University of Stavanger

FACULTY OF SCIENCES AND TECHNOLOGY

SUBJECT: **PET605 Well intervention and Plug & Abandonment**
DATE: **November 23, 2013**

TIME: **09:00 – 13:00**

AID: **Simple calculator**

THE EXAM CONSISTS OF 8 PAGES (including this front page)

REMARKS: The exam is divided into two parts, one concerning well intervention and one plug and abandonment. Each part will count 50% in the final grading.

Well intervention:

A 1

a) List three methods/technologies we can use for entering a live well.

b) A well is 3000 meters deep. The reservoir pressure at this depth is 500bar. The average density of the gas condensate in the well is 0.3 sg. What will the shut in wellhead pressure be in bar and psi?

c) A gas producing well is shut in with a SIWHP of 350 bar. A tool with weight 320 N is to be run into the well with a cable as shown in the figure on next page. The cable diameter is 2.5 mm. Will the weight of the tool be sufficient to get down into the well ? (we neglect friction in the stuffing box and buoyancy in the lubricator)

Plug and Abandonment:

B 1

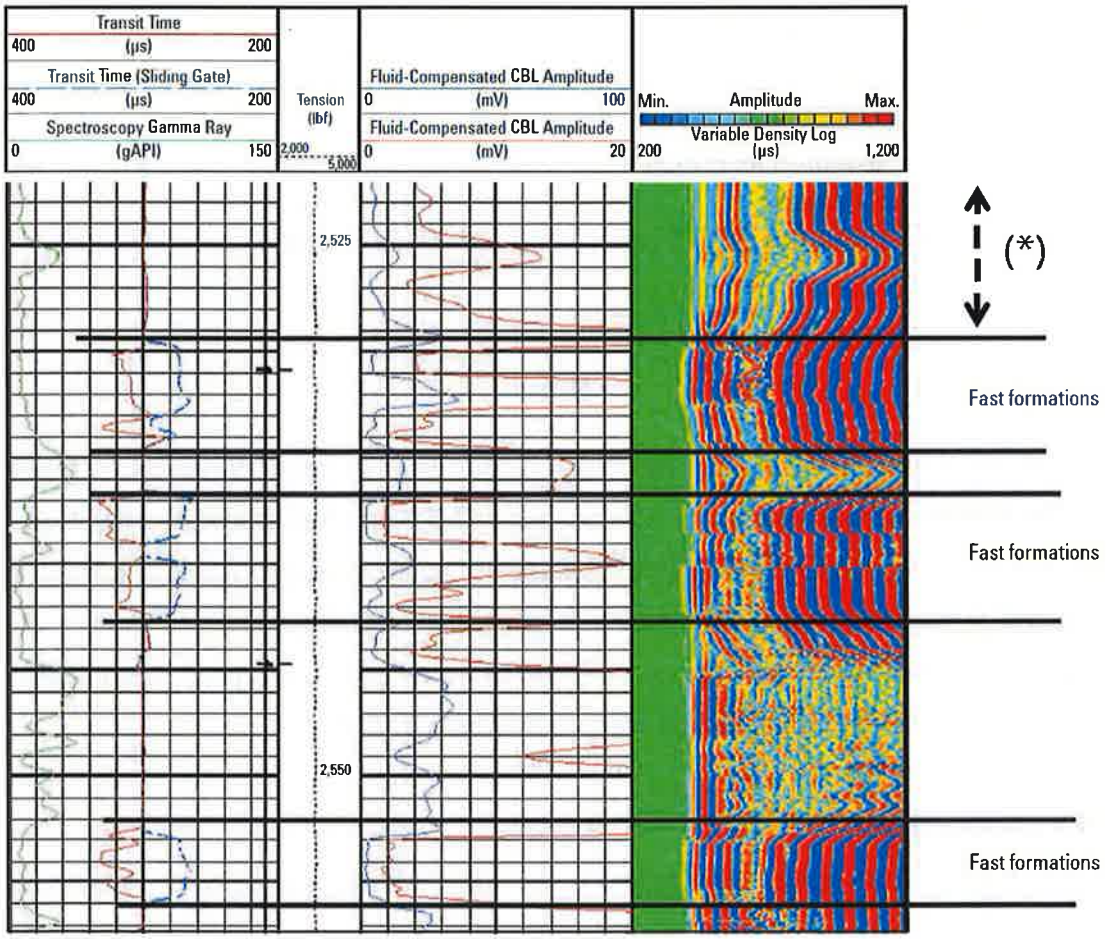
1) What are the potential permanent barrier materials with respect to guidelines on qualification of materials for the suspension and abandonment of wells (Oil & Gas UK, Issue 1, July 2012)? (Mention at least five materials).

2) NORSOK Standard D-010, suggests some characteristics for potential permanent well barriers. Write five characteristics.

