FACULTY OF SCIENCE AND TECHNOLOGY

SUBJECT: MPE 450 Modern Well Design

DATE: May 18, 2009

TIME: 0900-1300

AID: Approved calculator

THE EXAM CONSISTS OF 4 PROBLEMS ON 6 PAGES

REMARKS: Formula sheet is enclosed.

PLEASE STATE ALL ASSUMPTIONS

Problem 1: Mud weight and drilling problems (15%)

Give a description of the following drilling problems and give a recommendation of what mud weight (high or low) that should be used to decrease the problem.

a) Lost circulation
b) Reduced drilling rate
c) Borehole collapse
d) Fill
e) Pressure variations
f) Clay swelling
g) Washouts
h) Pore pressure estimations
i) Tight hole
j) Differential sticking

Problem 2: Mud weight and the median line principle (15%)

a) Define the median line principle. You are also required to make some schematic drawings containing the borehole and the in-situ stresses and relate some common borehole problems to the borehole stress/mud weight relationship.

b) A median line mud weight design methodology is often used. Fill in and describe as best you can each of the 6 stages of the design methodology:

1) Establish …
2) Draw …
3) Design …
4) Mark out …
5) Design …
6) Avoid …

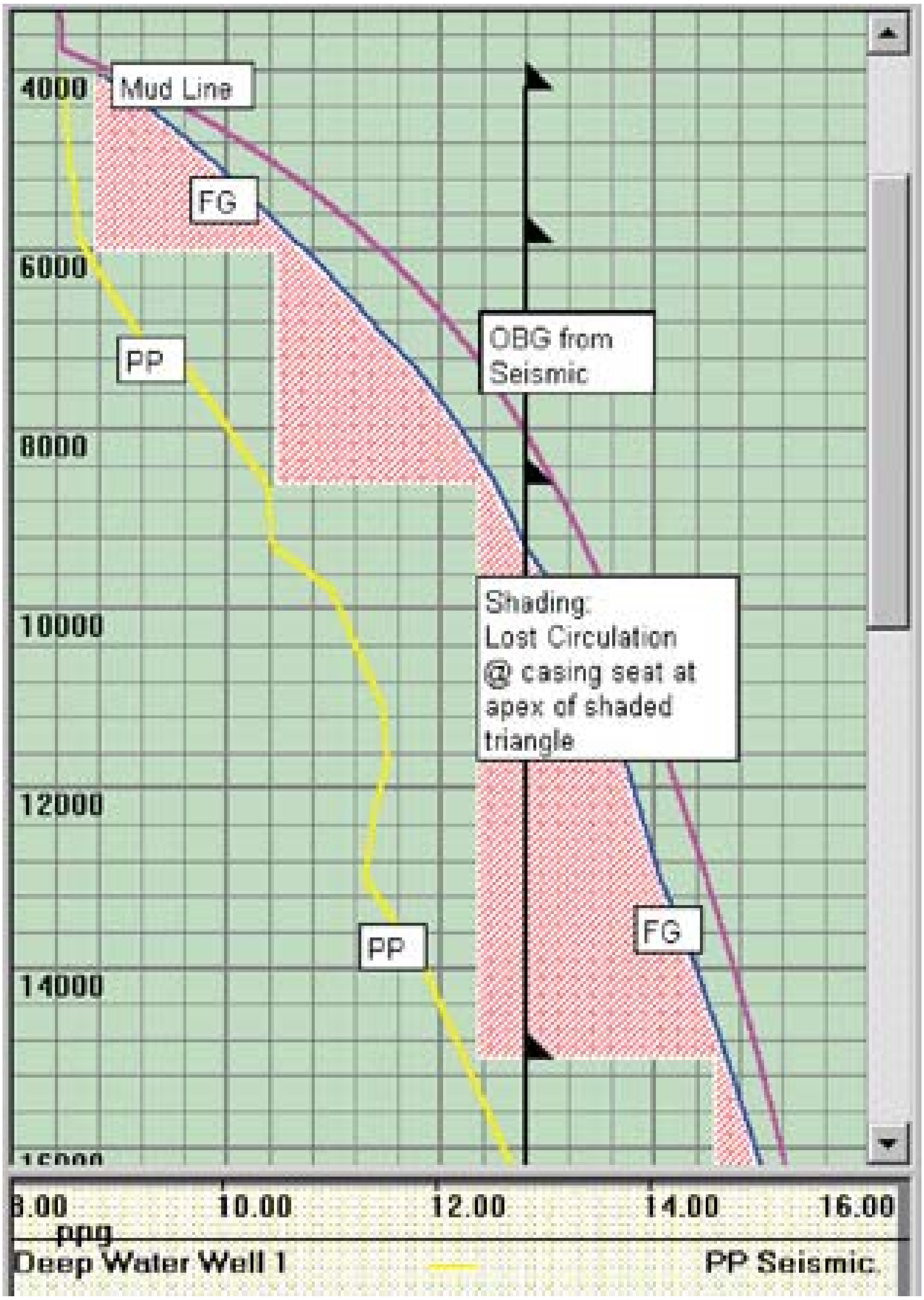
Problem 3: Casing setting depth from reduced well integrity considerations (30%)

