

## EXAM PART B – PLUG & ABANDONMENT (P&A)

Maximum score is 100 points

1. Define the following terms: (5p)
  - a. Well Barrier Element
  - b. Well Barrier Envelope
2. List five well abandonment challenges with regards to permanent P&A. (5p)
3. NORSOK Standard D-010 suggests some characteristics for potential permanent well barrier elements. List five characteristics. (5p)
4. In accordance with Oil & Gas UK issue 4, “*Guidelines for the suspension and abandonment of wells*”, any suggested plugging material shall fulfill some functional requirements. List four functional requirements of permanent barriers. (5p)
5. Write three reasons for not being able to perform P&A activities rigless. (15p)
6. A platform well (see Figure 1) has been drilled and completed with a vertical tree in 1985. The top of cement (TOC) in the B-annulus is below the permanent packer and the well suffers from sustained casing pressure in the A- and B-annulus. Caliper log shows big holes along the production tubing (shown with triangle on the well schematic). Operator decided to permanently plug and abandon the well. Through the operation, BOP has been necessitated to control the well pressure. List primary and secondary well barrier elements for temporarily abandonment while dismantling the XMT. (10p)

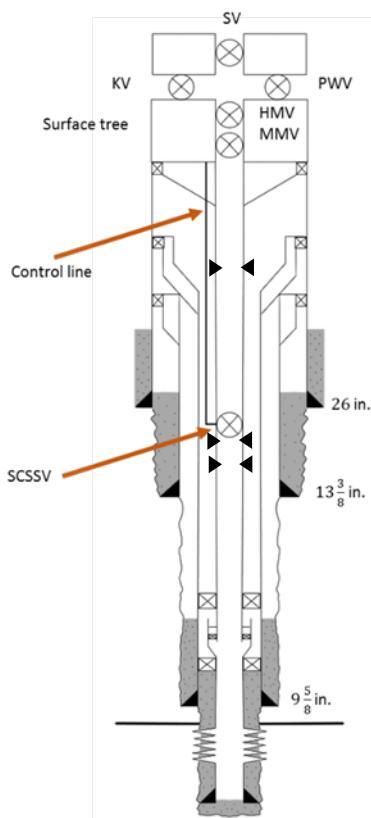


Figure 1 – A platform well completed with the vertical tree.

7. A well has been completed in the 1980's with an initial reservoir pressure of 9100 psi and the top reservoir at 14500 ft TVD. The reservoir is supported by an active aquifer and the current reservoir pressure is 7000 psi. Leak off test shows maximum mud weight of 16.0 ppg at the casing shoe of the production casing. Assume a gas density of 2.0 ppg. Calculate the minimum setting depth for the plug. [1 ft = 12-in., and 1 galUS = 231-in<sup>3</sup>] (**10p**)
8. You are asked to install a balanced plug across a suitable formation. For this job, a 4 ½-in. drillpipe will be used as workstring in an open hole with 8 ¾-in. diameter. The plug length is expected to be 200 ft and 24 bbl of fresh water will be pumped ahead of cement as spacer. Additional information: String capacity = 0.01422 bbl/ft, annular capacity = 0.0547 bbl/ft. State your assumptions if necessary. (**10p**)
- Calculate the required volume of cement.
  - Calculate the height of the cement plug with workstring in.
  - Calculate the required volume of spacer behind.
  - Calculate the volume of displacement fluid.
9. When in-situ formation creeps toward casing, it can create an annular barrier. The driving mechanism is believed to be "creeping". Explain the creep phenomenon, briefly. (**5p**)
10. To establish an annular barrier where there is no casing cement or poor cement, section milling is usually required. List four challenges that section milling operation creates. (**5p**)
11. Perforate, Wash and Cement technique is an alternative to section milling. After cementing through the perforations, the casing cement should be verified. To do so, cement inside casing is drilled out and the casing is logged by sonic logs. How do the created holes challenge the reliability of CBL/VDL logs? (**6p**)
12. Appendix A shows SBT (Segmented Bond Log) of a 10 ¾-in. casing. The in-situ formation is a carbonate formation with low source of gamma ray. Write your reflection on the cement quality of the given interval. Support your reflections with reasons and write them. Additional information: ATMN: Minimum Attenuation; ATMX: Maximum Attenuation; ATAV: Average Attenuation; CCL: Casing Collar Locator. (**10p**)
13. All the following alternatives are correct, EXCEPT: (**1p**)
- Steel tubular is not an acceptable permanent WBE unless it is supported by cement.
  - Elastomer seals used as sealing components in WBEs are not acceptable for permanent well barriers.
  - Control cables and lines shall be removed from areas where permanent well barriers are installed.
  - For permanent abandonment wells, it is not necessary to remove the wellhead and the following casings.
14. In order to measure the strength development of cement at downhole conditions, Ultrasonic Cement Analyzer (UCA) is deployed. Find the CORRECT alternative. (**1p**)
- It is an indirect strength measurement.

- b. It is more reliable than uniaxial compressive strength testing.
- c. It is more reliable than triaxial testing.
- d. It measures the shear bond strength.

15. All the following alternatives are correct, EXCEPT: (1p)

- a. Weight testing is used to verify cement plugs placed in openholes.
- b. Cement plugs placed inside casing are tested by hydraulic testing: either positive or negative pressure testing.
- c. Hydraulic testing is a non-destructive method to qualify cement plugs.
- d. CBL/VDL logging is also used to verify cement plugs placed inside casing.

16. Regarding CBL/VDL bond logs, find the CORRECT alternative: (1p)

- a. The time which it takes for the signal to go from transmitter to receiver is called "transit time".
- b. High amplitude on CBL means good casing to cement bonding.
- c. High attenuation on CBL means poor casing to cement bonding.
- d. Amplitude is the strength of the first arrival.

17. All the alternatives are correct, EXCEPT: (1p)

- a. A fundamental requirement for an effective seal is that the entry pressure of the seal to be greater than the buoyancy of the fluids in bearing formation beneath.
- b. The seal entry pressure, seal capacity, is the capillary pressure at which fluid pressure overpasses the capillary entry threshold and therefore, fluid leaks into the pore space of barrier.
- c. The capillary entry pressure is a function of pore radius.
- d. The capillary entry pressure is independent of fluid type.

18. When permanent plug is placed at the right depth, it shall create a good bond to the adjacent element. The bond force which holds the plug fixed in place is called: (1p)

- a. Hydraulic bond
- b. Shear bond
- c. Compressive bond strength
- d. None of the above alternatives

19. When placing cement at the desired depth, the in-place mud shall be removed sufficiently. Mud displacement during cementing is NOT a function of: (1p)

- a. Hole geometry and inclination
- b. Flow rate
- c. Degree of turbulence
- d. Dump bailer

20. Choose the CORRECT alternative with regards to types of XMT: (1p)

- a. It is impossible to measure the trapped pressure under the tubing hanger in wells completed with horizontal tree.
- b. To nipple down the vertical tree, there is no need to retrieve production tubing.
- c. Horizontal trees provide access to A-, B-, C-annulus.
- d. Compared to vertical trees, horizontal trees accommodate smaller diameter of production tubing.

21. Installation of large BOP during P&A introduces some challenges. Select the CORRECT alternative:  
**(1p)**

- a. A larger BOP means limited space and handling capacity in offshore wells
- b. A larger BOP means more fatigue stresses on the wellhead
- c. Function testing of BOP is more time consuming
- d. All above-mentioned alternatives

## Appendix A