3) Contamination of cement during placement is a concern. What are the possible mitigations according to the guidelines for the suspension and abandonment of wells (Oil & Gas UK, Issue 4, July 2012)? (Mention at least four items)

4) A representative from ConocoPhillips gave a presentation in the P&A course. Explain the well abandonment operational phases briefly.

5) Based on the given presentation by the internal guest lecturer;
   a) What are the reasons for that we in some cases can leave the tubing in hole while in other cases, we have to remove it?
   b) Describe when (or at what stage in the operational sequence) a temporary barrier is necessary during the permanent plug and abandonment operations?

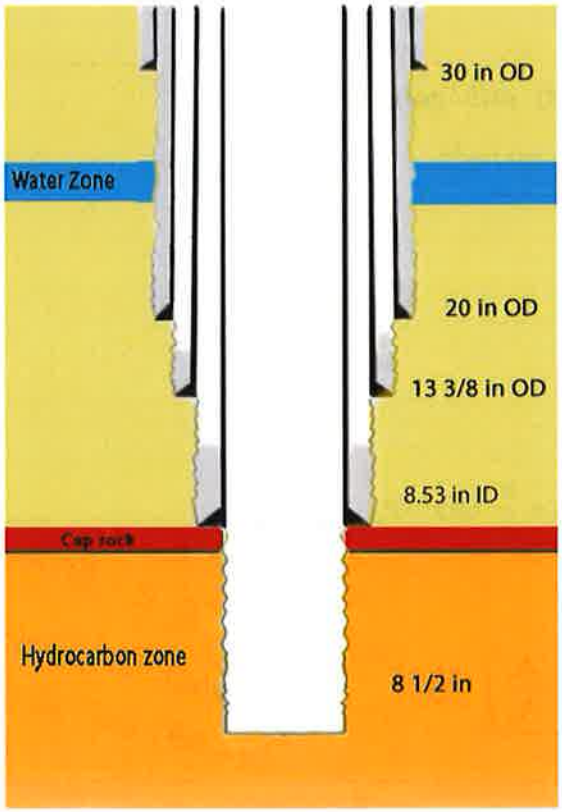


8) Well status, where the well operation is suspended without removing the well control equipment, is called …
   a) Temporary abandonment
   b) Permanent abandonment
   c) Suspension
   d) Well intervention

9) Absence of SCP (Sustained Casing Pressure) during the life cycle of the well indicates that …
   a) Poor sealing capability of the casing cement.
   b) Milling operations is necessary.
   c) Running leak off test is necessary.
   d) Good sealing capability of the casing cement.

Length of the cement plugs should meet the Norsok D-010 rev. 3 requirements.

c) Calculate the required volume of slurry for the primary barrier.



University of Stavanger

FACULTY OF SCIENCES AND TECHNOLOGY

SUBJECT: **PET605 Well intervention and Plug & Abandonment**
DATE: **February 12, 2014**

TIME: **09:00 – 13:00**

AID: **Simple calculator**

THE EXAM CONSISTS OF 7 PAGES (including this front page)

REMARKS: The exam is divided into two parts, part A concerning well intervention and part B, plug and abandonment. Each part will count 50% in the final grading.

Well intervention:

A

1. List three methods/technologies we can use for entering a live well.
2. What are the main benefits of using tractors in connection with wire-line operations?
3. Why is fatigue considered to be a major concern when using coiled tubing?
4. The fluid density in a well is estimated to be 830 kg/m^3. A 2 3/8" (P110) pipe is to be snubbed into the well. OD = 60.33 mm, Wall thickness t is 0.19" (4.83 mm). Mass per length is 6.6 kg/m. Shut in well head pressure is 65 bar. The friction in the stripper rubber is estimated to be 5000 N. Find the max required snubbing force.

4) What is the main difference between WELL SUSPENSION status and TEMPORARY ABANDONMENT with respect to NORSOK D-010, third revision?
5) NORSOK Standard D-010 suggests some characteristics for potential permanent well barriers. List five characteristics.
6) What is the recommendation of NORSOK D-010, third revision, for the positioning of the secondary well barrier with respect to formation integrity?
7) Cemented casing is a sufficient barrier to vertical flow in the annulus. List two different methods in order to verify the TOC (Top of Cement) in the annulus, with respect to Oil & Gas UK guidelines, issue 4.
8) How can the sealing capability of the casing cement be assessed with respect to Oil & Gas UK, issue 4? List four items.
9) Based on the Oil & Gas UK guidelines, issue 4, hydraulic testing is not recommended for verifying a permanent barrier in an open hole. What would be the reason and what technique is recommended?
10) List five potential permanent barrier materials with respect to guidelines on qualification of materials for the suspension and abandonment of wells, Oil & Gas UK, Issue 1.
11) List three potential functional failures of plugging materials with respect to Oil & Gas UK guidelines, issue 4.
12) List five critical material properties related to potential failure modes with respect to guidelines on qualification of materials for the suspension and abandonment of wells, Oil & Gas UK, Issue 1.
13) List four well parameters that influence the quality of CBL (Cement Bond Log).
14) The VDL (Variable-Density Log) is commonly used as an adjunct to the CBL (Cement Bond Log), and offers better insight into its interpretation. The below scheme is a typical VDL pattern. Three places are marked as; (a), (b) and (c). Identify mud, casing, cement and formation arrivals.

