Reservoir Fluids and Flow
TPG 4145

Due Date for Delivery: Monday Sept. 17, 2012

Problem 1:

This problems involves the Troll gas field in Norway, containing approximately 45 Tcf (45E12 scf) initial "free" gas in place at an initial reservoir pressure of approximately 158 bara and temperature of 70°C (measured at the approximate water contact of 1350 m TVDSS, true vertical depth sub-sealevel). Assume the average gas thickness is 100 m.

For this problem (because we've only talked about gas so far) we will make the very-silly assumption that Troll does not contain oil. In fact it does, with an average thickness of about 10 m (varying from a few meters to 20 meters), and totaling some 4 billion barrels across the entire field!

We'll assume an initial discovery well was drilled through the gas reservoir and into an underlying water aquifer. The well was completed with production casing with outer diameter 9-5/8" (inches). A pressure gauge was lowered into the casing and reached the well bottom at a depth of 1500 m.

Assume the well is not producing:

1. What pressure was measured at 1500 m. Assume water density of 1050 kg/m^3 and that water was located in the tubing from the water-gas contact at 1350 m down to the bottom at 1500 m.
2. What pressure was measured at the surface (sea level) assuming an average temperature in the tubing of 40°C? You can also assume a constant Z_g value in the tubing containing the static gas column.
3. Plot pressure versus depth from sealevel to 1500 m TVDSS.
4. What is the estimate of hydrocarbon (gas) reservoir volume? How many such volumes would be required to fill the Trondheim fjord which has a total volume of about 235 km^3?

Prior to production startup, a production tubing with 7" outer diameter / 6" inner diameter was installed. The tubing is isolated from the casing by a downhole packer located just above the top of the gas formation at 1250 m TVDSS. If the well started producing at a rate of 2E6 Sm3/d, answer the following questions:

5. At 1000 m TVSSS inside the tubing a pressure of 100 bara and temperature of 40°C were measured. What is the gas flow velocity in m/s inside the tubing at 1000 m TVDSS? What is the Reynold's number?
6. With 50 such wells, each producing 2E6 Sm^3/d, how much of the total initial gas in place (Sm^3) is being produced per year? How long will it take to produce half (50%) of the initial gas in place?
7. With these 50 wells and assuming a gas sales price of USD 4/Mscf, how much revenue is expected per year? Also express the ***daily*** revenue in terms of your life salary (25 years x NOK 700,000/year).