

Example 10.2—Recoveries for a Gas/Condensate Reservoir. The gas/condensate reservoir for the CVD data shown in Tables 10.3 through 10.5 has the following reservoir properties: $A = 113.149$ acres, $\bar{h} = 10$ ft, $\phi = 10\%$, $S_{wi} = 20\%$, $p_i = 5,713$ psig, and $p_d = 4,000$ psig.

1. Determine the original primary-separator gas, second-stage-separator gas, and total gas and total condensate in place by volumetrics.

2. Determine the recoverable reserves of each stream at the dewpoint (4,000 psig).

3. Determine the recoverable reserves of each stream at the abandonment pressure (605 psig).

Solution. Table 10.6 shows the step-by-step solution. At the dewpoint, 10.5% of both the liquid and the gas has been recovered. At abandonment pressure, 85.2% of the gas has been recovered but only 33.65% of the liquid has been recovered because the condensate has been dropping out of the vapor in the reservoir and has become unrecoverable.

Data

Component	Hydrocarbon (mol%)						
	At 5,713 psig	At 4,000 psig	At 3,500 psig	At 2,900 psig	At 2,100 psig	At 1,300 psig	At 605 psig
Carbon Dioxide	0.18	0.18	0.18	0.18	0.18	0.19	0.21
Nitrogen	0.13	0.13	0.13	0.14	0.15	0.15	0.14
Methane	61.72	61.72	63.10	65.21	69.79	70.77	66.59
Ethane	14.10	14.10	14.27	14.10	14.12	14.63	16.06
Propane	8.37	8.37	8.25	8.10	7.57	7.73	9.11
<i>iso</i> -butane	0.98	0.98	0.91	0.95	0.81	0.79	1.01
<i>n</i> -butane	3.45	3.45	3.40	3.16	2.71	2.59	3.31
<i>iso</i> -pentane	0.91	0.91	0.86	0.84	0.67	0.55	0.68
<i>n</i> -pentane	1.52	1.52	1.40	1.39	0.97	0.81	1.02
Hexanes	1.79	1.79	1.60	1.52	1.03	0.73	0.80
Heptanes plus (C ₇₊)	6.85	6.85	5.90	4.41	2.00	1.06	1.07
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
C ₇₊ molecular weight	143	143	138	128	116	111	110
C ₇₊ specific gravity	0.795	0.795	0.790	0.780	0.767	0.762	0.761
Deviation factor, <i>z</i>							
Equilibrium gas	1.107	0.867	0.799	0.748	0.762	0.819	0.902
Two-phase	1.107	0.867	0.802	0.744	0.704	0.671	0.576
Wellstream produced— cumulative % of initial		0.000	5.374	15.438	35.096	57.695	76.787

	Initial Fluid in Place	Cumulative Recovery Per MMscf of Original Fluid						
		At 4,000 psig	At 3,500 psig	At 2,900 psig	At 2,100 psig	At 1,300 psig	At 605 psig	At 0 psig
Wellstream, Mscf	1,000	0	53.74	154.38	350.96	576.95	767.87	935.15
Stock-tank liquid, bbl	135.7	0	6.4	15.4	24.0	29.7	35.1	
Primary-separator gas, Mscf	757.87	0	41.95	124.78	301.57	512.32	685.02	
Second-stage gas, Mscf	96.68	0	4.74	12.09	20.75	27.95	37.79	
Stock-tank gas, Mscf	24.23	0	1.21	3.16	5.61	7.71	10.40	

ρ (psig)	Retrograde-Liquid Volume (% hydrocarbon pore space)
4,000	0.0
3,500	3.3
2,900	19.4
2,100	23.9
1,300	22.5
605	18.1
0	12.6

