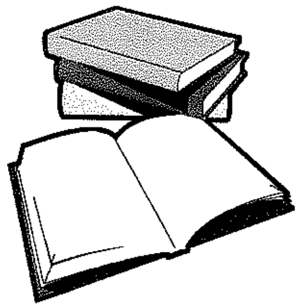
EXAMINATION:- Drilling & Production Engineering AES1330

25th August 2006

- 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 and notes. With this exercise, a 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.
- It is ***not permitted*** to bring old examination papers to the examination room. In the event that the invigilator observes any candidate with an old paper, then the individual involved will be requested to leave the examination room immediately.



Marks allocation

	a	b	c	d	e	f	Total
Question 1	4	2	2	4			12
Question 2	4	2	2	2	2		12
Question 3	2	2	3	3	2		12
Question 4	2	2	3	3	2		12
Question5.1	2						2
Question 5.2	2						2
Question 5.3	1	1					2
Question 5.4	2						2
Question 5.5	2						2
Question5.6	1	1					2
Question 5.7	2						2
Question 5.8	2						2
Question 5.9	2						2
Question 5.10	2						2

Total: *68 marks*

QUESTIONS

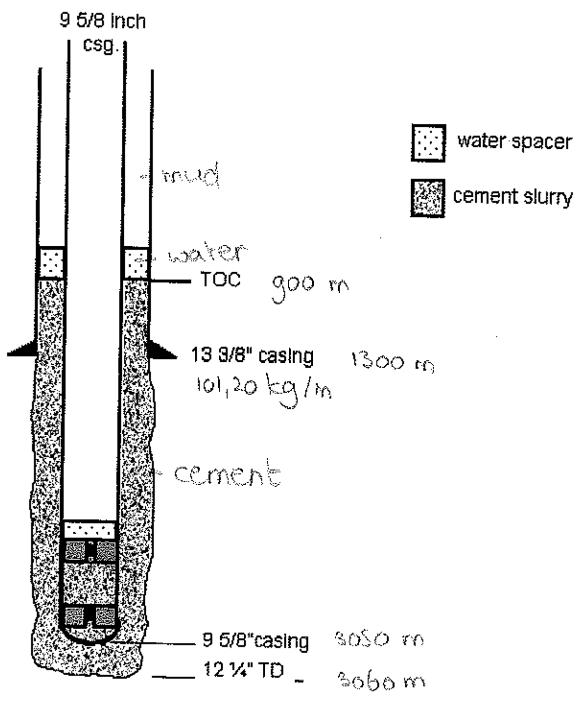
1. Cementation:

12 1/4 inch hole has been drilled to section TD (total depth) and it is planned to run and set the 9-5/8 inch casing.

The casing is run without problems and the cementation is about to commence. The following data is known:-

Depth of the 12 1/4 inch hole	3060 metre
Depth of the 9-5/8 inch casing	3050 metre
Weight of the 9-5/8 inch casing	64.74 kg/m
Depth of the previous casing (13 3/8 inch casing)	1300 metre
Weight of the previous casing (13 3/8 inch casing)	101.20 kg/m
Gradient of the cement slurry to be used	16.8 kPa/m
Yield value of the dry cement	1.39 litre/kg
Mix water for the cement slurry	0.84 litre/kg
Gradient of the drilling fluid	12.0 kPa/m
Specific density of the water spacers	10.0 kPa/m
Water spacer volume ahead of the cement slurry	3 m³
Water spacer volume after the cement slurry	1 m³
Casing shoe track length	25 metre
Planned top of cement (TOC)	900 metre

Because of a 'washed-out' hole we require *20 % more* cement than the theoretical volume between hole diameter and casing, also in the 10m rat hole below the casing



1a **Calculate the required volume (m3) of cement slurry to perform this cementation.**

1b **Calculate the amount of dry cement (MT) required to perform this cementation.**

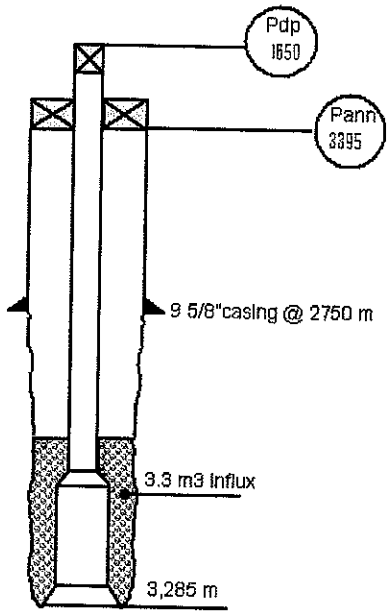
1c **Calculate the amount of mix water (m3) required to perform this cementation.**

1d **Calculate the hydrostatic pressure differential (kPa) between the annulus and casing when the cement displacement is completed.**

