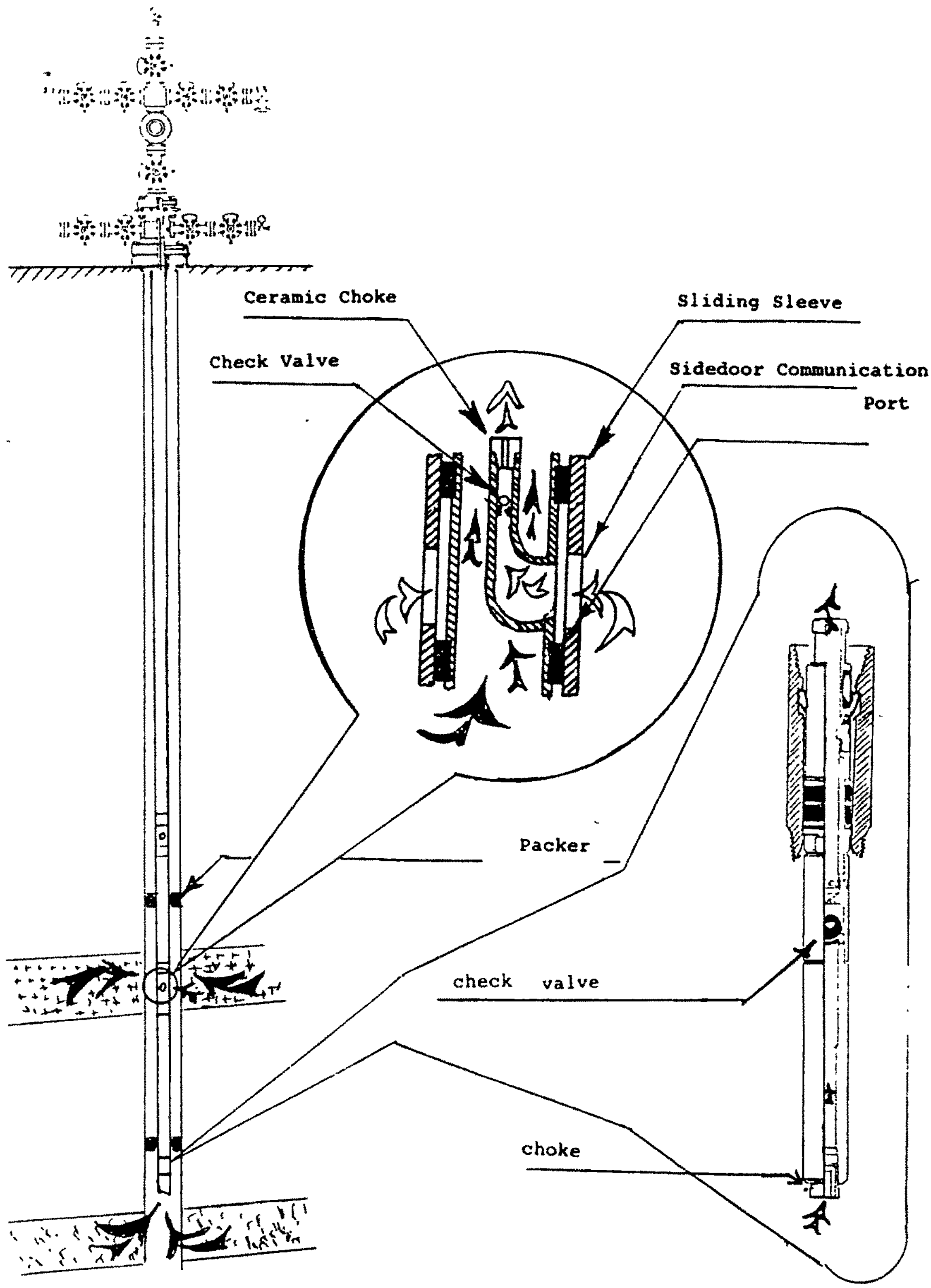

FIGURE 6.3 MODIFIED COMMINGLING SYSTEM

6.2.2 MIXING OF TWO IDEAL GAS STREAMS

Bird and co-workers[72] have analyzed mixing of two ideal gas streams through an ejector. A similar approach has been employed for calculating the resultant velocity, pressure and temperature condition as given below.

A schematic diagram of mixing of two streams is shown in Figure 6.4. At the plane 'a' two streams merge, one with velocity v_1 and cross sectional area S_1 and the other with velocity v_2 and area S_2. Plane 'b' is chosen far enough downstream such that the two streams have gotten completely mixed and the velocity is almost uniform at v_3. The flow is turbulent and the velocity profiles are assumed to be completely flat.

Assuming negligible change in potential energy between plane 'a' and 'b' and neglecting frictional pressure drop and assuming adiabatic operations with no change in heat capacity of the fluid, the mass, momentum and energy balances can be given by equations 6.4, 6.5 and 6.6 respectively.

$$W_3 = W_1 + W_2 \qquad (6.4)$$

$$W_3 v_3 + P3\ S3 = W_1 v_1 + P_1 S_1 + W_2 v_2 + P_2 S_2 \qquad (6.5)$$

$$W_3\,[C_p\,(T_3 - T^\circ) + 1/2\ v_3^2)] = W_1\,[\,C_p\,(T_1 - T^\circ) + 1/2\ v_1^2\,]$$
$$+ W_2\,[Cp.\,(T_2 - T^\circ) + 1/2\ v_2^2] \qquad (6.6)$$

If the datum temperature T° is taken as zero degree K in equation (6.6), the equation becomes :

$$W3\,(C_p.\,T_3 + 1/2\ v^2\,) = W_1\,(\,C_p.\,T_1 + 1/2\ v_1^2\,) + W_2\,(C_p.\,T_2 + 1/2\ v_2^2) \qquad (6.7)$$

The quantities in the righthand side of equations (6.4), (6.5) and (6.7) can be calculated and are designated as W, P and E respectively.

Eliminating pressre P_3 and the cross sectional area S_3 from equation (6.5) and the use of ideal gas law, we get

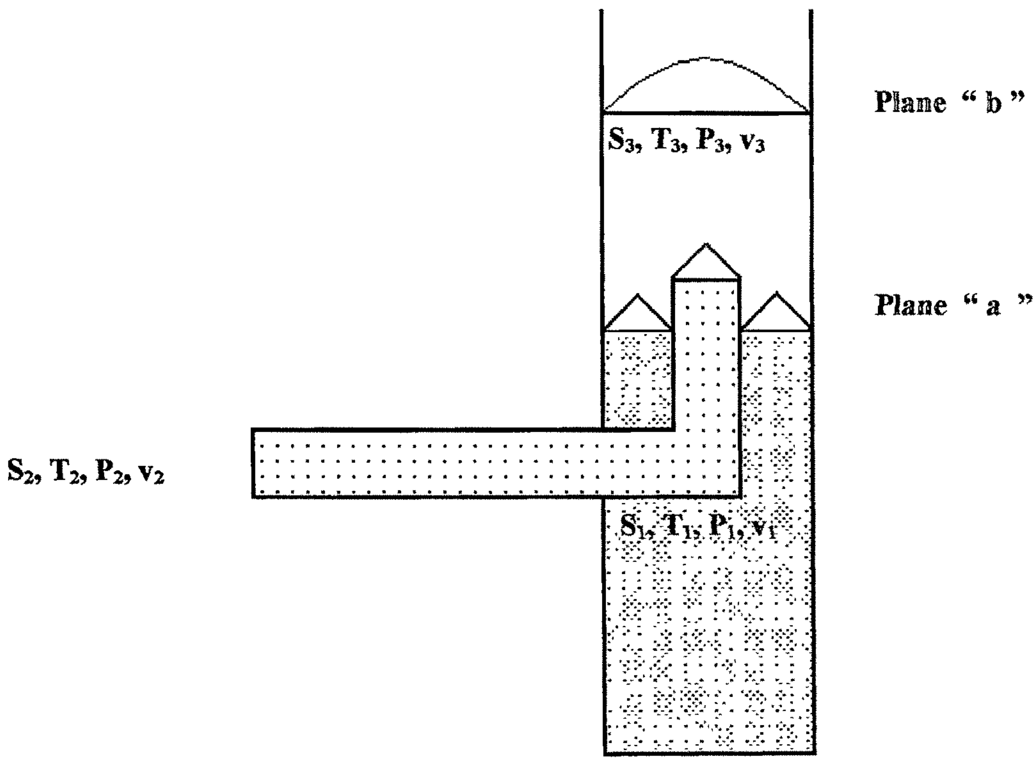

Fig.6.4 Mixing of two ideal gas streams

$P_3 = (\rho_3 R T_3)/ M$ (ideal gas law) ....(6.8)

and

$M_3 = \rho_3 v_3 S_3$ ....(6.8a)

$v_3 + (R T_3)/(M) = P/W$ ....(6.9)

Elimination of of T_3 between equations (6.7) and (6.9) gives the following equation.

$v_3^2 - (2 (\gamma/(\gamma+1) P/W)v_3 + 2 ((\gamma-1)/(\gamma+1) E/W) =0$ .....(6.10)

where $\gamma = C_p/C_v$

Equation (6.10) is a quadratic equation for v_3 in terms of the known quantities W, P, E and γ and solutions are given by

$v_3 = P/W (\gamma/(\gamma+1) [1 + (1-2(\gamma^2-1)WE/ \gamma^2 P^2]$ .....(6.11)

When the quantity $[(\gamma^2-1)/ \gamma)]$ WE/P_2 equals 0.5 , the velocity of the final stream, v_3 , is sonic. Therefore, in general one of the solutions for v_3 is supersonic and one is subsonic. Only the subsonic solution can be obtained in the turbulent mixing process under consideration, since the supersonic flow is unstable in the presence of any significant disturbance.

Once the velocity v_3 is known, the pressure P_3 can be calculated as follows :-

$W v_3 + P_3 S = P$ (6.12)

$P_3 S = P-Wv_3$ (6.13)

$P_3 = (P - Wv_3)/ S$ (6.14)

Once v_3 and P_3 are known , T_3 can be calculated using the equation (6.9)

$v_3 + (R T_3)/(M v_3) = P/W$ (6.9)

$T_3 = (Mv3/R) (P/W - v3)$ (6.15)

6.3 MODELING OF COMMINGLING FLOW WITH BOTTOMHOLE CHOKE

The main controlling factor for choke size selection of a commingling system is the Tubinghead pressure. So, it is necessary to calculate the pressure drop inside the tubing string so as to get the desired Tubinghead pressure. The various pressure components of this system are shown in Figure 6.6. The major assumptions made in this model are :-

(i) mist flow conditions in the downstream sides of chokes.
(ii) mixing of two ideal gas streams
(iii) critical flow through chokes with a critical pressure ratio of 0.528.