e) Temporary abandonment
f) Leak testing
g) Permanent well barrier
h) Well integrity

$\lambda = \frac{0{,}316}{Re^{0{,}25}}$, friction factor – turbulent flow – Reynolds number larger than 2300

$$\Delta P_f = \frac{\lambda \cdot l \cdot \rho \cdot v^2}{2 \cdot d \cdot 10^5}$$

Re – Reynolds number
ρ- fluid density kg/m^3
v - fluid velocity m/s
d – inner pipe diameter – m
μ – viscosity - Pa·s
λ- friction factor
l – length of pipe - m
ΔP_f – pressure loss – bar

$P = Q \cdot \Delta p$
P – effect- W
Q – pump rate – m^3/s
Δp – pressure loss – Pa

Well intervention and P&A 2014 — 1/9

1) ∘ Snubbing
∘ Coiled tubing
∘ Wireline

2) Main benefit is to be able to enter inclined/horizontal wells

3) ~~Fatigue~~ major concern because operating with forces beyond the yield strength of the pipe ⇒ plastic...

4) $\rho_f = 830\ kg/m$
$OD = 2\ 3/8'' = 60.33$
$t = 0.19'' = 4.83mm$
$m/L = 6.6\ kg/m$
$WHSIP = 65\ bar$
$F_f = 5kN$

5)

6) $F_{snub} + BF \cdot L \cdot W_{string} \cdot g = \frac{\pi}{4} OD^2 \cdot P_{WH} + F_f$

$$BF = \frac{7850 - \left(830 \cdot \frac{\frac{\pi}{4} \cdot 60.33^2}{\left(\frac{\pi}{4} \cdot 60.33^2 - 50.67^2\right)}\right)}{7850} = \frac{5033}{7850} = 0.64$$

(struck out: 2450, 0.31)

$\rho_i = 0$ antar luft inni?

BF = feil
Resten riktig

$$F_{snub} = \frac{\pi}{4} \cdot 0.06033^2 \cdot 65 \cdot 10^5 + 5000 - 0.64 \cdot 449 \cdot 6.6 \cdot 9.81 = 4976N$$

$$L = \frac{65 \cdot 10^5 \cdot \frac{\pi}{4} \cdot 0.06033^2}{0.64 \cdot 6.6 \cdot 9.81} = 449m$$

Antar en at der kun e luft inni røret heilt + en når balance point?

$Q = V \cdot A$

9) Horsepower required: ~~$\frac{5\,bar}{0.75} = 6.67\,bar \ldots \approx 667\,kW$~~

$$V = \frac{Q}{A} = \frac{7.4 \cdot 10^{-3}\,L/sek}{0.00349} = 2.12\,m/s$$

$$Re = \frac{1.03 \cdot 2.12 \cdot 0.0667}{1 \times 10^{-3}} \times 10^{3} = 145646 \Rightarrow \text{turbulent}$$

$$\lambda = \frac{64}{145646} = 4.4 \times 10^{-4} \quad \frac{0.316}{145646^{0.25}} = 0.016$$

$$\Delta p_f = \frac{0.016 \times 2800 \times 1030 \times 2.12^2}{2 \cdot 0.067 \cdot 10^5} = 15.5\,bar + 5 = 20.5\,bar$$

GOOD!

$$P = \frac{7.8 \cdot 0.95 \cdot 20.5 \times 10^{5}}{0.75} \times 10^{-3} = \frac{20254\,W}{745.7\,W/hp} = 27.2\,hp$$

& Well intervention and ~~P&A~~ Februar 2014

B

1) 5 permanent well abandonment challenges on the NCS
   -

2) Well abandonment phases:
   - Phase 1 - Reservoir abandonment
   - Phase 2 - Intermediate abandonment
   - Phase 3 - Wellhead and conductor removal

3) 4 cement ~~plug placement~~ techniques:
   one stage cement job => Normal job, squeeze with shoe
   - two stage cement job => Open ports in tubing + packer below for zonal cementation...
   - Grouting
   - Cementing through drillpipe
   - Multistage cementing

4 plug placement techniques:
   - Balanced plug, samme substans innenfor og utfor tubing
   - Dump bailer, cement with mechanical plug, en beholder m/cement + wireline
   - Two-plug method, se på powerpoint...
   - Coiled tubing