2. Pressure Control :

Following a successful 9 5/8" cementation, operations continued with the drilling of the 8 ½" hole section. Whilst drilling ahead at a depth of 3075 meters a ***'kick'*** is experienced. The Driller closes in the well, and it is observed that an influx of volume **3.8 m³** has been taken. The driller collects and records all the data associated with the kick as follows:-

Drill string pressure P_{dp}	1,650 kPa
Annulus pressure P_{ann}	3,395 kPa
Drilling Fluid Gradient	13.5 kPa/m
Slow circulating pressure @ 30 strokes/min	5,300 kPa
Capacity between drillcollar & open hole	18.4 l/m
Capacity between drillpipe & open hole	24.0 l/m
Length of drillcollars in the hole	114 m
Pump output	13.88 l/stroke



2a. **What is the height of the influx in the annulus, the influx gradient (in kPa/m), and state if have we drilled into abnormal pressured oil, water or gas ?**

2b. **What is the heavy mud (Kill mud) gradient (kPa/m) required to balance the reservoir pore pressure?**

2c. **What will the standpipe pressure (Pst) be at the beginning of the well kill, (just as the pump is turned on?** – assume the kill is performed at 30strokes per minute.

2d. The well is killed using the weight and wait (engineers) method. **What will the standpipe pressure (Pst) be at the end of "phase 1" (pump still running at 30 strokes per minute)?**

2e. During the kill operations, there is a problem with the transfer of returning mud at surface. The Driller decides to stop the well kill operation, he closes in the well on the choke and shut down the pump. After closing in, the pump stroke counter is seen to read the stroke count equivalent to the full drill-pipe plus BHA volume (i.e the internal drillstring volume from surface to bit – end of phase 1). **What will be the observed drill-pipe pressure at this point.**

3. Artificial Lift

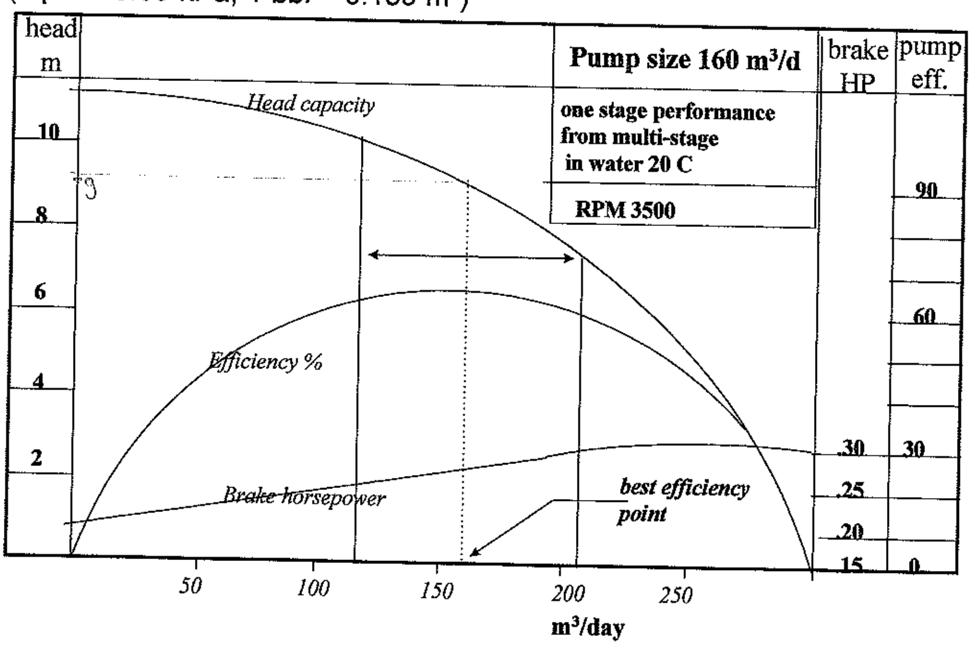
3a. It is planned to install either gas lift or an ESP in the following well, to achieve a production rate of 1000 bbl/day.

Depth	10000 ft
Watercut	0%
Reservoir pressure	2400 psi
Productivity Index PI	2 bbl/day/psi

What are the advantages and disadvantages of these two methods of artificial lift?

3b. If an ESP is installed at the bottom of the well, the required pressure at the outlet of the ESP is 2300 psi, in order to achieve the required tubing head pressure. Calculate the pressure difference that must be supplied by the pump at the planned production rate (1000 bbl/day).

3c How many stages should the ESP have, based on the following performance curve (1 psi = 6.89 kPa, 1 bbl = 0.159 m^3)



3d If instead gas lift is installed, the gas injection pressure on surface is 1000 psi. The tubing head pressure of the well is 500 psi. The fluid gradient is 0.4 psi/ft, the gas gradient 0.04 psi/ft and the flowing well gradient approximately 0.25 psi/ft. Determine the deepest point at which gas can be injected (i) without gaslift valves and (ii) with gaslift valves.