The total pressure drop from the reservoir to the Tubinghead may be considered as the sum of the following individual pressure drops :

a) Pressure drop inside the lower reservoir (ΔP_1)

b) Pressure drop between the perforation and the upstream side of the lower choke (ΔP_2)

c) Pressure drop across the lower choke (ΔP_3)

d) Pressure drop inside the tubing string between downstream of the lower choke and upstream side of the upper choke (ΔP_4)

e) Pressure change during mixing upper layer fluid with the lower fluid stream (ΔP_5)

f) Pressure drop inside the tubing string between the plane of complete mixing in the downstream side of the upper choke and the tubing head (ΔP_6)

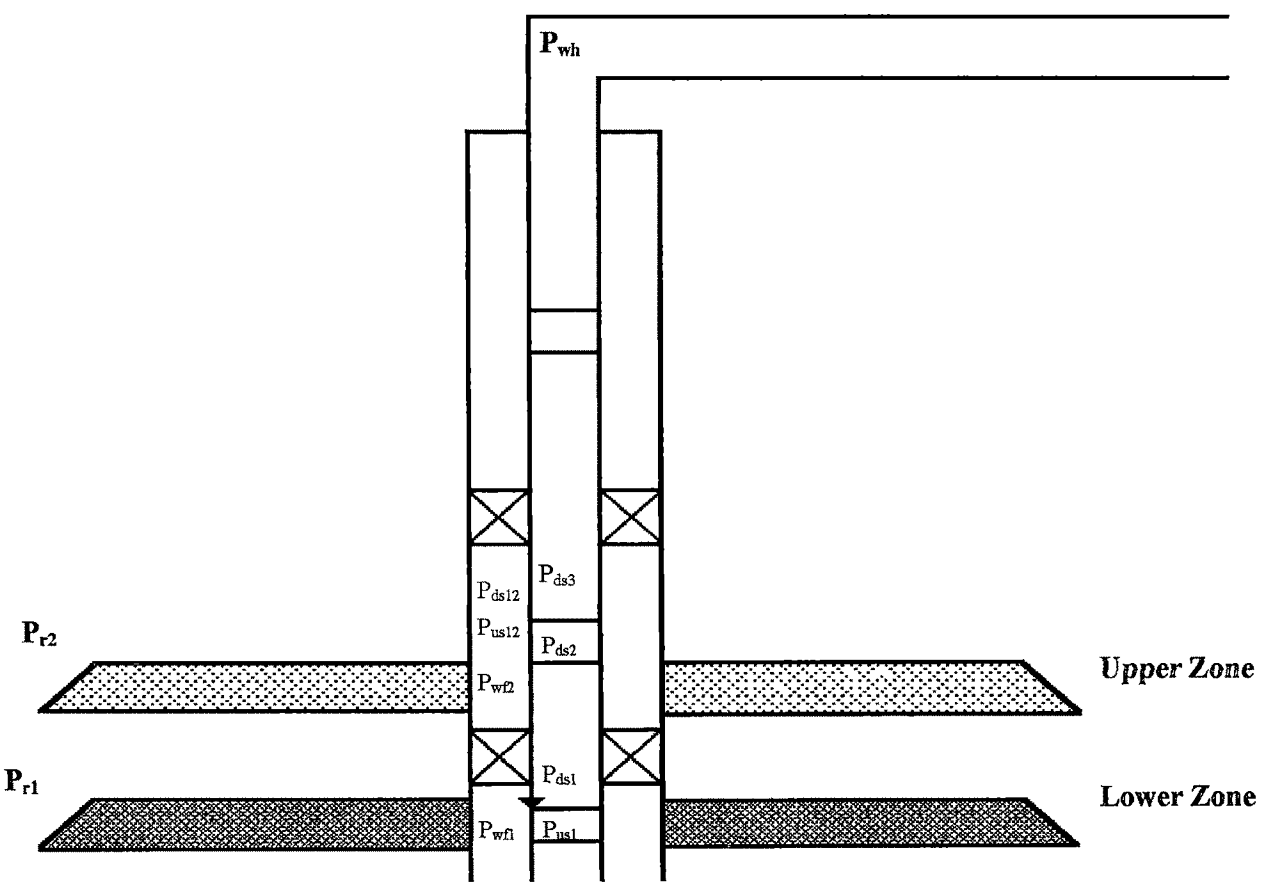

Fig. 6.5 Comingling flow pressure elements

So, the tubing head pressure can be written as

$$P_{wh} = P_r - \Sigma(\Delta P_i) \quad .....(6.18)$$

where

$$\Delta P_1 = P_{r1} - P_{wf1} \quad .....(6.19)$$

P_{wf1} **= flowing bottomhole pressure of lower zone, (psi)**

P_{r1} **= lower reservoir pressure, (psi)**

Alternately

$$\Delta P_1 = P_{r1} - PI\, Q_{o1} \quad .....(6.20)$$

Q_{o1} **can be calculated using the choke flow equation presented in Chapter - V with a discharge co-efficient of 1.574**

ΔP_2 **can be safely neglected as the tubing shoe is placed against the perforation and the lower choke is placed in the tubing shoe.**

Assuming critical flow through choke, the pressure drop across the choke can be written as follows:-

$$\Delta P_3 = P_{wf1}(1-0.528) \quad .....(6.21)$$

The pressure drop between the downstream side of the lower choke and the upstream side of the upper choke (ΔP_4) can be calculated using mist flow conditions for lower zone flow rate.

The pressure change during mixing of two streams (ΔP_5) can be calculated as follows :-

The pressure drop inside the upper reservoir for a flow rate Q_{o2} can be written as

$$\Delta P_{12} = P_{r2} - P_{wf2} \quad .....(6.22)$$

$= P_{r2} - Q_{o2}\, PI_2$

and the pressure drop across the upper choke can be calculated as

$\Delta P_{32} = P_{wf2} - (1 - 0.528)$ .....(6.23)

The resultant pressure (P_{ds3}) of mixing of two streams with pressures P_{ds2}, P_{ds12} and flowrates Q_{o1} and Q_{o2} with temperatures T_1 and T_2 can be calculated using the equations 6.4 to 6.19 assuming mixing of two ideal gas streams. Since the temperature drop across the choke is negligible, a linear temperature gradient is used to calculate the temperature at different depths. This pressure drop term may be either positive in case of downstream pressure of the upper choke is lower than the lower stream pressure or negative in case the downstream pressure of the upper choke is higher than the lower stream pressure.

After calculating the resultant pressure of two streams, the pressure drop inside the tubing string up to the wellhead (Δ P6) can be calculated using Orkizwskhi's mist flow model.

Thus the Tubinghead pressure in the commingling system can be calculated.

6.4 EXPERIMENTAL

Flowing oil wells in the center of the reservoir completed with single alternate completion were selected for conducting the field trial tests. A typical single alternate completion system is shown in figure 6.6.

The following procedure was adopted while conducting the field trial tests:-

1. Lower layer was allowed to flow through a surface choke

2. At stabilized conditions' flow and pressure measurements were made

3. The well was closed for buildup studies

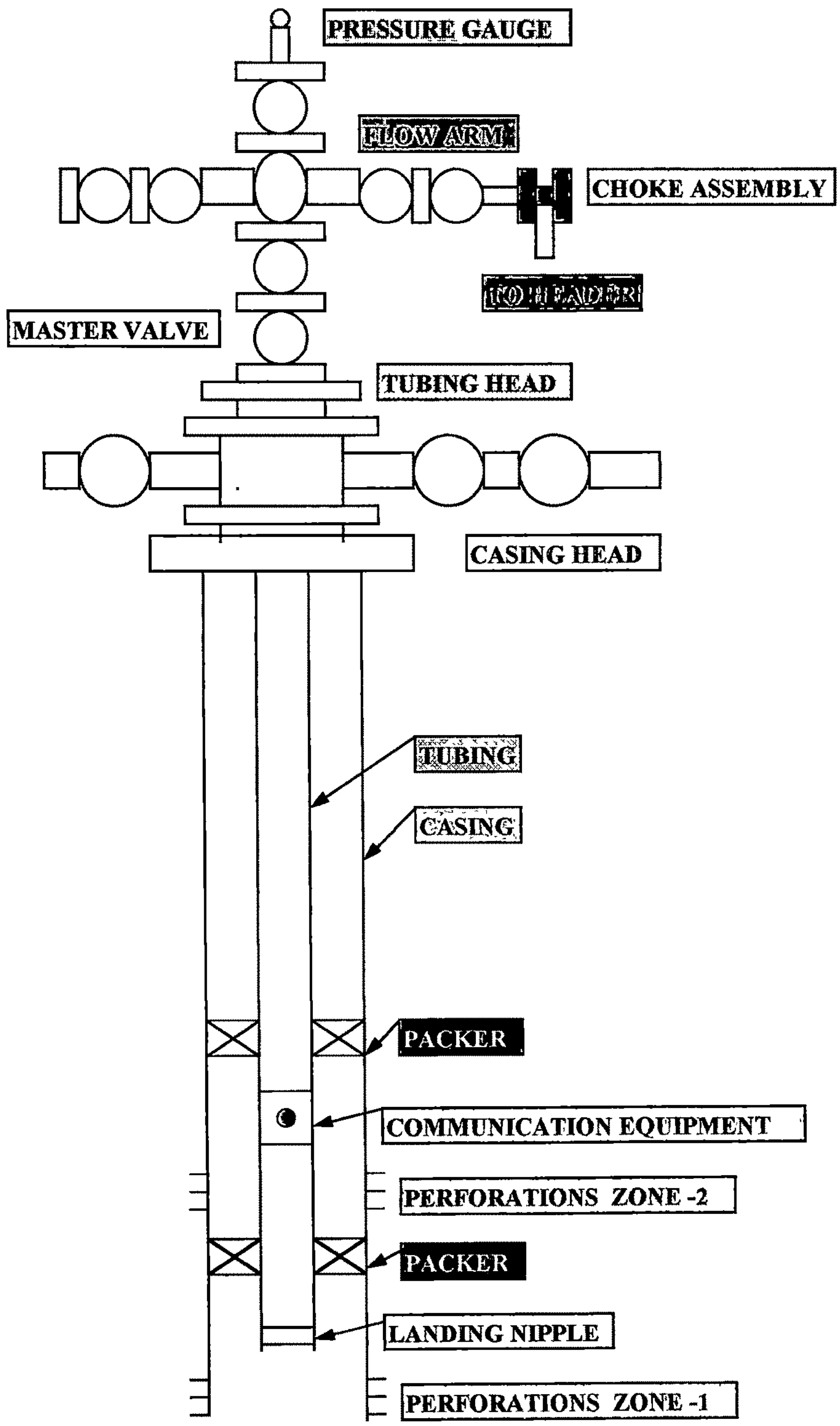

FIGURE - 6.6 SCHEMATIC DIAGRAM OF SINGLE ALTERNATE COMPLETION

4. Then the upper layer was opened through the communication equipment in the tubing string.

5. The lower layer was closed by installing a blanking plug in the landing nipple by means of a wireline.

6. The upper layer was allowed to flow through a surface choke.

7. At stabilized conditions' flow and pressure measurements were made.

8. The well was closed for buildup studies.

9. The well was opened and the blanking plug in the landing nipple was removed.

10. From the flow data and the derived reservoir properties, chokes were selected for each layer separately using the choke size selection procedure described in Chapter-V.

