

Appendix B

CONSTRUCTING THE DISSOLVED GAS CONCENTRATION VS. PRESSURE TABLE FOR THE DEPRESSURIZATION CASE STUDY

At least two well-spaced data points are needed to adequately define the variation of dissolved gas concentration as pressure changes. However, only one data point could be read off directly from the PVT data set that was supplied and it indicated the gas concentration at the bubble point (Table B-1) – computed as the cumulative sum of the GOR (gas to oil ratio) values at each stage of a two-stage separator test i.e. 632scf/stb @stage1 + 269scf/stb @stage2 = 901scf/stb @bubblepoint (see Table B-1). Note that the GOR values recorded at the end of a separator stage do not describe the dissolved gas concentration at that point but merely state the amount of gas evolved in scf/stb over the course of the separation stage (more like the producing GOR). Thus in Table B-1, 632scf/stb is simply the volume of gas evolved as the pressure dropped from 3165psia to 1000psia.

Figure B-1 illustrates a simple schematic of a two-stage separator test. We will use the labels in Figure B-1 to reemphasize the previous point viz: If the GOR at stage1 and stage2 are given as $V1/L2$, and $V2/L2$, respectively, then $(V1+V2)/L2$ represents the solution GOR at the bubble point. Again, $V1/L2$ tells us nothing about gas still in solution.

Making a sound estimate of the dissolved gas concentration below the bubble point requires new information from a differential PVT test which we currently do not have. Still, a rough estimate could be made by going back to Table B-1 once again. Since 901scf/stb is the total amount of gas in the oil at 3165psia and since 632scf/stb was produced as the pressure dropped from 3156psia to 1000psia, then the amount of gas left in solution at this point becomes $901\text{scf/stb} - 632\text{scf/stb} = 269\text{scf/stb}$. Now

interpreted as concentrations of solute (gas) in the solvent (oil), column 5 in Table B-1 presents the new GORs at both 1000psia and 14.7psia.

Table B-2 shows the newly modified GORs expressed in units more suited for use in our numerical model. Starting with an identical oil volume as in the cell only depressurization of 20ml and adjusting the gas concentration values to account for oil volume expansion with pressure (Table B-3), 1.632×10^{-3} kg of gas was found to have been liberated as pressure dropped from 3165psia to 1014.7psia. And with a molar mass of 0.0297kg - computed by inserting the gas density at standard conditions (14.7psia and 60°F) into the Ideal Gas law, Equation B-1 returned 25.13ml as the volume of gas evolved over the course of the pressure drop and through a constant temperature of 225°F. Moreover, 25.13ml lies between 25.5ml and 23.61ml – which were respectively obtained through PVT analysis and the cell only depressurization over the same pressure range.

$$V = \frac{mRT}{MP} \tag{B-1}$$

where V is the gas volume; m the mass of gas liberated = 1.632×10^{-3} [kg]; R the universal gas constant = $8.314 \text{ [m}^3 \text{ Pa K}^{-1} \text{ mol}^{-1}\text{]}$; T the current temperature = 380.372 [K]; M the molar mass of gas = 0.0297 [kg]; P the current pressure = 6.996×10^6 [Pa].

Table B-1: Summary of a two-stage separator test; Columns 1-4 were given whilst column 5 was derived.

Stage	Separator Pressure, psia	Separator Temperature, °F	Gas Oil Ratio, scf/stb	Gas Oil Ratio, scf/stb (as concentrations)
0	3165	225	901	901
1	1000	225	632	269
2	14.7	60	269	0