Well intervention and P&A 2014

9)

10) Permanent barrier materials for suspension and abandonment

- Cement
- Cement derivatives
- Formation
- Grouts
- Thermosetting materials
- Gels
- Metals

11) Critical material properties related to potential failure mode

- Permability
- Absorbtion
- Hardness
- Density
- Chemical resistance

12) Potential functional failure modes:

- Cracking
- Shrinking / expansion
- Thermal expansion difference
- Creep
- Dissolution

Eksamen intervention P&A 23/11-13

A1

a) 3 methods for entering a well
- Snubbing
- Coiled tubing
- Wireline

b) Shot in well pressure: $500 - 3000 \cdot 0.3 \cdot 0.0981 = \underline{412 \text{ bar}}$

c) $F_{PA} = \frac{\pi}{4} OD^2 \cdot P_{WH} = \frac{\pi}{4} \cdot (2.5 \times 10^{-3})^2 \cdot 350 \cdot 10^5 = 172 \text{ N}$

Weight is larger than F_{PA}, so good to go =)

d) $P_{WH} = \frac{320 \text{N}}{\frac{\pi}{4} \cdot (2,5 \cdot 10^{-3})^2} = \underline{652 \text{ bar}}$

e) $F = 250 \text{kg} \cdot 9,81 \cdot \left(1 - \frac{0.76}{7.85}\right) = \underline{2215 \text{N}}$

Intervention 2013

A2

c) ~~$\rho = 820\ kg/m^3$~~

$$F_{max,snubb} = F_{PA} + F_F$$

$$F_{PA} = \frac{\pi}{4} \cdot OD^2 \cdot P_{WH} = \frac{\pi}{4} \cdot (60.33 \times 10^{-3})^2 \cdot 60 \times 10^5 = \underline{17152\ N}$$

$$F_{MAX} = 17152\ N + 5000\ N = \underline{22{,}2\ kN}$$

d) $$L_{D_I} = \frac{P_{WH} \cdot \frac{\pi}{4} \cdot OD^2}{(\omega_s + \frac{\pi}{4} ID^2 \cdot \rho_{Pipe} - \frac{\pi}{4} \cdot OD^2 \cdot \rho_w) g}$$

$$L_{D_{II}} = \frac{P_{WH} \frac{\pi}{4} OD^2}{BF \cdot \omega_s \cdot g}$$

$$BF = \frac{\rho_s - \left(\rho_o \frac{A_o}{A_s} - \rho_i \cdot \frac{A_i}{A_s}\right)}{\rho_s}$$

$$L_{D_I} = \frac{60 \times 10^5 \cdot \frac{\pi}{4} \cdot (60.33 \cdot 10^{-3})^2}{\left(6.6 + \frac{\pi}{4}(50.67^2) \cdot 0 - \frac{\pi}{4} \cdot (60.33 \cdot 10^{-3})^2 \cdot 820\right) \cdot 9.81} = \underline{411\ m}$$

$$BF = \frac{7850 - 820\left(\frac{60.33^2}{60.33^2 - 50.67^2}\right)}{7850} = 0.65 \quad \left(\text{Vanlig BF gir } 1 - \frac{820}{7850} = 0.9\right.$$

$$L_{B_{II}} = \frac{60 \times 10^5 \cdot \frac{\pi}{4} \cdot 60.33^2}{0.65 \cdot 6.6 \cdot 9.81} = \underline{408\ m} \approx \underline{411\ m}$$

Eksamen P&A November 2013

B1

Potential well barrier materials UK

1) • Cement
   • Cement derivatives
   • Formation
   • Grouts
   • Thermosetting materials
   • Gels
   • Metals

2) NORSOK D-010 characteristics for perm. abandonment: (s. 96 NORSOK)
   1) Provide long term integrity
   2) Impermable
   3) Non-shrinking
   4) Able to withstand mechanical loads/impact
   5) Resistant to chemicals/substances
   6) Ensure bonding to steel
   7) Not harmful to the steel tubulars integrity

3) Mitigation against contamination during cementing
   • Washer (?)
   • Bridge plugs and retainers
   • Scavenger (chemical added to mud to react with contaminant)
   • Tailpipe or stinger
   • Diverter tool
   • Mechanical plugs
   • Darts → same function as a ball
   • Ball

Eksame Well intervention & P&A 2013

6)

a) Dual barrier solution:

- Plug: Should contain >100 ft of good cement (typically 500ft)
- Annulus should ——||—— opposite each internal plug.

Combination barrier solution:

- Plug should contain >200 ft of good cement (typi. 800 ft)
- Annulus ——————||—— opposite the internal plug.

b) If only one permanent barrier, the potential internal pressure from zone A must not exceed the casing shoe fracture pressure.

7)