11. The choke for the lower layer followed by the choke for the upper layer were installed in the landing nipple and communication device respectively.

12. The well was allowed to flow for sufficient time to get stabilized.

13. At stabilized conditions the liquid flow rate, gas flow rate, and Tubinghead pressure were measured.

6.5 RESULTS AND DISCUSSION

Surface choke data for individual layers have been measured before putting them into commingling production. These data are presented in Table 6.1. The data obtained on commingling production are presented in Table 6.2. The flow

parameters of surface choke and commingled production system are compared in terms of oil production, gas production and gas oil ratio and are presented in Table 6.3. It has been observed that the commingled production system yields increase in oil production and decrease in gas production. Further the produced gas oil ratio of commingling system is less than the gas oil ratios of both the zones. It has also been observed that the combined flow rate of oil through commingling production system is more than those of the sum of the two separate flowrates through surface choke production. This also indicates that the system uses lower reservoir gas energy to lift unit mass of oil which in turn will increase the recovery of oil from each zone. This is because the commingling system employs bottomhole choke for flowing the zones.

6.5.1 COMMINGLING CHOKE SIZE SELECTION

1. **The individual zones were allowed to flow through sufficient time to get adequate response from the reservoir.**

2. **Flow measurements were made for both the zones through different surface/ wellhead chokes.**

3. **Pressure build up data have been recorded for individual zones separately.**

4. **The reservoir parameters were interpreted from the pressure buildup and flow measurement data for both the zones.**

5. **Adopting the procedure for optimum bottomhole choke size selection described in Chapter V maximum possible choke sizes have been selected for both the zones.**

6. **Varying the size of the choke for the lower zone for a given choke size for the upper zone the downstream pressures of the upper choke were calculated both**

from the wellhead for a given Tubinghead pressure and from the bottom of the well using the commingling flow model presented in this chapter.

7. Plots of choke downstream pressures calculated from the top of the well and from the bottom of the well against the lower zone choke sizes have been made. Plots of flowrates from the lower zone and calculated Tubinghead pressure have also been made.

8. The intersection of the two choke downstream pressure plots gives the choke size combination for the given Tubinghead pressure.

9. It is likely that we get different choke combination for a given Tubinghead pressure and the reservoir pressure.

10. The best combination has to be decided based on the productivity of the individual zones and reservoir characteristics.

A flow diagram for the choke size selection for a given Tubinghead pressure is shown in Figure 6.7. A block diagram for calculating the resultant pressure of mixing of two ideal streams is presented in Figure 6.8. The values of downstream pressure of the upper choke calculated from the surface and from the bottom are presented in Tables 6.4 through 6.11 for various combinations of chokes for a typical well. The negative value of Tubinghead pressure shows that the pressure drop inside the tubing string is more than the available bottomhole pressure. Plots of lower choke size versus upper choke downstream pressure calculated from the wellhead and from the bottom of the well are presented in Figures 6.9 through 6.16. The predicted and measured Tubinghead pressures of the field trial tests are tabulated in Table 6.12. It can be seen from this table that the predicted Tubinghead pressures are in close match with the measured values. Cross plots for tubinghead pressure and flow rates have been drawn and presented in figures 6.16 and 6.18. The points on the plots are very close to the diagonal of the plots show the

model best predicts the commingling data and substantiates the validity of the commingling flow model proposed in this investigation.

6.6 CONCLUSIONS

1. **Field trial test results show that the modified commingling production system resulted in and increase in oil production and decrease in produced gas oil ratio.**

2. **Since the commingling production system involves the use of bottomhole choke it has got all the advantages of the bottomhole choke production system.**

3. **A choke size selection procedure has been evaluated.**

4. **The model developed for commingling production system is found to predict the field trial test data reasonably well.**

TABLES OF CHAPTER-VI

TABLE 6.1 SURFACE CHOKE DATA BEFORE COMMINGLING

TEST NO.	ZONE	CHOKE SIZE (mm)	FLOW RATE (M^3/D)	GAS LIQUID RATIO (M^3/M^3)
1	LOWER	6	87.00	661.00
	UPPER	6	41.00	1296.00
2	LOWER	8	55.00	1358.00
	UPPER	6	89.00	811.00
3	LOWER	4	31.90	1195.00
	UPPER	6	50.00	189.00
4	LOWER	5	-	88376.00
	UPPER	5	58.10	352.00
5	LOWER	6	98.54	213.00
	UPPER	4	62.36	374.00
6	LOWER	6	99.00	510.00
	UPPER	5	39.60	523.00
7	LOWER	6	45.00	745.00
	UPPER	8	35.00	1140.00
8	LOWER	6	68.00	1325.00
	UPPER	6	77.00	354.00

TABLE 6.2 COMMINGLING PRODUCTION DATA

TEST NO.	ZONE	CHOKE SIZE (1/64 INCH)	COMBINED FLOW RATE (M^3/D)	COMBINED GAS LIQUID RATIO (M^3/M^3)
1	LOWER	10		
	UPPER	16	329.00	333.00
2	LOWER	10		
	UPPER	12	180.00	621.00
3	LOWER	10		
	UPPER	12	188.00	488.00
4	LOWER	10		
	UPPER	12	97.00	977.00
5	LOWER	12		
	UPPER	16	361.74	245.00
6	LOWER	10		
	UPPER	16	203.00	374.00
7	LOWER	10		
	UPPER	16	108.00	156.00
8	LOWER	10		
	UPPER	16	210.00	326.00

TABLE 6.3 COMPARISON OF SURFACE CHOKE DATA WITH COMMINGLING PRODUCTION DATA

		SURFACE CHOKE PRODUCTION			COMMINGLINGING PRODUCTION		
TEST NO.	ZONE	CHOKE SIZE (mm)	FLOW RATE (M^3/D)	GAS LIQUID RATIO (V/V)	CHOKE SIZE (1/64 INCH)	COMBINED FLOW RATE (M^3/D)	COMBINED GAS LIQUID RATIO (M^3/M^3)
1	LOWER	6	87.00	661.00	10		
	UPPER	6	41.00	1296.00	16	329.00	333.00
2	LOWER	8	55.00	1358.00	10		
	UPPER	6	89.00	811.00	12	180.00	621.00
3	LOWER	4	31.90	1195.00	10		
	UPPER	6	50.00	189.00	12	188.00	488.00
4	LOWER	5	-	88376.00	10		
	UPPER	5	58.10	352.00	12	97.00	977.00
5	LOWER	6	98.54	213.00	12		
	UPPER	4	62.36	374.00	16	361.74	245.00
6	LOWER	6	99.00	510.00	10		
	UPPER	5	39.60	523.00	16	203.00	374.00
7	LOWER	6	45.00	745.00	10		
	UPPER	8	35.00	1140.00	16	108.00	156.00
8	LOWER	6	68.00	1325.00	10		
	UPPER	6	77.00	354.00	16	210.00	326.00

TABLE 6.4 COMMINGLING CHOKE SIZE SELECTION (TEST NO. 1)

UPPER BOTTOMHOLE CHOKE SIZE = 6/64 "
UPPER ZONE FLOW RATE = 150.16 BBLS/DAY

BOTTOM CHOKE SIZE (1/64 INCH)	BOTTOM ZONE FLOW RATE BBLS/DAY	TOTAL FLOW RATE BBLS/DAY	AFTER CHOKE PRESSURE (FROM BOTTOM)	AFTER CHOKE PRESSURE (FROM SURFACE)	TUBING HEAD PRESSURE PSI
6	180.36	330.52	2049	1307	1492
8	320.63	470.79	2029	1431	1348
10	500.29	650.45	2004	1527	1226
12	721.43	871.59	1973	1610	1112
14	981.94	1132.1	1936	1697	988
16	1282.54	1432.7	1894	1810	834
18	1623.21	1773.37	1846	1976	620
20	2003.96	2154.12	1793	2240	303

TABLE 6.5 COMMINGLING CHOKE SIZE SELECTION (TEST NO. 1)

UPPER BOTTOMHOLE CHOKE SIZE = 8/64 "
UPPER ZONE FLOW RATE = 266.96 BBLS/DAY

BOTTOM CHOKE SIZE (1/64 INCH)	BOTTOM ZONE FLOW RATE BBLS/DAY	TOTAL FLOW RATE BBLS/DAY	AFTER CHOKE PRESSURE (FROM BOTTOM)	AFTER CHOKE PRESSURE (FROM SURFACE)	TUBING HEAD PRESSURE PSI
6	180.36	447.32	2041	1219	1572
8	320.63	587.59	2021	1344	1427
10	500.29	767.25	1996	1458	1287
12	721.43	988.39	1965	1567	1148
14	981.94	1248.9	1929	1683	995
16	1282.54	1549.5	1886	1825	810
18	1623.21	1890.17	1838	2023	564
20	2003.96	2270.92	1785	2323	212

TABLE 6.6 COMMINGLING CHOKE SIZE SELECTION (TEST NO. 1)

UPPER BOTTOMHOLE CHOKE SIZE = 10/64 "
UPPER ZONE FLOW RATE = 417.12 BBLS/DAY

BOTTOM CHOKE SIZE (1/64 INCH)	BOTTOM ZONE FLOW RATE BBLS/DAY	TOTAL FLOW RATE BBLS/DAY	AFTER CHOKE PRESSURE (FROM BOTTOM)	AFTER CHOKE PRESSURE (FROM SURFACE)	TUBING HEAD PRESSURE PSI
6	180.36	597.48	2031	1190	1591
8	320.63	737.75	2011	1308	1453
10	500.29	917.41	1986	1430	1305
12	721.43	1138.55	1955	1558	1147
14	981.94	1399.06	1918	1700	968
16	1282.54	1699.66	1876	1874	752
18	1623.21	2040.33	1828	2109	470
20	2003.96	2421.08	1775	2450	75

