25/18

University of
Stavanger

FACULTY OF SCIENCE AND TECHNOLOGY

SUBJECT: PET 535: MODERN WELL DESIGN

DATE: MAY 19 , 2015

TIME: 0900 - 1300

AID: CALCULATOR

THE EXAM CONSISTS OF 6 PAGES

REMARKS: PLEASE STATE ASSUMPTIONS

Problem 1: Casing Design

You are asked to design a surface casing. The design parameters are as follows:

		BOKA
Depth of casing:	1100 m	1000m
Depth to seabed:	225 m	110 m
Depth to sea level:	25 m	42 m
Depth to top of tail cement:	1000 m	900m
Depth to top lead cement:	225 m	
Depth next open hole section:	1820 m	3100m
Design fracture gradient at casing shoe:	1.57 s.g.	1,83
Pore pressure gradient, casing shoe:	1.03 s.g.	1,45
Pore pressure gradient, next section:	1.40 s.g.	
Formation fluid density:	0.76 s.g.	
Mud density:	1.20 s.g.	1,3
Mud density, next open hole section:	1.50 s.g.	1,7
Lead cement density:	1.45 s.g.	1,5
Tail cement density:	1.90 s.g.	1,9

The casing data are:

18-5/8 in. grade X-70, 84.5 lb/ft. casing

Weight:	186 kg/m
Crossectional inner area:	1527 cm^2.
Burst strength:	197 bar
Collapse resistance:	43 bar
Pipe body yield strength:	800 x 10^3 daN

Remember to define the important assumptions.

a) Prepare a drawing of the situation: the casing during installation. Define two criteria for casing collapse. Compute the design factor for these scenario.

b) Prepare a drawing of the situation: the burst design. Define a burst scenario. Compute the design factor for burst.

c) Define two scenarios for tension design. Compute the design factors.

d) Compute the casing test pressure.

e) Compute the kick margin of the casing section.

f) Define the weak point in the well.

Problem 2: Geomechanics

a) Show an expression for the horizontal in-situ stress. How would you select the mudweight relative to this? What do we call this concept?

b) Three LOT data sets are given in a well as follows:

Depth(m):	LOT(s.g.):	Pore(s.g.):	Overburden(s.g.):	Inclination(°):
890	1,51	1,03	1,62	0
1124	1.35	1.21	1.76	30
1540	1,27	1,30	1,80	39

Estimate the LOT values for vertical hole sections.

c) Compute the horizontal stress levels from the data above.
State all assumptions.

Problem 3: Fundamentals

Please identify the most correct answer below. Just write answer number, f.eks. a1, b1, and so on.

a) Which equilibrium condition dominate geomechanics:
   1) Stress equilibrium
   2) Newtons 2^{nd} law
   3) Maxwell equations
   4) Conservation of mass

b) Which statement is correct:
   1) The dog leg is the vertical angle
   2) The DLS act in the vertical plane
   3) The DLS is a 3 dimensional parameter
   4) The DL is the derivative of the angle

c) Stresses transforms in space according to:
   1) Linearly
   2) Squared trigonometric law
   3) Cubic trigonometric law
   4) None of the above

d) Replacing the mud in the drill string with sea water leads to:
   1) Reduction in surface pipe tension
   2) Increase in surface pipe tension
   3) No change in surface pipe tension
   4) Differential sticking

e) Surface casing is installed:
   1) Through the marine riser
   2) Before riser is installed
   3) Through the BOP
   4) After riser is installed

f) On jack-up rigs
   1) Always implement riser margin
   2) New rigs uses dynamic positioning
   3) Have the weight of the well on mud line suspension system
   4) Can work in 200 m of water

g) Wellhead systems
   1) Horizontal X-mas trees are mostly used subsea
   2) Vertical X-mas trees are mostly used subsea
   3) BOP is mainly used during production of the well
   4) One well barrier is sufficient for low pressure wells

