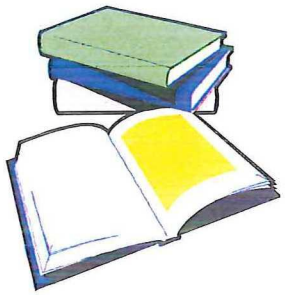
TU Delft – Drilling and Production AES1330

Written Exam – 02 July 2013

Duration: 3 hours

- Write your name and personal student number ***clearly*** at the top of ***each*** page.
- Decimal points and comma's in this examination paper are used in the *English* manner, thus, for example 100,000 is hundred thousand, not 100 with three decimals !
- It is important to supplement all your answers with your personal calculation sheets, as points are also awarded for the actual method being applied.
- Use sketches and drawings freely if this will facilitate your calculations and / or make it easier to understand the actual situation in the exercise. (Note this also assists the examiner in judging the level of understanding in the event of an incorrect arithmetical answer)
- You may consult all your study books, lecture notes and hand-outs. **All handwritten notes and solutions to exercises are forbidden and using them is fraud.**
- Where needed simple and quick to use handout with ***tables*** has been given to you to speed up the search for the required capacities, buoyancy's, weights, etc.



Marks allocation

QUESTION	1	2	3	4	5	6	7	8	9	10	Total
1	6	2	2								10
2	3	3	3	6	2	3					20
3	4	4	8	9							25
4	2	4	6	4	4						20
5	2	2	3	5	5	2	2	2	2		25

Total : *100 marks*

1. Tripping [10 pts]

The following data is available:

Depth of vertical 8-1/2" hole	2500 m
9-5/8" casing shoe	1500 m
Mudweight	1.67 sg
Pore pressure gradient	14.9 kPa/m
Open hole capacity	0.076 m3/m
Casing capacity	0.082 m3/m
Drill pipe metal displacement	0.0042 m3/m
Average stand length	28.3 m

1.1 Calculate the maximum number of stands that can be pulled dry without filling up the well, before the well starts to flow [6 pts]

1.2 Explain how primary well control is kept during the trip out of hole [2 pts]

1.3 What could be another cause to loose primary well during a trip out of hole [2 pts]

2. Well Control [20 pts]:

We are now drilling a long 12-1/4" hole section at 2720 m MD/TVD. The well kicks quite unexpectedly, because a poor reservoir prognosis. The crew was alert and closed in the well quickly.
The following information has been pre-recorded:

Drill String	
- 12 pcs 8-1/4" OD by 2-1/4" Drill Collar (each Drill Collar is 10 m)	Capacity: 2.57 l/m
- 18 pcs of 5" OD HWDP (each HWDP is 10 m)	Capacity: 4.61 l/m
- 5" OD Drill Pipe to surface	Capacity: 8.97 l/m
- 13-3/8" OD casing N80: 68 ppf	Shoe set at 927 m
- Leak-Off Pressure	4375 kPa
- Drilling Fluid Gradient during Leak-Off	12.8 kPa/m
Drilling Fluid and Pump	
- Current Drilling Fluid Gradient	15.2 kPa/m
- Slow Circulation Pressure at 40 Strokes/min	3200 kPa
- Mud Pump Output (at 97% efficiency)	16 litres/stroke

Closed in well information:

- Stabilised Shut-In Drill Pipe Pressure or SIDPP [P_{DP}]: 815 kPa
- Stabilised Shut-In Casing Pressure or SICP [P_{ANN}]: 1370 kPa
- Influx volume: 3500 litres

2.1 Calculate the current MAASP. [3 pts].

2.2 Calculate the Reservoir pressure at 2720 m [3 pts]

2.3 Calculate the **Kill Mud Gradient** (round off value to one decimal behind point). [3 pts]

2.4 Construct the Kill Graph on Scale for a wait and Weight Method and a kill rate of 40 SPM, clearly showing [6 pts]

a. SIDPP [Pdp]
b. PL [=Pc1 at 40 SPM]

c. ICP
d. FCP
e. Strokes for phase 1

2.5 If we apply the Wait and Weight Method, what would be the Circulation Pressure from Phase 2 onwards. [2 pts]

2.6 The influx height across the DC/HWDP has been calculated to have a TV height of 83 m. What is the **influx gradient and the type [oil, water or gas?]** [3 pts]

3. Casing Design [25 pts]

3.1. Why is it usually necessary to drill a well in stages, setting casing after each stage. [4 pts]

3.2. What are the usual "collapse" design criteria for a casing? [4 pts]

3.3. A 7" casing is installed in a well. The casing shoe is at depth 12000 ft. Sketch the Collapse Pressure as a function of depth, if the well is being drilled with mud of relative density 1.6. Take a Design factor of 1.0. (The hydrostatic pressure gradient of water is 0.4335 psi/ft. [8 pts]