TABLE 6.7 COMMINGLING CHOKE SIZE SELECTION (TEST NO.1)

UPPER BOTTOMHOLE CHOKE SIZE = 12/64 "
UPPER ZONE FLOW RATE = 600.65 BBLS/DAY

BOTTOM CHOKE SIZE (1/64 INCH)	BOTTOM ZONE FLOW RATE BBLS/DAY	TOTAL FLOW RATE BBLS/DAY	AFTER CHOKE PRESSURE (FROM BOTTOM)	AFTER CHOKE PRESSURE (FROM SURFACE)	TUBING HEAD PRESSURE PSI
6	180.36	781.01	2019	1218	1551
8	320.63	921.28	1999	1330	1419
10	500.29	1100.94	1974	1457	1267
12	721.43	1322.08	1943	1600	1093
14	981.94	1582.59	1906	1766	890
16	1282.54	1883.19	1864	1973	641
18	1623.21	2223.86	1816	2249	317
20	2003.96	2604.61	1763	2640	-127

TABLE 6.8 COMMINGLING CHOKE SIZE SELECTION (TEST NO.' .1)

UPPER BOTTOMHOLE CHOKE SIZE = 14/64 "
UPPER ZONE FLOW RATE = 817.55 BBLS/DAY

BOTTOM CHOKE SIZE (1/64 INCH)	BOTTOM ZONE FLOW RATE BBLS/DAY	TOTAL FLOW RATE BBLS/DAY	AFTER CHOKE PRESSURE (FROM BOTTOM)	AFTER CHOKE PRESSURE (FROM SURFACE)	TUBING HEAD PRESSURE PSI
6	180.36	997.91	2004	1309	1445
8	320.63	1138.18	1984	1418	1315
10	500.29	1317.84	1959	1551	1158
12	721.43	1538.98	1928	1709	969
14	981.94	1799.49	1891	1900	741
16	1282.54	2100.09	1849	2142	457
18	1623.21	2440.76	1801	2462	88.9
20	2003.96	2821.51	1748	2910	-412

TABLE 6.9 COMMINGLING CHOKE SIZE SELECTION (TEST NO. 1)

UPPER BOTTOMHOLE CHOKE SIZE = 16/64 "
UPPER ZONE FLOW RATE = 1067.82 BBLS/DAY

BOTTOM CHOKE SIZE (1/64 INCH)	BOTTOM ZONE FLOW RATE BBLS/DAY	TOTAL FLOW RATE BBLS/DAY	AFTER CHOKE PRESSURE (FROM BOTTOM)	AFTER CHOKE PRESSURE (FROM SURFACE)	TUBING HEAD PRESSURE PSI
6	180.36	1248.18	1987	1480	1256
8	320.63	1388.45	1967	1591	1125
10	500.29	1568.11	1942	1733	959
12	721.43	1789.25	1911	1908	753
14	981.94	2049.76	1874	2127	497
16	1282.54	2350.36	1832	2406	175
18	1623.21	2691.03	1784	2777	-242
20	2003.96	3071.78	1731	3289	-808

TABLE 6.10 COMMINGLING CHOKE SIZE SELECTION (TEST NO. 1)

UPPER BOTTOMHOLE CHOKE SIZE = 18/64 "
UPPER ZONE FLOW RATE = 1351.46 BBLS/DAY

BOTTOM CHOKE SIZE (1/64 INCH)	BOTTOM ZONE FLOW RATE BBLS/DAY	TOTAL FLOW RATE BBLS/DAY	AFTER CHOKE PRESSURE (FROM BOTTOM)	AFTER CHOKE PRESSURE (FROM SURFACE)	TUBING HEAD PRESSURE PSI
6	180.36	1531.82	1968	1756	962
8	320.63	1672.09	1948	1874	824
10	500.29	1851.75	1923	2028	645
12	721.43	2072.89	1892	2224	417
14	981.94	2333.4	1855	2474	131
16	1282.54	2634	1813	2797	-233
18	1623.21	2974.67	1765	3224	-708
20	2003.96	3355.42	1712	3810	-1348

TABLE 6.11 COMMINGLING CHOKE SIZE SELECTION (TEST NO. 1)

UPPER BOTTOMHOLE CHOKE SIZE = 20/64 "
UPPER ZONE FLOW RATE = 1668.47 BBLS/DAY

BOTTOM CHOKE SIZE (1/64 INCH)	BOTTOM ZONE FLOW RATE BBLS/DAY	TOTAL FLOW RATE BBLS/DAY	AFTER CHOKE PRESSURE (FROM BOTTOM)	AFTER CHOKE PRESSURE (FROM SURFACE)	TUBING HEAD PRESSURE PSI
6	180.36	1848.83	1947	2173	523
8	320.63	1989.1	1927	2302	375
10	500.29	2168.76	1902	2474	178
12	721.43	2389.9	1871	2697	-75
14	981.94	2650.41	1834	2983	-398
16	1282.54	2951.01	1792	3354	-812
18	1623.21	3291.68	1744	3846	-1352
20	2003.96	3672.43	1691	4517	-2076

TABLE 6.12 COMPARISON OF THP AND FLOWRATE PREDICTION BY CHOKE SIZE SELECTION PROCEDURE WITH THAT OF MEASURED VALUES

TEST NO	MEASURED FLOW RATE BBLS/DAY	PREDICTED FLOW RATE BBLS/DAY	MEASURED TUBING HEAD PRESSURE PSI	PREDICTED TUBING HEAD PRESSURE PSI
1	2069.40	1512.79	853.20	959.31
2	1132.00	1568.81	1208.70	1268.07
3	1182.50	1181.78	1066.50	1031.18
4	610.10	1092.16	796.32	756.00
5	2275.10	1795.21	1166.00	1064.64
6	1276.90	1794.05	910.08	810.88
7	1132.20	1577.80	481.30	511.92
8	1320.90	1715.93	1208.70	1180.62