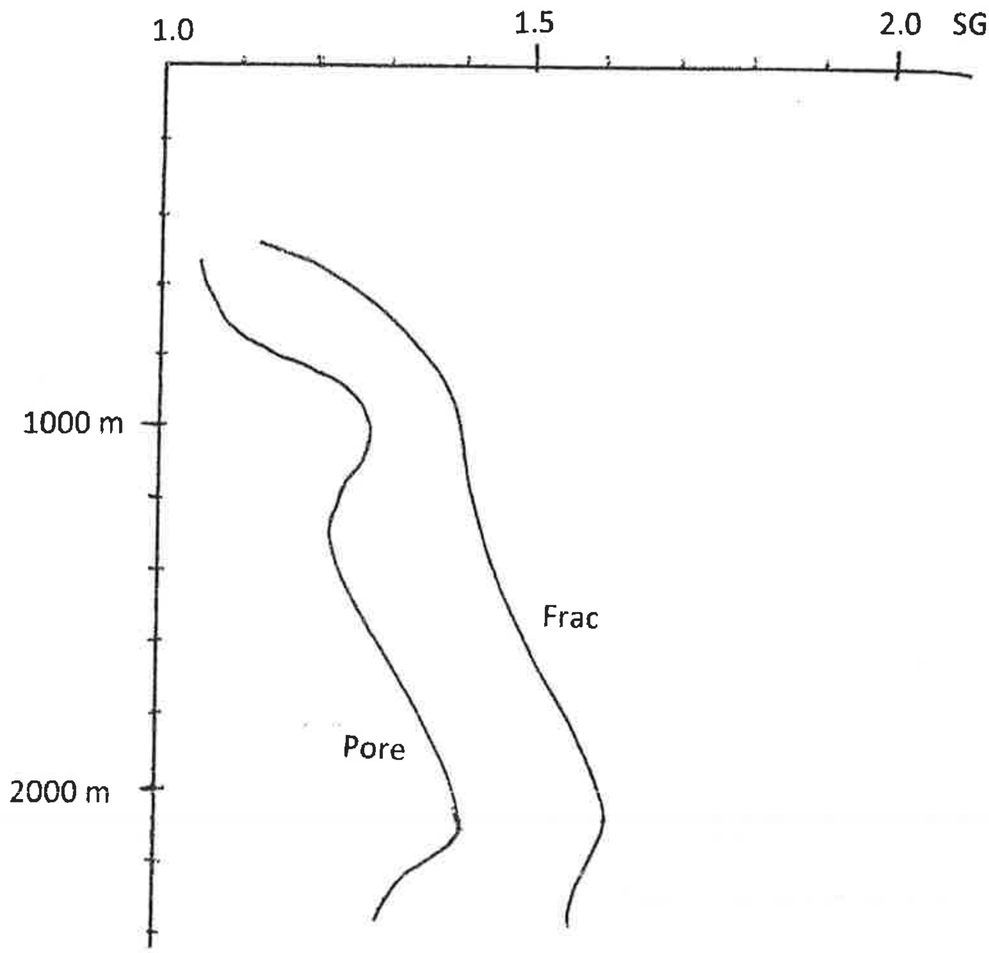
Problem 4: Casing depth and mud weight selection

a) Using the gradient curve below propose the depth of the following casings:

- 7 in liner
- 9-5/8 in production casing
- 13-3/8 in intermediate casing
- 20 in surface casing
- 30 in conductor casing

b) Propose a mud weight program for the well. Define assumptions.

You can draw directly on the figure below and include this page in your exam.



c) Consider implementing a riser margin. Is this possible? Explain!

Problem 5: Data normalization

You are planning a subsea infill well in a production field. Your design is based on data from the production platform which has a wellhead elevation of 120 m. You are going to use a jackup drilling rig with a air gap of 40 m. The water depth is 300 m. The data from the production platform are:

Pore press. Grad.(sg)	0.82	0.90	0.95	1.10	1.15	1.20
Depth(m)	500	700	900	1100	1300	1500

a) Define the normalization equations.

b) Normalise the pore pressure gradient to drillfloor level and sea level. Show all three curves in a plot.

c) Connect each data point with a curve for the three reference levels. Explain the meaning of this curve. What do we call this curve?

Some Formulas

$P(bar) = 0.098 \times d(s.g.) \times D(m)$

$P_3 = Cq^m$

$P_2 = \rho q^2/2A^2 0.95^2$

Index:	Equation:	Criterion:	Fraction parasitic pressure loss:	Flow rate:
1	qP_2	Max. HP	$1/(m+1)$	$P_1/C(m+1)$
2	$q\sqrt{P_2}$	Max. jet impact	$2/(m+2)$	$2P_1/C(m+2)$
3	$q3/2\sqrt{P_2}$	New A	$3/(m+3)$	$3P_1/C(m+3)$
4	$q^2\sqrt{P_2}$	New B	$4/(m+4)$	$4P_1/C(m+4)$
5	$q^{5/2}\sqrt{P_2}$	New C	$5/(m+5)$	$5P_1/C(m+5)$

$A = q\{\rho/2P_2\}^{1/2}/0.95$

Using the units of: density(kg/l), flowrate (l/min) and pressure (bar), the nozzle area in in^2 can be obtained by dividing the equation above with 122.4.

$d_{RKB1} = d_{RKB2}D/(D-\delta h)$

$LOT = 2\sigma_a - P_o$

$P_{wf}(\gamma) = P_{wf}(0) + {}^1/_3\,(P_o - P_o^*)\sin^2\gamma$

$P_{wf}(0) = \{P_{wf}(\gamma) + (\sigma_o - 1/2P_o)\sin^2\gamma\}/\{1 + 1/2\sin^2\gamma\}$

$\Delta\sigma_a = \Delta P_o(1-2\nu)/(1-\nu)$

$\Delta P_{wf} = \Delta P_o(1-3\nu)/(1-\nu)$

$P_{burst} = 2\sigma_{tensile}\, t/D_o$

$P_{collapse} = \{2CE/1 - \nu^2\}\{1/(D_o/t - 1)^2 D_o/t\}$

$(\sigma_t/\sigma_{yield}) = 1/2(\sigma_a/\sigma_{yield}) \ +/- \{1 - 3/4(\sigma_a/\sigma_{yield})^2\}^{1/2}$

$\rho = (d_p D - 1.03h_w)/(D - h_f - h_w)$

$$d_{wf2} = d_{wf1}\frac{D_1}{D_2} + d_{sw}\frac{D_{w2} - D_{w1}}{D_2}$$

$$D_2 = D_1 + (D_{w2} - D_{w1}) + (D_{f2} - D_{f1})$$