3.4 Design the casing string as cheaply as possible using N-80 grade casing, which has the following collapse strength. [9 pts]

	Nominal weight lbs/ft	N-80
Minimum collapse pressure	20.00	
psi	23.00	3830
	26.00	5410
	29.00	7020
	32.00	8600
	35.00	10180
	38.00	11390

4. Stimulation [20 pts]

4.1. Explain the roles of the pre-flush, the main flush and the post-flush in matrix acidizing of sandstone formations. [2 pts]

4.2. An HF/HCl acid blend is formed of 1% by wt HF and 10% HCl. Calculate the volumetric dissolving power for the primary reaction of HF with sodium feldspar $NaAlSi_3O_8$, given by

$$NaAlSi_3O_8 + 14\ HF + 2H^+ \leftrightarrow Na^+ + AlF_2^+ + 3SiF_4 + 8H_2O$$

The molecular mass of sodium feldspar is 262.3 and of HF 20. The density of the acid blend is 1070 kg/m^3 and of sodium feldspar 2700 kg/m^3. [4 pts]

4.3. In a sandstone acidizing treatment, the above acid blend is used to remove sodium feldspar. The porosity of the sandstone is 0.25 and it contains 4% [by volume] sodium feldspar. The aim is to remove all sodium feldspar to a depth of 10 cm. The borehole radius is 10 cm. What is the minimum required volume of acid blend in m^3/metre of perforated interval. [6 pts]

4.4 What are the potential problems in pumping acid into such a long open-hole interval. How can you try to avoid these? [4 pts]

4.5 What are thought to be the reasons for failure in using mud-acid with high HF concentrations? [4 pts]

5. Short calculation questions / General knowledge:

5.1 Explain how the wired drill pipe can be used to determine a kick [2 pts]

5.2 What is the difference between the directional control of the well using a rotary steerable system and a positive displacement motor [2 pts]

5.3 What type of drill string vibration exists, what could be the cause, and what could be the result? [3 pts]

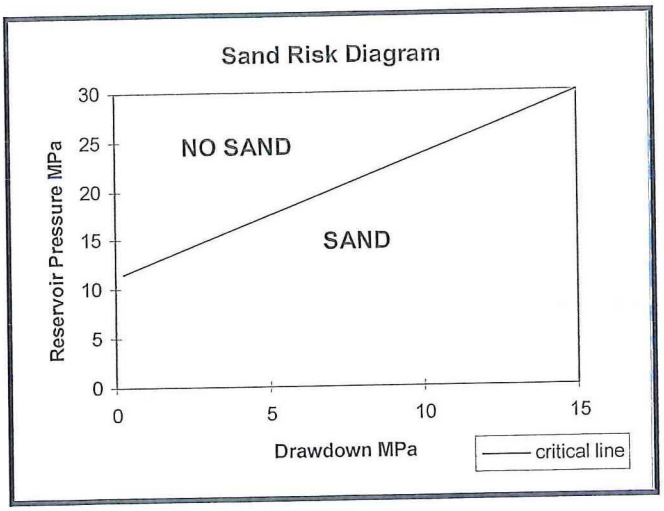
5.4 The 12-1/4" hole is being drilled with 8-1/4" Drill Collars and 5" HWDP. All joints are 10 m long. The Drill collars weigh 239 kg/m and the HWDP weigh 74 kg/m. The mud gradient is 12.0 kPa/m, with a buoyancy of 0.844, the hole inclination is 25 degrees. If we would like to drill with 25 metric ton Weight on Bit (WOB), how many HWDP do we need in the string to get the required WOB? Note: only 90% of the Bottom Hole Assembly (BHA) length may be placed in compression. [5 pts]

5.5 We want to drill an offshore exploration well in a water depth of 75 m. We need to select a suitable rig, what type would this be? Give at least 2 reasons what you based your selection on. [5 pts]

a. Barge rig
b. Platform rig
c. Jack-up rig
d. Semi-submersible
e. Drill ship

5.6 Name three methods for preventing hydrate formation in pipelines [2 pts]

5.7 The initial pressure in a reservoir is 15 MPa. The initial production rate from a well is planned at 200 m^3/day, and the PI is 20 m^3/day/MPa. The sand risk diagram is given on the right. Do you anticipate sand production? [2 pts]



5.8 In a gaslifted well, the gas injection pressure on surface is 6 MPa. The fluid gradient is 0.08 MPa/m, the gas gradient 0.004 MPa/m and the flowing well gradient approximately 0.04 MPa/m. Determine the deepest point at which gas can be injected (i) without gaslift valves and (ii) with gaslift valves. [2 pts]

5.9 What is the role of the proppant in a hydraulic fracturing treatment? [2 pts]