FIGURES OF CHAPTER-VI

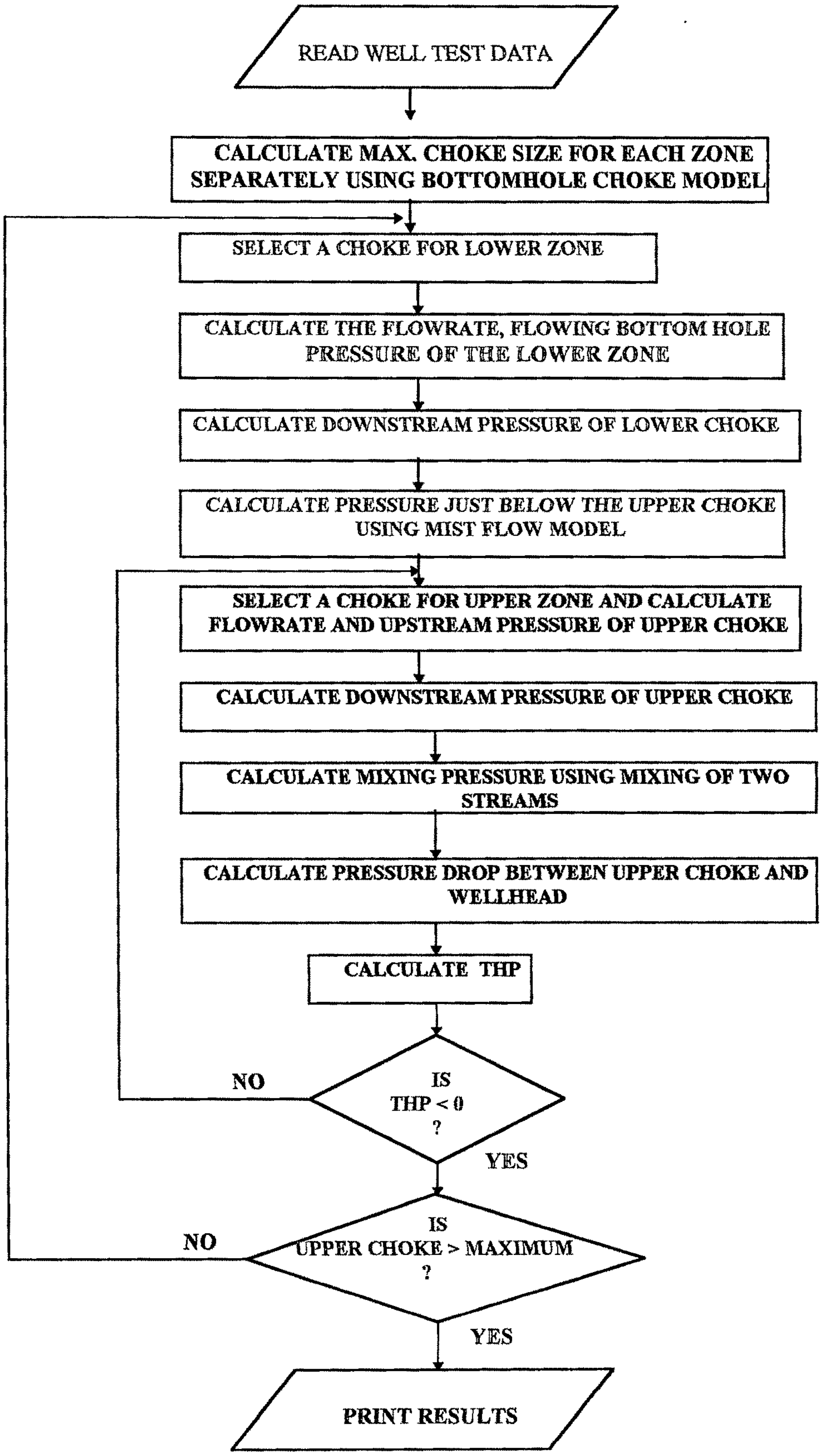

Fig. 6.7 Flow Diagram for Comingling Flow Model

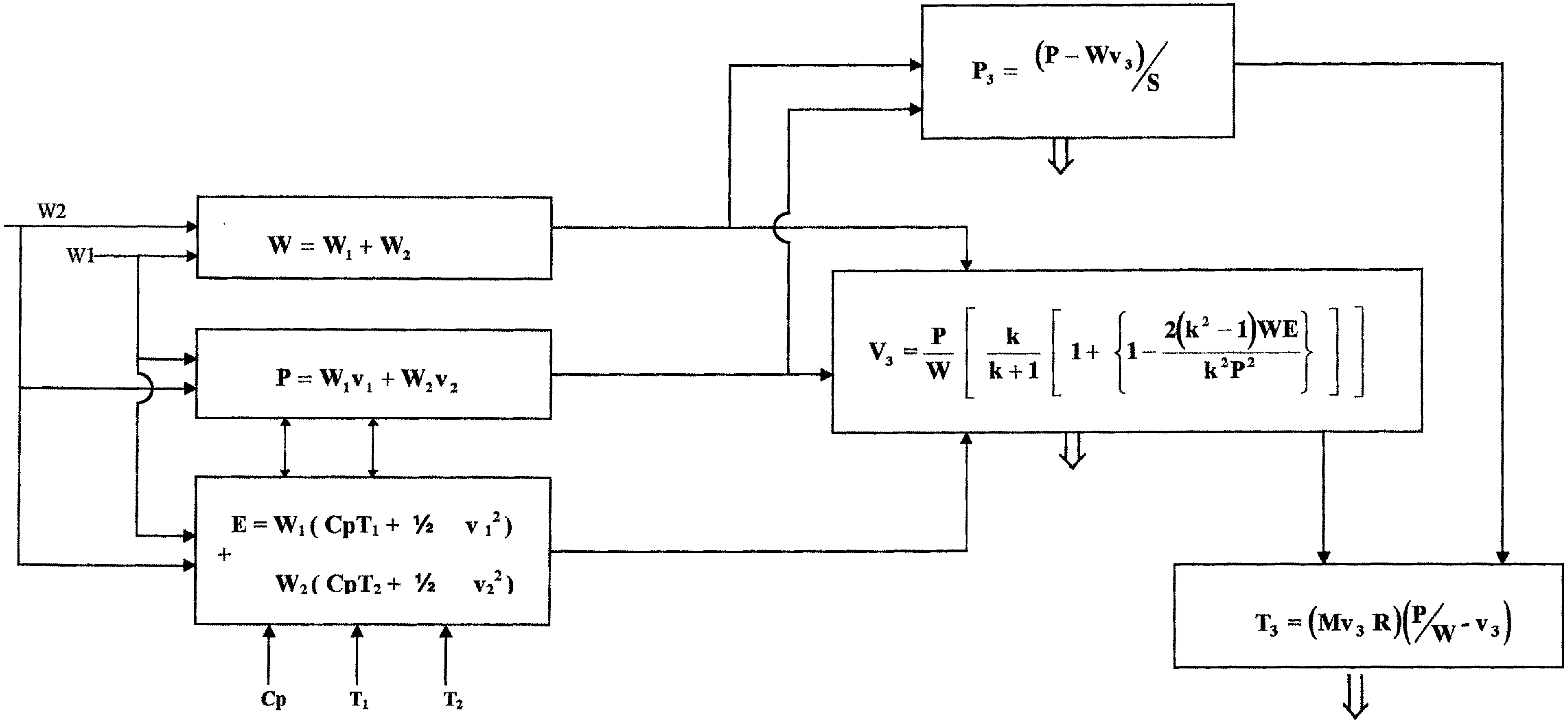

Fig. 6.8 Block diagram for resultant pressure calculation of mixing of two ideal gas streams

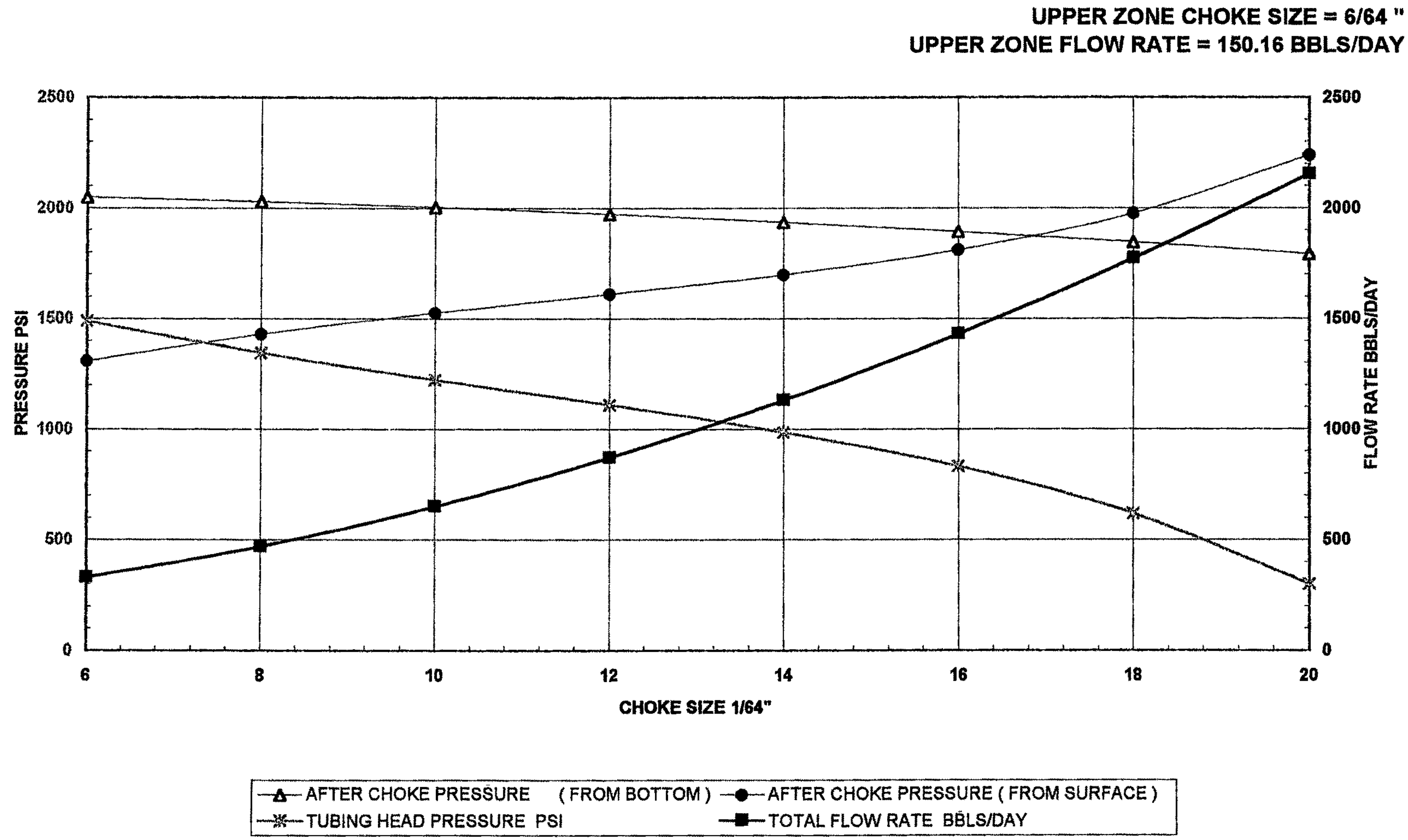

FIGURE 6.9 COMMINGLING CHOKE SIZE SELECTION (TEST NO.1)

UPPER ZONE CHOKE SIZE = 8/64 "
UPPER ZONE FLOW RATE = 266.96 BBLS/DAY

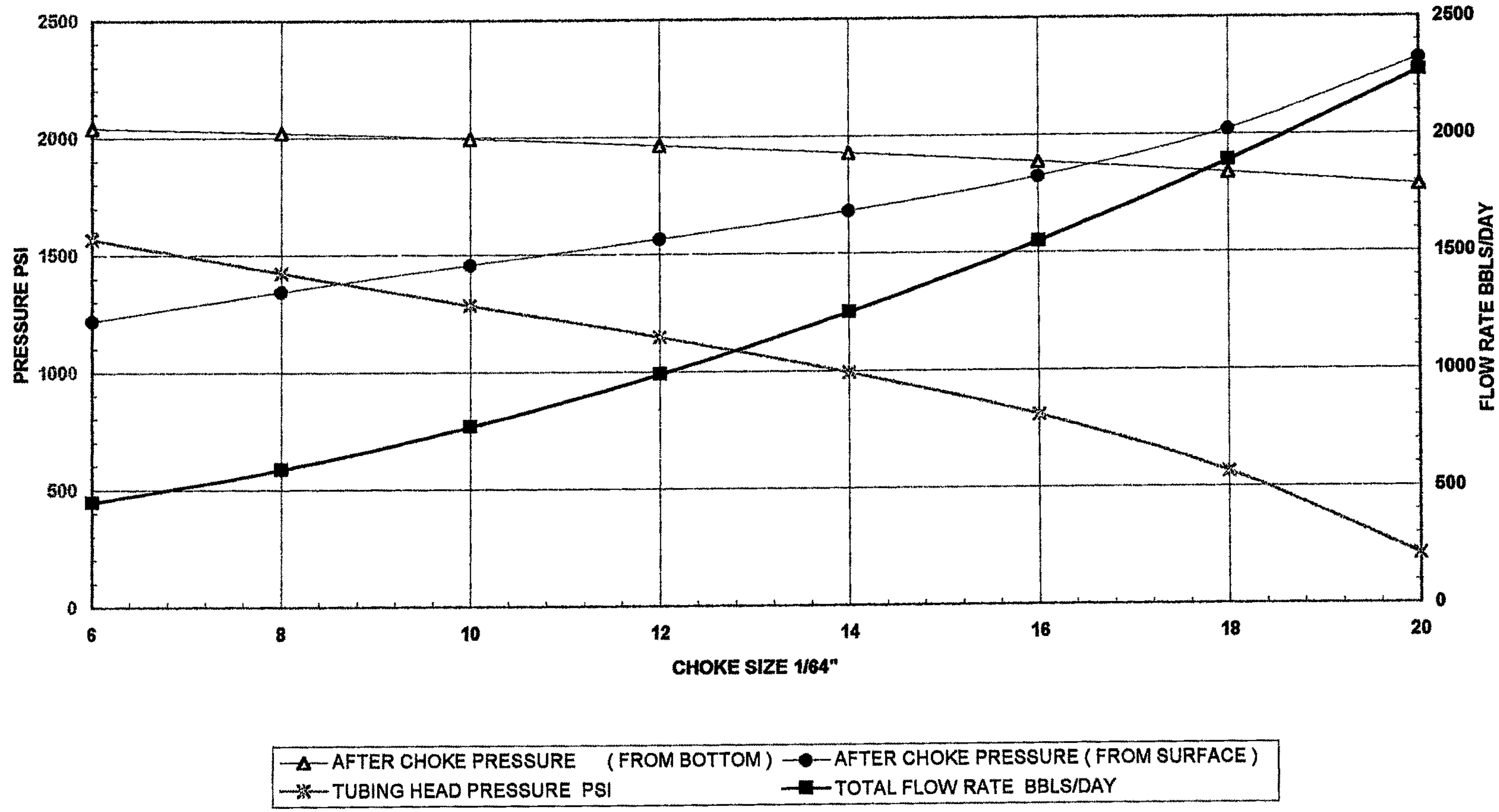

FIGURE 6.10 COMMINGLING CHOKE SIZE SELECTION
(TEST NO.1)

