University of Stavanger

FACULTY OF SCIENCE AND TECHNOLOGY

SUBJECT: PET 535: MODERN WELL DESIGN

DATE: MAY 22 , 2019

TIME: 0900 - 1300

AID: CALCULATOR

THE EXAM CONSISTS OF 6 PAGES

REMARKS: PLEASE STATE ASSUMPTIONS

Problem 1: Design of the Production Casing

We will design the production casing of a well. The following data applies:

9-5/8 in. 47 lbs/ft P110	
Weight:	68.73 kg/m
Burst strength:	651 bar — 15% SF?
Collapse:	366 bar
Tension:	6590 kN
Mud weight:	1,60 s.g.
Inner diam.	220,5 mm
Setting depth:	2909 mMD, 2350 mTVD
Depth next hole:	3341 mMD, 2655 mTVD
Cemented interval:	2131 – 2909 mMD, 1800 - 2350 mTVD
Produktion packer at	2414 mMD, 2000 mTVD
Pore press. Gradient:	1.55 sg
Pore fluid density:	0.76 sg
bar x cm^2 = daN	

The well is vertical down to 1000 m, followed by a sharp build up. From 1000 m to the bottom assume a constant inclination of 45 degrees.

Assume that the well is drilled from a jack-up rig with 25 m airgap. Please write all assumptions. You may assume realistic data if desired.

✗ a) Prepare a figure of the well and define two criteria for burst of the production casing, and determine the safety factor.

✗ b) Decide a criterion for collapse and determine the factor of safety.

✗ c) Determine the total weight in air of the casing string, and the buoyed weight in the well. Determine the factor of safety. Bending may be neglected.

✗ d) Where is a weak point in the well if any?

Pburst,max + 0.76 · 0.098 · 2350
grad > frac. grad

Problem 2: Temperature induced pressures

One problem with subsea wellheads is the potential of trapped pressures. The pressure inside the B-annulus may increase due to thermal effects. In the following you are asked to investigate this as follows:

a) Show the relationship between pressure increase and temperature increase. Explain the conditions for the equation.

✗ b) Assume that the coefficient of thermal expansion is 3×10^{-4} (1/°C), and the compressibility coefficient is -3×10^{-5}(1/bar). Compute the pressure increase if bottomhole temperature remains constant but the surface temperature has increased 150 °C

Problem 3: 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.

isotropic

Problem 4. Hydraulics

Please define the most correct answer.

	A	B	C
1. Reynolds number defines:	Inertial/viscous forces	Viscous/inertial forces	None
2. Bernoullis equation is a conservation of:	Mass	Momentum	Energy
3. Pipe friction factor applies for:	Laminar flow	Turbulent flow	Both
4. Viscous effects applies for	Laminar flow	Turbulent flow	Both
5. Drillstring hydraulics is mostly:	Laminar	Turbulent	None
6. Flow through bit nozzles is:	Laminar	Turbulent	Both
7. Flow through the marine riser is:	Laminar	Turbulent	Both
8. Increased flow rate gives	Less nozzle press.	More nozzle press.	I don't know

Problem 5: Governmental regulations

HSE, reduce injury, accidents on ↑ people and material/equipment

X A. Why are the authorities, i.e the Petroleum Safety Authority (PSA) making laws & regulations for the oil & gas industry and which governmental ministry is the PSA underneath and relating to? Petroleum directorate, used to be one, but then they split

X B. The PSA`s laws & regulations are risk based and mostly system oriented; describe with your words what is meant by that and use an example if you can?

Based on experience, history, tradition. Help perform operations

X C. Why are risk assetments mandatory prior to all well activities and in the daily work what tools are normally used for this purpose, two important principles are used in risk work, the ALARP and BAT principles, please explain what is meant by these?

X D. Describe the context between probability & concequence in a risk asessment excersise and how will you describe a risk factor?

probability give different situations that can happen
consequence shows which consequences they can have

X E. Mention some differences in the well barrier situations going from drilling to well completion mode

Drilling: ~~Mud column~~, cement, casing, mud column BOP

Completion: DSV, ~~X-mas thtree~~, ~~packer fluid~~ Packers, annular safety valve

→ liner protection

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.

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

× $LOT = 2\sigma_a - P_o$

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

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

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

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

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

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

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

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

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

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

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

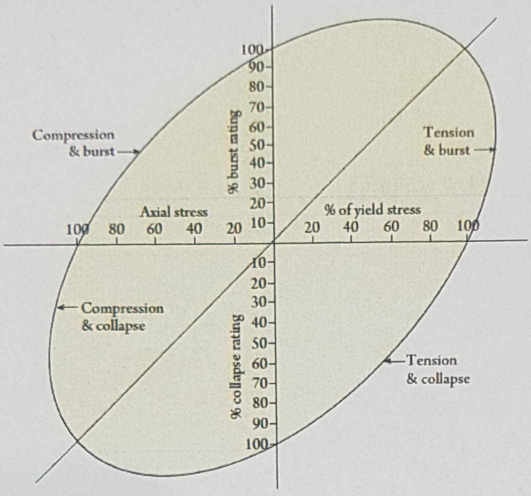
× $$\frac{\Delta V}{V} = \frac{1}{2}\alpha\Delta T$$

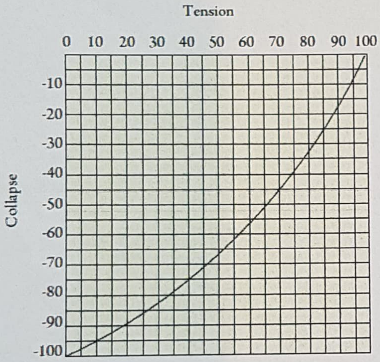
× $$\Delta P = \left(\frac{-1}{c}\right)\frac{\Delta V}{V}$$

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
bar x cm^2 = daN

$P_{wf} = 2\sigma_n - P_o$


Compression
& burst
Tension
& burst
Axial stress
% of yield stress
% burst rating
% collapse rating
Compression
& collapse
Tension
& collapse


Tension
Collapse