You are asked to perform a reduced integrity design for the 14” casing string in the well below. The 12 ¼” open hole is planned to 4900m using a 5” drill pipe and mud weight of 1.55 s.g. The 14” casing is a grade P-110, 86 lbs/ft, with a burst pressure of 569 bars. The geologists expect the formation fluid to be methane gas with density of 0.17 s.g. Based on experience with high wear on casing, a safety factor of 20% must be applied.

Calculate the following:

- Deepest setting depth of 14” casing [meters].
- Maximum allowable fracture gradient to ensure that the formation below the casing shoe represent the weak point [s.g.].
- Minimum fracture gradient to be able to drill the 12 ¼” open hole section to 4900m [s.g.].
- Kick margin [m^3].

Hint: You should convert numbers in the figure into meters and s.g.



OBG = Overburden gradient
FG = Fracture gradient
PP = Pore pressure

Problem 4: Casing design (40%)

You are designing a 9 5/8” production casing. A 5000 psi wellhead is installed.

The following well data applies:

Depth of casing:	4900	m
Depth to production packer:	4850	m
Depth to seabed:	900	m
Depth to sealevel:	30	m
Depth to top cement:	4575	m
Pore pressure gradient:	1.52	s.g.
Formation fluid density:	0.79	s.g.
Mud density:	1.55	s.g.
Cement density:	1.74	s.g.
Completion fluid density:	1.15	s.g.

The following casing data applies:

9-5/8” grade P-110, 47 lbs/ft casing

Casing weight:	69.9	kg/m
Crossectional inner area:	382	cm^2
Wall thickness:	0.472	inch
Burst strength:	651	bar
Collapse strength:	366	bar
Pipe body yield strength:	7200	kN

The following minimum casing design factors applies:

Tension	1.4
Burst	1.0
Collapse	1.0

Other corrections that applies:

Collapse strength derating due to biaxial forces (see figure on next page).

Derating of tensional strength due to wear:	10	%
Derating due to corrosion below packer	5	%
Additional tension due to bending	1040	kN

Evaluate different collapse, burst and tension criteria and calculate the following design factors:

- Collapse design factor
- Burst design factor
- Tension design factor

Is the proposed casing (9-5/8” grade P-110) an acceptable choice for this production casing?