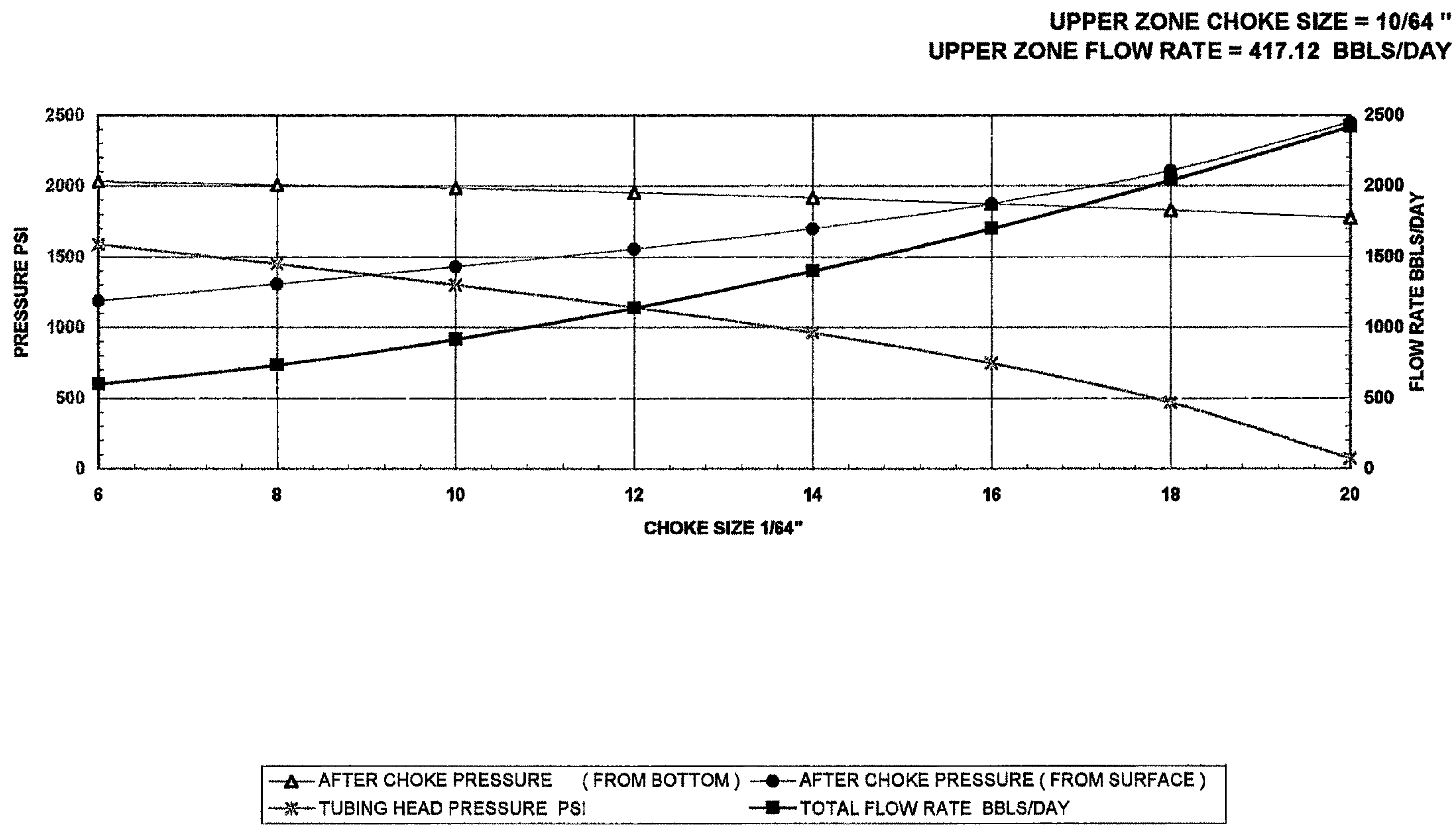

FIGURE 6.11 COMMINGLING CHOKE SIZE SELECTION (TEST NO.1)

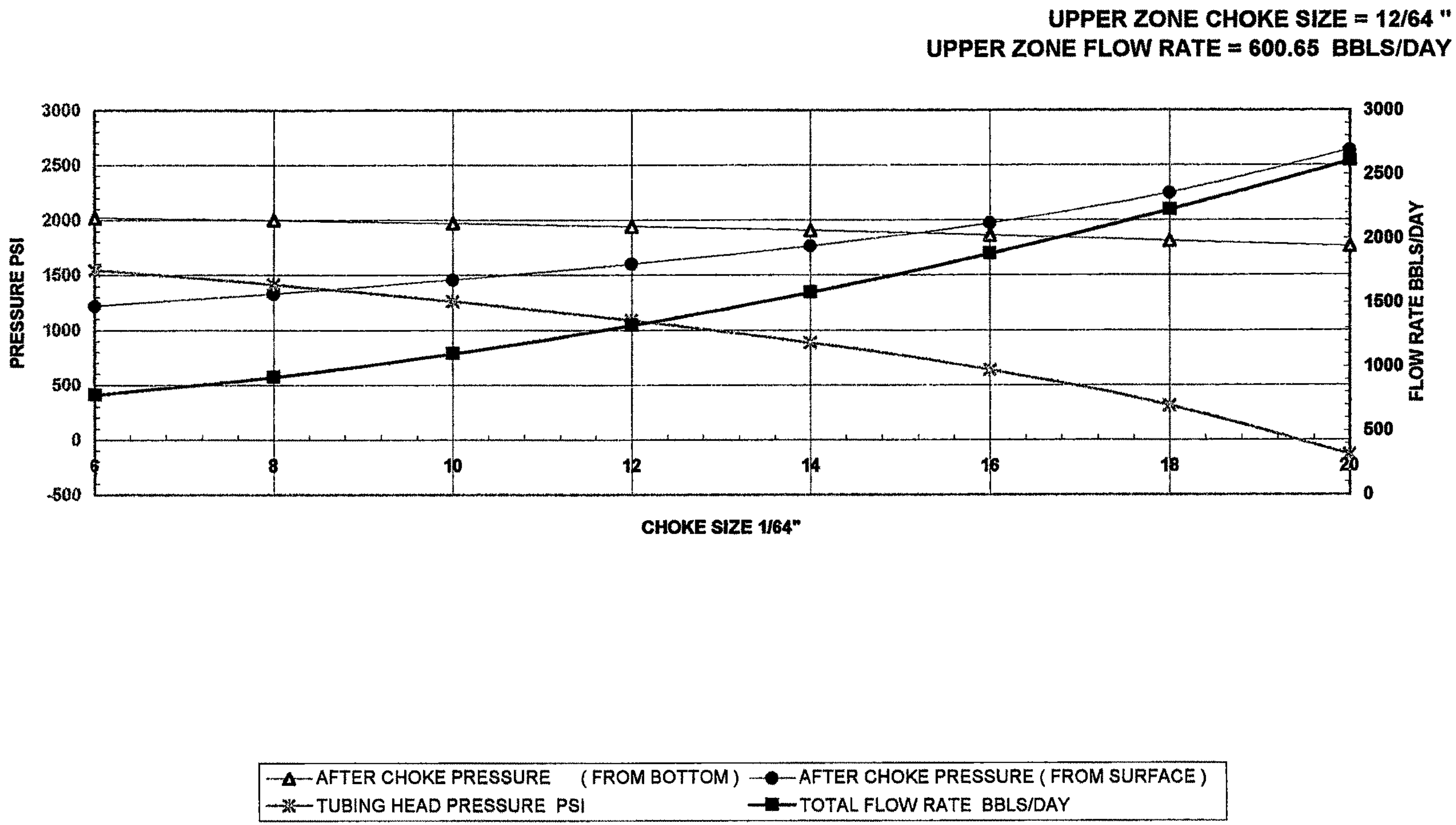

FIGURE 6.12 COMMINGLING CHOKE SIZE SELECTION (TEST NO. 1)

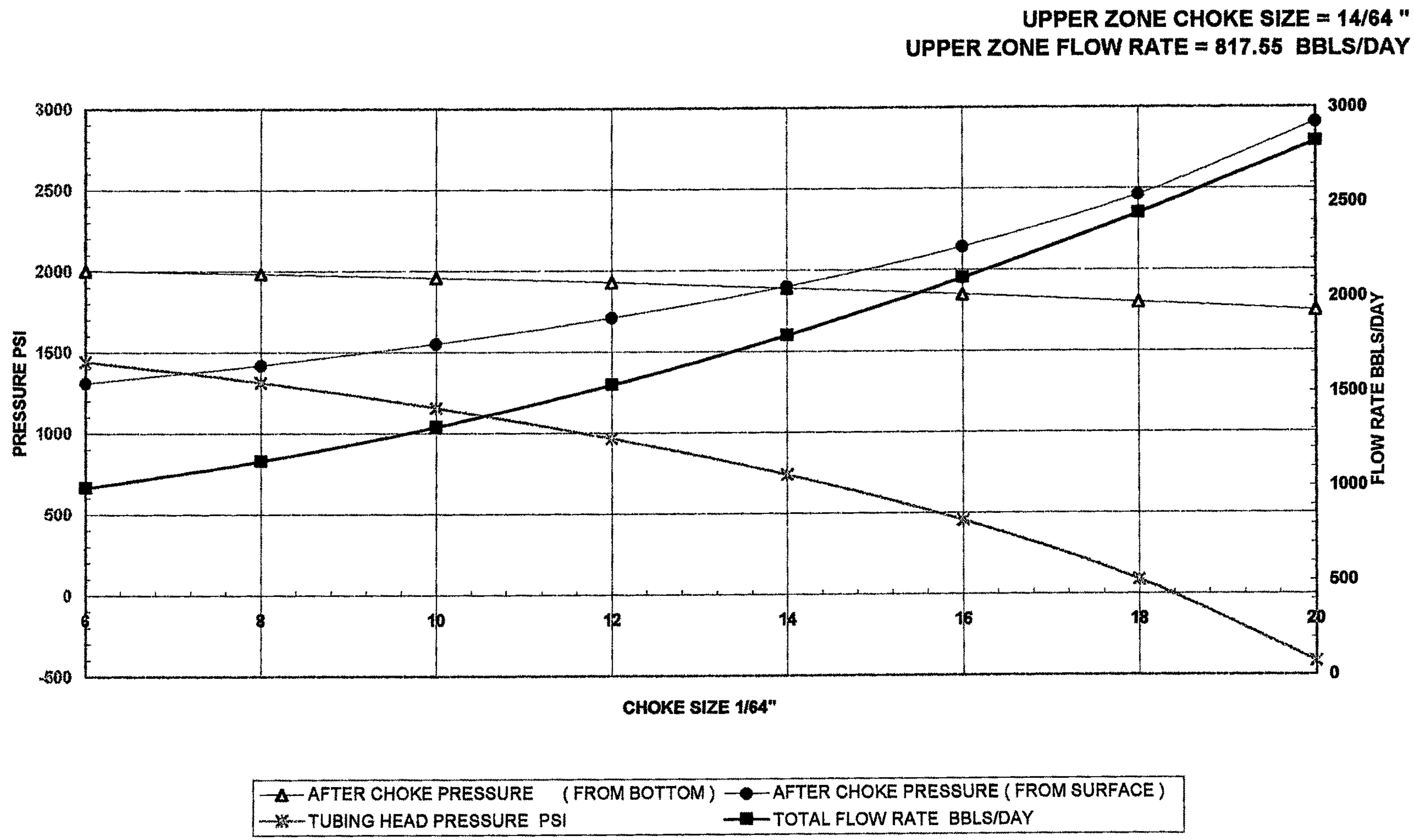

FIGURE 6.13 COMMINGLING CHOKE SIZE SELECTION
(TEST NO. 1)