3e The gaslift valves are adjusted to operate at a pressure 100 psi above the flowing well gradient. Estimate from a graph the setting depths and setting pressures of the first two valves.

4. Stimulation

4a Explain the roles of the pre-flush, the main flush and the post-flush in matrix acidising of sandstone formations.

4b In a sandstone acidising treatment, the mud-acid is an HF/HCl acid blend, formed of 1.5% by wt HF and 13.5% HCl. One of the minerals present is kaolinite $Al_4Si_4O_{10}(OH)_8$. Calculate the Volumetric Dissolving Power for HF for the primary reaction given by

$$Al_4Si_4O_{10}(OH)_8 + 24\ HF + 4H^+ \leftrightarrow 4AlF_2^+ + 4SiF_4 + 18H_2O$$

The molecular mass of kaolinite is 516.4 and of HF 20. The density of the acid blend is 1070 kg/m^3 and of kaolonite 2800 kg/m^3.

4c The wellbore has diameter 20 cm. The interval to be treated is 50m in height. The sandstone has porosity 0.25 and it contains 2% of kaolonite. A volume of 60 m^3 of mud-acid is pumped into this interval. Assume homogeneous penetration. Calculate the depth from the wellbore for which all the mud-acid will react with all kaolinite.

4d What are the potential problems in pumping acid into such a long openhole interval. How can you try to avoid these?

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

5. Short calculation questions / General knowledge:

5.1 There are Drill collars available that weigh 123.5 kg/m and each collar is 9.5m in length. How many collars are required to achieve 10,000 daN weight on bit (WOB) in a vertical hole with a mud weight of 14.5 kPa/m. (Note only 90% of total collar weight is to be used on the bit.)

5.2 A formation strength test was performed at the casing shoe with a mud weight of 12.4 kPa/m a Maximum Allowable Annular Surface Pressure (MAASP) of 6,450 kPa was achieved prior to *'leak-off'* occuring. We are now drilling ahead with a mud weight of 13.3 kPa/m.
Calculate what change (if any) will there be to the MAASP ?

Note: Casing shoe depth: 1980m (AHBDF – Along Hole Below Drill Floor), 1950m (TVDBDF – True Vertical Depth Below Drill Floor)

5.3 With respect to Directional Drilling & Borehole surveying:-

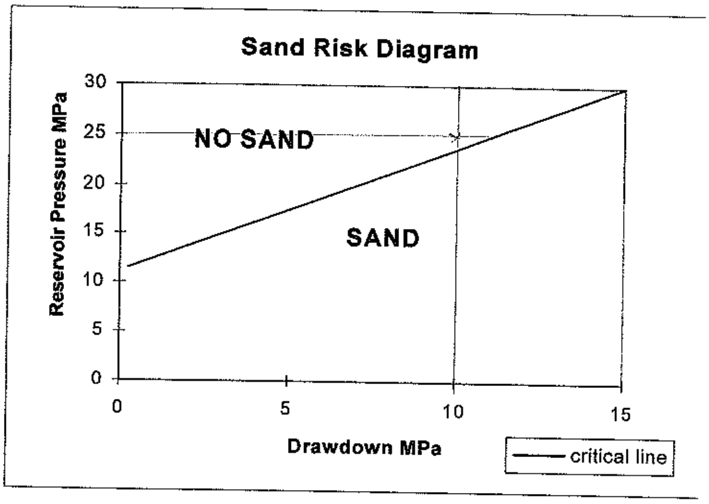
a) Identify **TWO** techniques used to enable a well to be drilled directionally

b) Identify the **TWO** measurements (and their units) that are required to be taken to monitor the directional progress of a well.

5.4 A Drilling Rig has **FOUR** main functions or systems that are required in the drilling process, name these **FOUR** functions/systems.

5.5 Where is the "Swivel" found on a traditional drilling rig, and what is its main purpose.

5.6 **(a)** What are the available types of sand control?
(b) The initial pressure in a reservoir is 25 MPa. The initial production rate from a well is planned at 600 m^3/day, and the PI is 60 m^3/day/MPa. The sand risk diagram is given here. Do you anticipate sand production?



5.7 A well completion is designed for safe operations. Name 3 other aims that are important in designing the well completion.

5.8 Name three types of deposition that can occur in a well as a result of phase changes. Describe how to prevent one of these types of deposition.

5.9 State the formula for the Stokes velocity of an oil droplet in water. Use this formula to explain how a hydrocyclone separates oil and water.

5.10 Describe the advantages and disadvantages of J-lay over S-lay for offshore pipelines.