Solution

Hydrocarbon pore space	
Given	1,131.49 acre-ft (from geological data)
	1,131.49 acre-ft
	× 7,758 bbl/acre-ft
$\phi = 10\%$ (from core analysis)	× 0.10
$S_{wi} = 20\%$ (from core analysis)	× (1 - 0.20)
	= 702,247 bbl hydrocarbon pore space
Cumulative recovery	
In-place reserves at original reservoir pressure of 5,713 psig	
Wellstream	702,247 bbl pore space
	× 1.591 Mscf wellstream/bbl pore space
	= 1,117,275 Mscf
Stock-tank liquid	1,117,275 Mscf wellstream
	× 135.7 bbl stock-tank oil (STO)/MMscf wellstream
	= 151,614 bbl
Primary-separator gas	1,117,275 Mscf wellstream
	× 757.87 Mscf separator gas/MMscf wellstream
	= 846,749 Mscf
Second-stage-separator gas	1,117,275 Mscf wellstream
	× 96.68 Mscf second-stage gas/MMscf wellstream
	= 108,018 Mscf
Primary +secondary+stock-tank gas	= 981,839 Mscf
In-place reserves at dewpoint of 4,000 psig	
Wellstream	702,247 bbl pore space
	× 1.424 Mscf wellstream/bbl pore space
	= 1,000,000 Mscf
Stock-tank liquid	1,000,000 Mscf wellstream
	× 135.7 bbl STO/MMscf wellstream
	= 135,700 bbl
Primary-separator gas	1,000,000 Mscf wellstream

Second-stage-separator gas	1,000,000 Mscf wellstream
	× 96.68 Mscf second-stage gas/MMscf wellstream
	= 96,680 Mscf
Total gas in place at 4,000 psig	= 878,780 Mscf
Cumulative recoveries at dewpoint	
Wellstream	1,117,275 Mscf in place at 5,713 psig
	– 1,000,000 Mscf in place at 4,000 psig
	= 117,275 Mscf produced
	= 10.5 %
Stock-tank liquid	151,614 bbl in place at 5,713 psig
	– 135,700 bbl in place at 4,000 psig
	= 15,914 bbl produced
	= 10.5 %
Primary-separator gas	846,749 Mscf in place at 5,713 psig
	– 757,870 Mscf in place at 4,000 psig
	= 88,879 Mscf produced
	= 10.5 %
Second-stage-separator gas	108,018 Mscf in place at 5,713 psig
	– 96,680 Mscf in place at 4,000 psig
	= 11,338 Mscf produced
	= 10.5 %
Total gas recovery at dewpoint	= 103,059
	= 10.5 %

TABLE 10.6—SOLUTION TO EXAMPLE 10.2 (continued)

Cumulative recovery (production below the dewpoint with abandonment pressure assumed to be 605 psig)	
Wellstream in place at dewpoint of 4,000 psig	= 1,000,000 Mscf
Cumulative recoveries at 605 psig	
Stock-tank liquid	1,000,000 Mscf original wellstream
	× 35.1 bbl STO/MMscf original wellstream
	= 35,100 bbl
Primary-separator gas	1,000,000 Mscf original wellstream
	× 685.02 Mscf separator gas/MMscf original wellstream
	= 685,020 Mscf
Second-stage-separator gas	1,000,000 Mscf
	× 37.79 Mscf second-stage-separator gas/MMscf
	= 37,790 Mscf
Total gas	= 1,000,000 × (285.02+37.79+10.4)
	= 733,190 Mscf
Total recoverable reserves (basis two-stage separation at 500 psia and 50 psia at 70°F)	
Stock-tank liquid	
Production to dewpoint	= 15,914 bbl
Production below dewpoint	= 35,100 bbl
Total	= 51,014 bbl
	= 33.65 %
Primary-separator gas	
Production to dewpoint	= 88,879 Mscf
Production below dewpoint	= 685,020 Mscf
Total	= 773,899 Mscf
Second-stage-separator gas	
Production to dewpoint	= 11,338 Mscf
Production below dewpoint	= 37,790 Mscf
Total	= 49,128 Mscf
Total Gas	103,059 Mscf
	+ 733,190 Mscf
	= 836,249 Mscf
	= 85.2 %