UPPER ZONE CHOKE SIZE = 16/64 "
UPPER ZONE FLOW RATE = 1067.82 BBLS/DAY

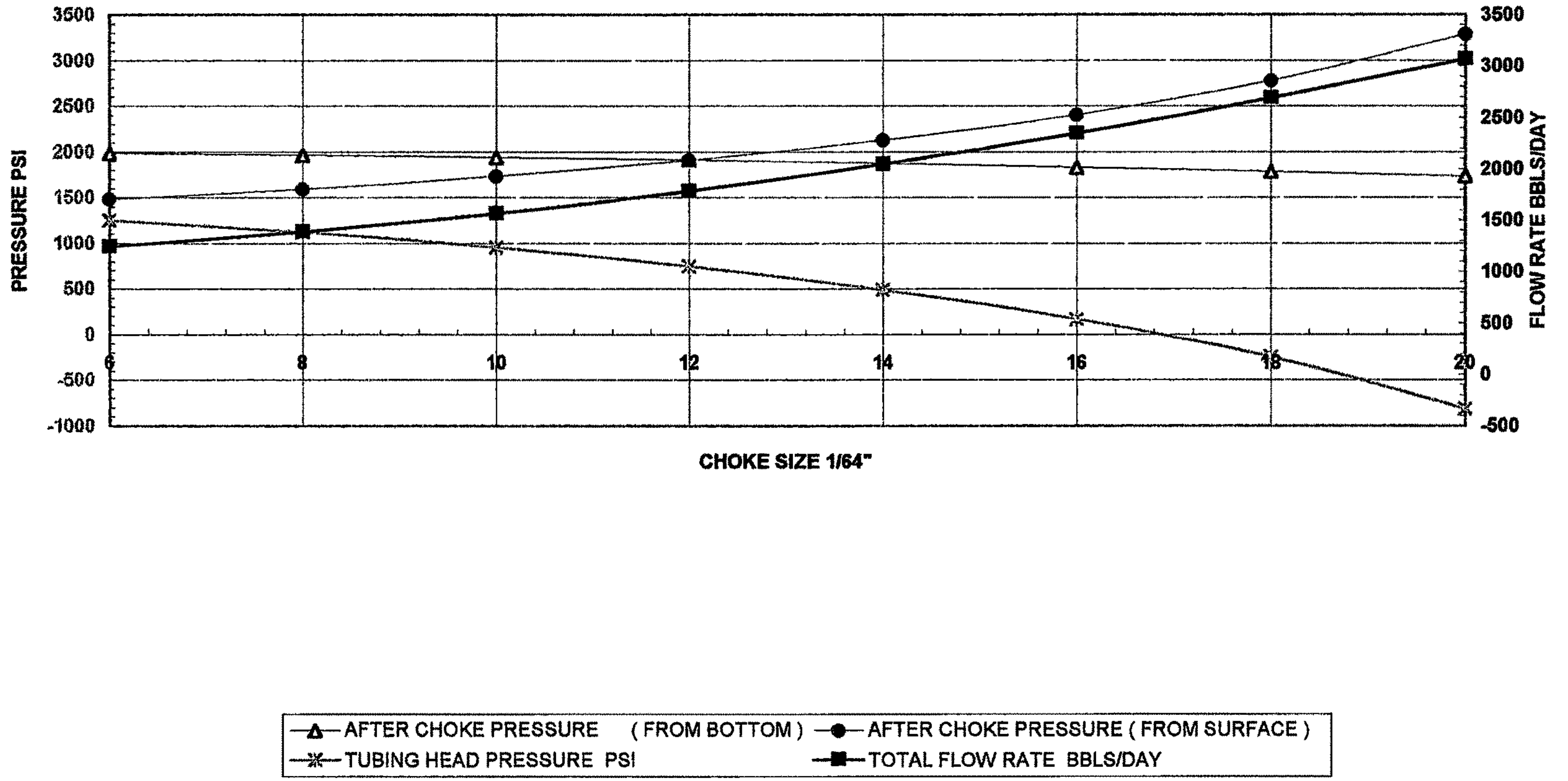

FIGURE 6.14 COMMINGLING CHOKE SIZE SELECTION
(TEST NO.1)

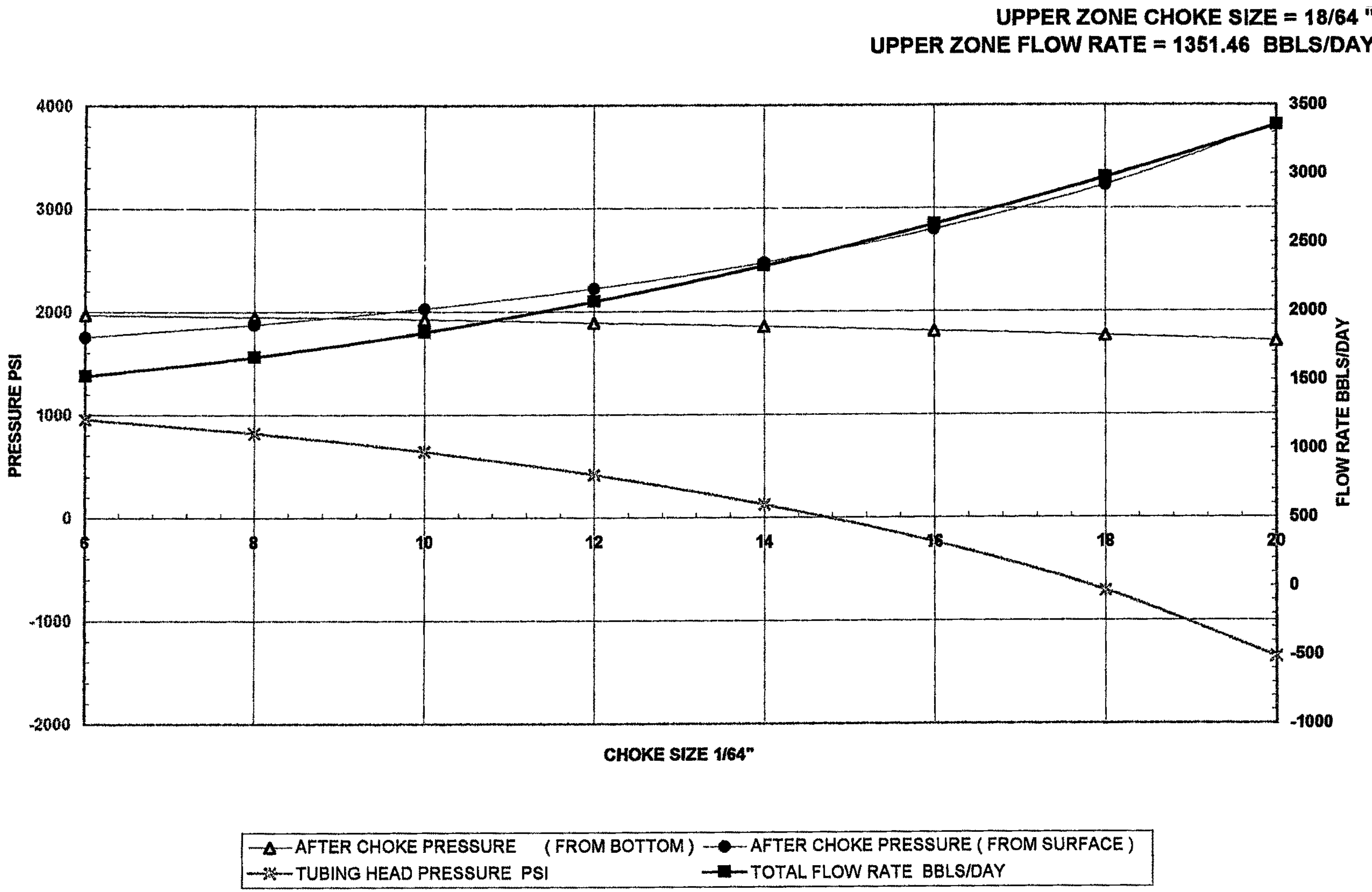

FIGURE 6.15 COMMINGLING CHOKE SIZE SELECTION
(TEST NO.1)

