TENTAMEN : Production Technology I (mp3440)
January 21 1999

Answer all questions. Answer in either English or Dutch (or a mixture).

Question 1

a) Explain the phase behaviour of a hydrocarbon as it is produced from the reservoir, through the tubing and into the surface facilities.

b) Oil is produced from a reservoir at depth 10000 feet. The reservoir pressure is 3500 psi and the reservoir temperature is 195 F. The oil has API gravity 35, gas specific gravity 0.65, and producing gas/ oil ratio 600 scf/bbl. Use Standing's black oil correlation to calculate the bubble point pressure for the oil at the reservoir temperature.

c) This oil is produced by a vertical well with 4½" tubing. The watercut is zero and the PI of the well is 10 bbl/day/psi. The production rate is 1000 bbl/day. Calculate the flowing bottom hole pressure and the tubing head pressure, using the Duns/Ros gradient curves.

d) Estimate from the Duns/Ros curve the depth in the tubing at which gas comes out of solution (accuracy to within 500 ft). Ignore temperature effects - assume oil stays at reservoir temperature.

e) At a later time, the reservoir pressure has dropped to 2950 psi. Calculate the minimum production rate for which the gas stays in solution while in the formation. What are the consequences if gas comes out of solution before entering the well?

Question 2

a) Use the Duns/Ros gradient curves to calculate the flowing bottomhole pressure p_{wf} for the following well at the flowrates 400, 600, 800, 1000, 1500 and 2000 bbl/day

depth of producing interval	15000 ft
GOR	2000 scf/bbl
Water cut	0%
Tubing size	2 7/8"
Tubing head pressure	500 psi

b) The initial reservoir pressure is 3500 psi and the PI is 2 bbl/day/psi. What is the initial production rate and flowing bottomhole pressure ?

c) It is planned to produce the reservoir at a plateau rate of 20000 bbl/day. It is believed that there is a strong aquifer to maintain reservoir pressure. How many wells would you drill?

d) After some years, it becomes clear that aquifer is not strong enough to maintain reservoir pressure, and the reservoir pressure drops to 3200 psi. What is the production rate at this reservoir pressure, assuming the PI has not changed. It is decided to stimulate the wells, to improve the PI and restore production. Calculate the new PI if the production is to be restored to the desired plateau level.

e) If the reservoir pressure continues to fall, and the PI stays constant at this new value, what is the lowest stable rate of production from an individual well?

Question 3

a) Describe the advantages and disadvantages of gas-lift compared with other forms of artificial lift.

b) It is planned to install gaslift in a well that has stopped flowing. The tubing head pressure is 200 psi and the pressure gradient in the oil is 0.4 psi/ft. If the gas injection pressure on surface is 1000 psi and the gas gradient is 0.04 psi/ft, determine the deepest point at which gas can be injected without gaslift valves. What is the pressure at that depth?

c) When the well is flowing under gaslift, the tubing head pressure is maintained at 200 psi. From a wellflow simulator, it is found that the flowing well gradient is given approximately by the straight line through 200 psi with gradient 0.1 psi/ft. Determine the deepest point at which gas can be injected with gaslift valves. What is the pressure at that depth?

d) The gaslift valves are adjusted to operate at a pressure 100 psi above the flowing well gradient. Calculate the setting depths of the valves. Valves are not placed below 5000 ft.

e) What is the opening pressure of the bottom valve? The temperature at the depth of the valve is 60 C. Calculate the pressure in the nitrogen chamber, measured at surface temperature (15 C) before the valve is installed. The area ratio of the valve (A_b/A_p) is 5.

Question 4

a) A well is producing under the following conditions

Depth	10000 ft
GLR	1000 scf/bbl
Watercut	0%
Tubing size	4½"
Reservoir pressure	1700 psi
Productivity Index PI	4 bbl/day/psi

Calculate the flowing bottomhole pressure at a production rate of 800 bbl/day.

b) This production rate of 800 bbl/day (120 m^3/day) is produced by an ESP installed at depth 5000 ft (not at the bottom of the hole). The tubing head pressure is 500 psi. For the given tubing size, the ESP manufacturer offers a series of three pumps with different operating ranges. The performance curves of the three pumps are given below. The dashed lines indicate the best efficiency point. Calculate the number of stages for each type of pump which can be used. (note : 1 kPa = 6.89 psi)

c) Which of the two possible pumps would you choose, considering their efficiency. Explain how you can optimise the efficiency using a variable speed drive.

d) The pump performance curves are given for frequency 50 Hz. What happens to the best efficiency point of pump C if the frequency is increased to 60 Hz. Estimate the head produced by one stage of Pump C at its best efficiency point for frequency 60Hz.