YOU ARE REQUIRED TO MAKE FIGURES FOR ALL DESIGN CRITERIA

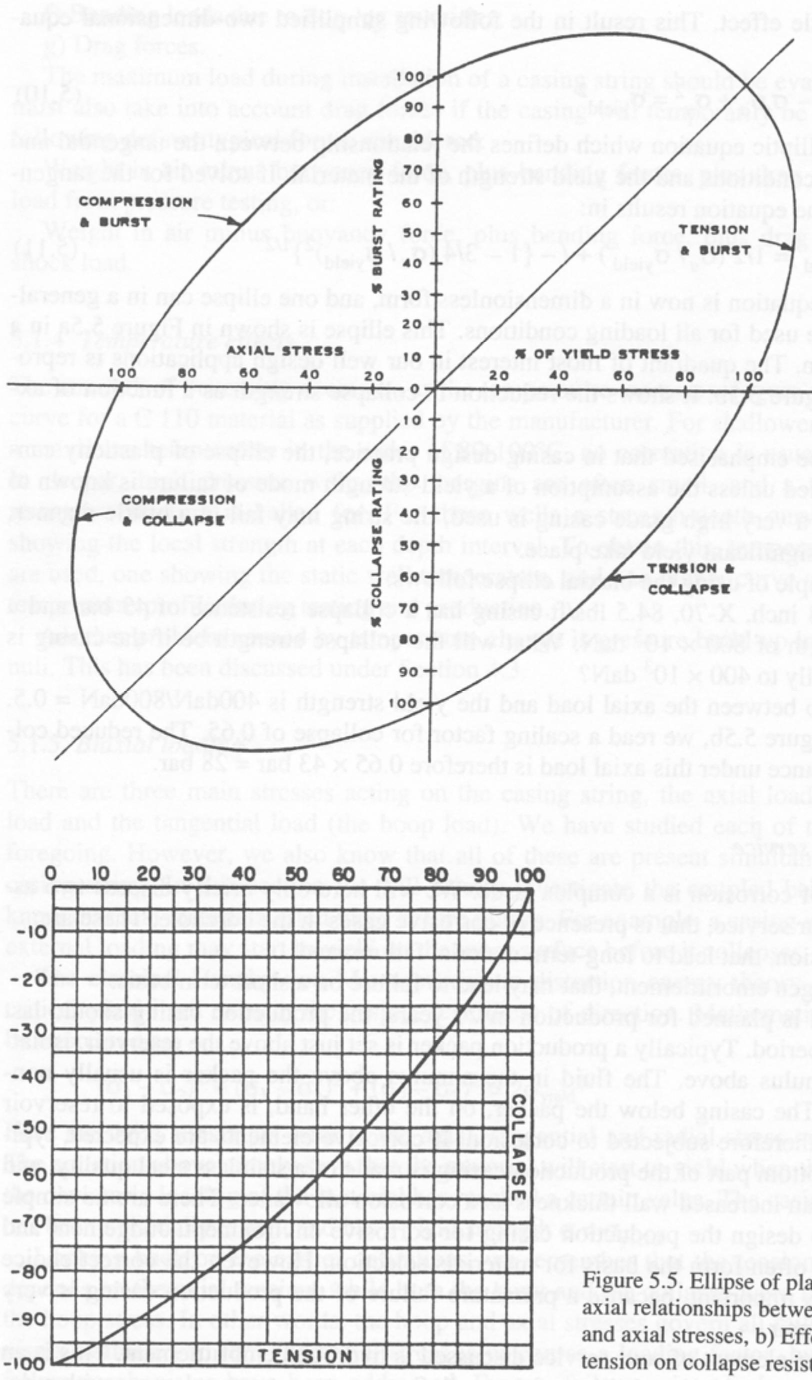


Figure 5.5. Ellipse of plasticity. a) Bi-axial relationships between tangential and axial stresses, b) Effects of axial tension on collapse resistance.

Some Formulas

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

$LOT = 2\sigma_a - P_o$

$P_{wf}(\gamma) = P_{wf}(0) + {}^{1}/_{3}\,(P_o - P_o^*)\sin^2\gamma$

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

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

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

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

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

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

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

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

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

$$D_2 = D_1 + \left(D_{w2} - D_{w1}\right) + \left(D_{f2} - D_{f1}\right) + \left(\frac{d_{ob1}}{d_{ob2}} - 1\right)\left(D_1 - D_{w1} - D_{f1}\right)$$

Units

1 bar = 14.5 psi = 10^5 Pa
1 ft = 0.3048 m = 12 in
1 lb_f = 0.454 kp = 4.45 N
1 s.g. = 8.33 ppg