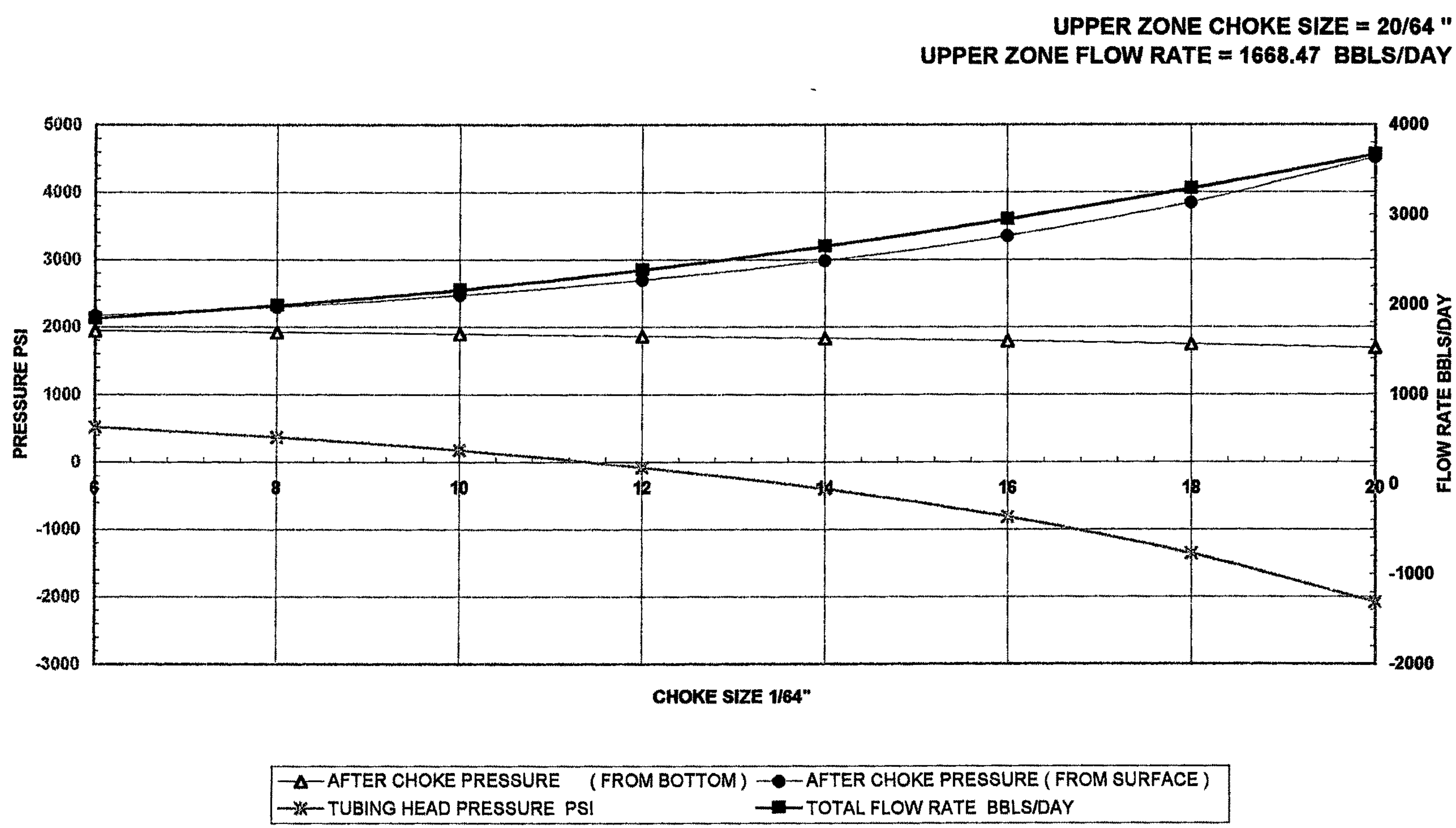

FIGURE 6.16 COMMINGLING CHOKE SIZE SELECTION
(TEST NO.1)

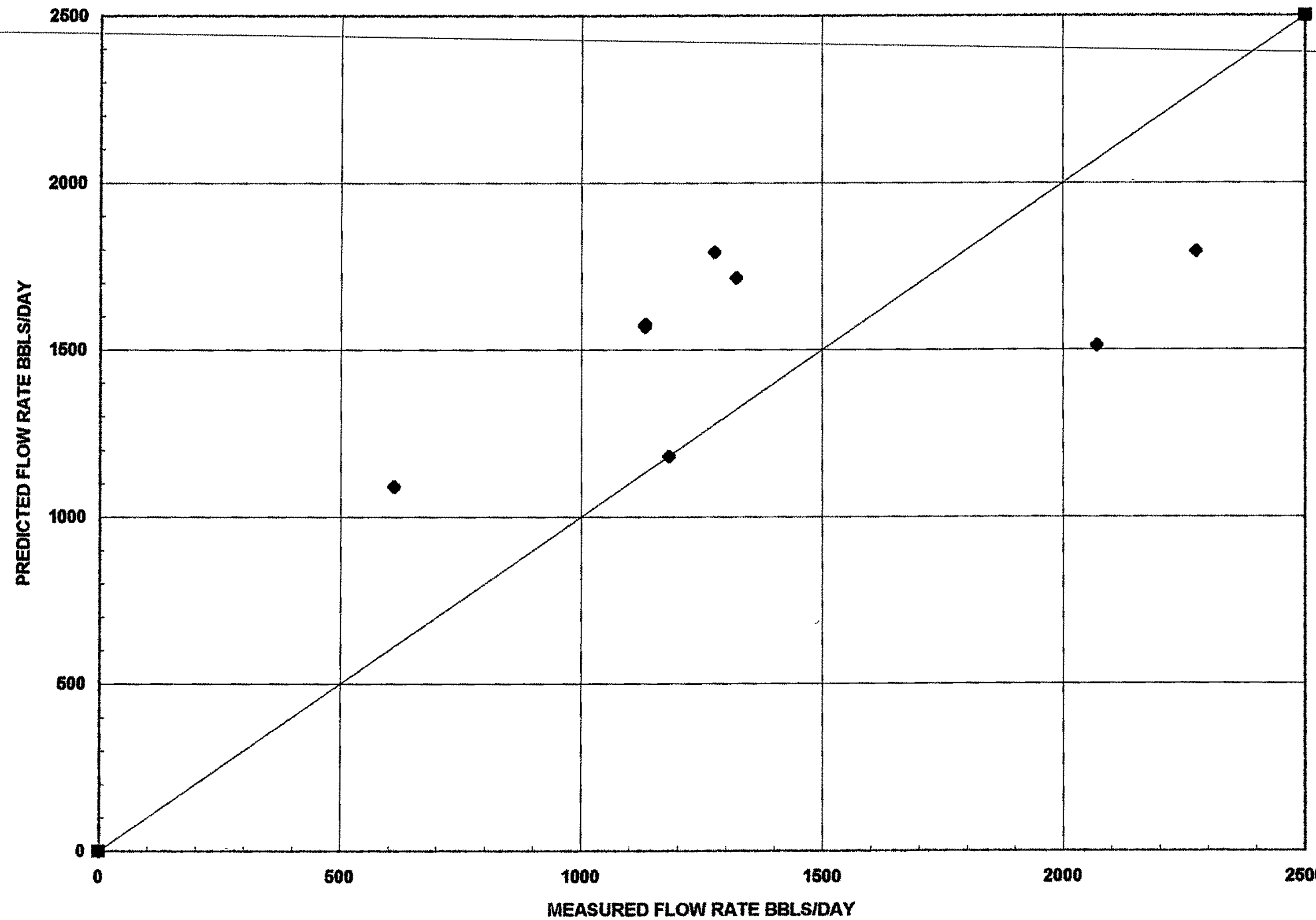

FIGURE 6.17 CROSS PLOT FOR COMMINGLING FLOW RATE

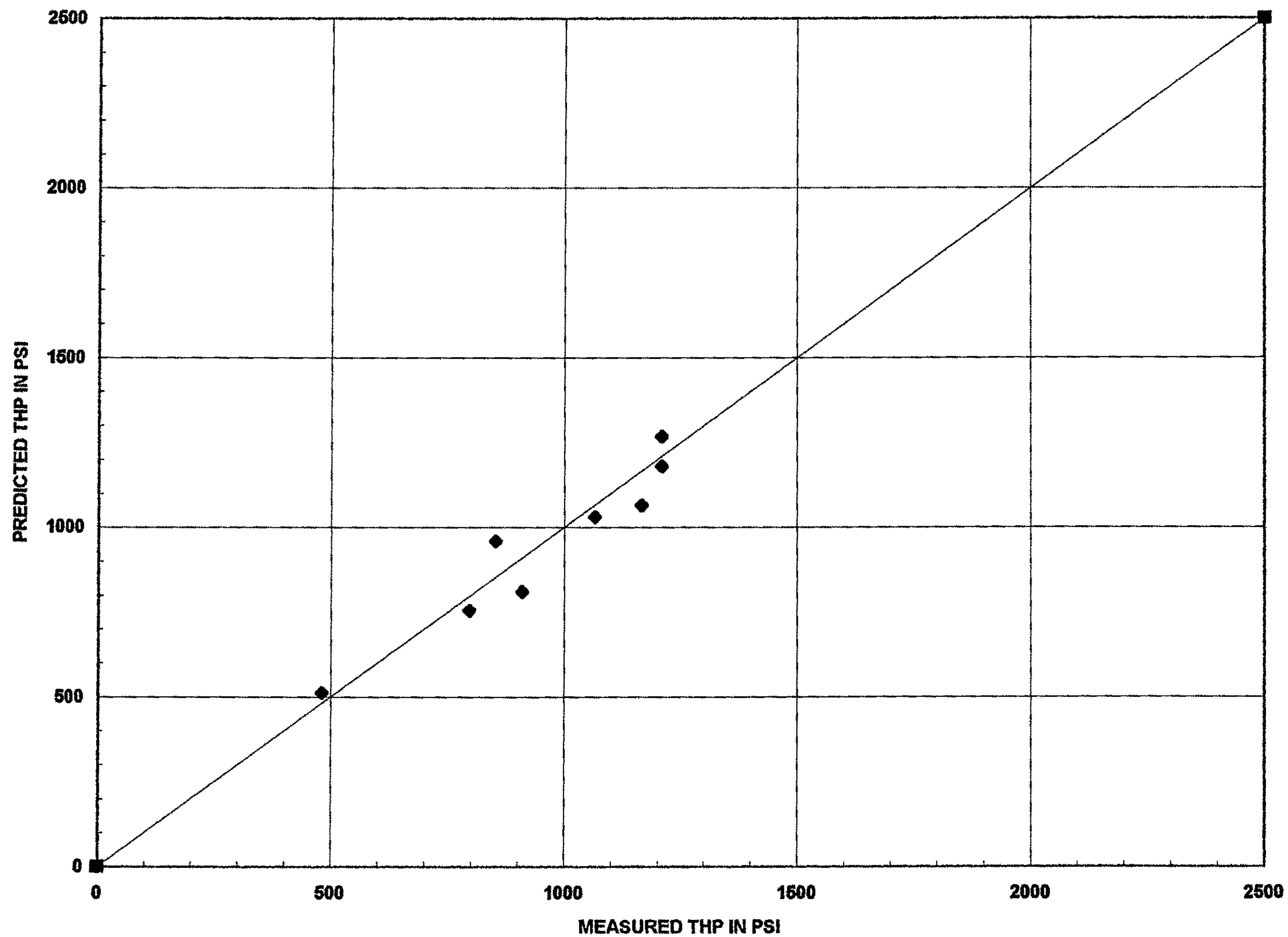

FIGURE 6.18 CROSS PLOT FOR COMMINGLING FLOW TUBINGHEAD PRESSURE