

## Part I (50p)

1. Based on the “*Guidelines for the Suspension and Abandonment of Wells, Oil & Gas UK issue 4*”, a permanent Plug and Abandonment (P&A) operation is divided into three distinct abandonment phases. Briefly explain the three phases. **(3p)**
2. According to NORSOK D-010, Rev. 4, a permanent well barrier should have some characteristics. List five characteristics. **(5p)**
3. According to NORSOK D-010, Rev. 4, for permanent P&A purposes primary and secondary barriers are necessary to be established for hydrocarbon potentials or abnormally pressured formations. Briefly explain the philosophy of the primary, secondary and environmental barriers. **(3p)**
4. List five well abandonment challenges on the Norwegian Continental Shelf (NCS). **(4p)**
5. According to “*Guidelines for the Suspension and Abandonment of Wells, Oil & Gas UK issue 4*”, the sealing capability of the casing cement should be assessed. List four verification methods of casing cement. **(4p)**
6. According to “*Guidelines on Qualification of Materials for the Suspension and Abandonment of Wells, Oil & Gas UK issue 1*”, potential barrier materials have been categorized into nine types. List five potential barrier materials and give an example for each. **(5p)**
7. Light Well Intervention Vessels (LWIV) have been proved to be a cost-efficient intervention approach for subsea wells. List four operations that could be performed by deploying a LWIV during a permanent P&A operation. **(5p)**
8. According to NORSOK D-010, Rev. 4, permanent plug in either openhole or cased hole shall be verified. List the verification method(s) for each scenario. **(3p)**
9. In cement logging, fast formation and unconsolidated formations influence the acoustic signal. Briefly explain them. **(5p)**
10. Briefly explain how casing size and thickness, and cement thickness can affect the CBL curve. **(5p)**
11. Besides CBL-VDL logs, there are two different techniques which could be used to determine cement isolation behind the casing. These two techniques have been listed as following. Explain the concept of each technique in your own words.
  - a) Listening to flow behind casing. **(2p)**
  - b) Measuring temperature effect of flow. **(2p)**

12. In P&A operations, the most common method for placing a plug in cased hole with an uncemented annulus has required section milling of casing.
- List 4 challenges are created by section milling. **(2p)**
  - How the risk of 'pack off' can be minimized in section milling of casing? **(2p)**

**Part II (13p)**

13. "Combination of the probability of occurrence of harm and the severity of that harm" is defined as: **(1p)**
- Leak
  - Probabilistic cost estimation
  - Risk
  - Well integrity
14. "Well status, where the well operation is suspended without removing the well control equipment" is defined as: **(1p)**
- Temporary P&A with monitoring
  - Permanent P&A
  - Suspension
  - Temporary P&A without monitoring
15. "A physical element which in itself does not prevent flow but in combination with other well barrier elements form a well barrier" is called: **(1p)**
- Well barrier
  - Well barrier element
  - Well barrier envelope
  - Well design processing
16. According to NORSOK D-010, Rev. 4, all the items are correct EXCEPT: **(1p)**
- Requirements for isolation of formations, fluids and pressures for temporary and permanent abandonment are the same.
  - The overburden formation including shallow sources of inflow shall be assessed with regards to abandonment requirements.
  - Multiple reservoir zones/perforations located within the same pressure regime shall not be regarded as one reservoir.
  - Permanent well barriers shall extend across the full cross section of the well, include all annuli and seal both vertically and horizontally.
17. According to NORSOK D-010, Rev. 4, all the followings are correct EXCEPT: **(1p)**
- The requirement for an external well barrier element is 50 m with formation integrity at the base of the interval.
  - If the casing cement is verified by logging, a minimum 30 m interval with acceptable bonding is required to act as a permanent external well barrier element.

- c. An internal well barrier element (e.g. cement plug) shall be positioned over the entire interval where there is a verified external well barrier element.
- d. The minimum of plug length, for one barrier, placed on a mechanical plug/cement as a foundation is 100 m.

18. All the followings are potential functional failure mode and root cause a permanent barrier material to fail EXCEPT: **(1p)**

- a. Shift in barrier position,
- b. Barrier leakage through the bulk material
- c. Barrier leakage around the bulk material
- d. Typical conditions for wells

19. All the followings are the roots which can cause leak around the bulk material EXCEPT: **(1p)**

- a. Shrinkage and expansion
- b. Chemical degradation
- c. Diffusive leakage
- d. Poor quality of barrier placement

20. Select the right answer: **(1p)**

- a. Temperature logging is often used to evaluate primary cement jobs.
- b. Temperature logging is mainly used to detect the top of the cement column.
- c. Temperature surveys are performed to detect leaks or channeling.
- d. All the above-mentioned items are correct.

21. Absence of SCP (Sustained Casing Pressure) during the life cycle of the well indicates that ... **(1p)**

- 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.

22. Viscoelasticity is defined as ... **(1p)**

- a. Property of materials that exhibit both shear bond strength and tensile bond strength.
- b. Property of materials that exhibit both viscous and bond strength characteristics when undergoing deformation.
- c. Property of materials that exhibit both bond strength and elastic characteristics when undergoing deformation.
- d. Property of materials that exhibit both viscous and elastic characteristics when undergoing deformation.

23. Select the correct answer with respect to NORSOK D-010, Rev. 4. **(1p)**

- a. For a temporarily abandoned well without monitoring, there is no maximum abandonment period.
- b. For a temporarily abandoned well with monitoring, there is a maximum abandonment period of three years.
- c. For temporary abandoned subsea wells without monitoring, a program for visual observation shall be established.
- d. For completed subsea wells that are not tied back to a production facility and cannot be monitored, a yearly (ROV) inspection is not necessary.

24. All the followings are correct EXCEPT: **(1p)**

- a. In well logging, sound waves are generally characterized by their slowness, which is the inverse of velocity.
- b. A sound wave loses energy as it propagates through a material. This loss of energy is called amplitude.
- c. In cement logging, it is sometimes mistakenly assumed that the transit-time curve says something about the cement. In fact, the most valuable function of the transit-time curve is quality control.
- d. On a CBL-VDL curve, the chevron patterns at the casing collars are visible.

25. Based on the NORSODK D-010, Rev. 4, “*the application of technical, operational and organizational solutions to reduce the risk of uncontrolled release of formation fluids throughout the entire life cycle of the well*” is called... **(1p)**

- a) Temporary abandonment
- b) Leak testing
- c) Permanent well barrier
- d) Well integrity

### **Part III (37p)**

26. Appendix A is a CBL-VDL curve shows the casing cement quality. Right down your reflection about the cement quality by listing your reasons. **(10p)**

27. In 2000, an oil producer well was drilled and completed on a fix installation. This well has been completed with a gas lift completion. The operator has decided to permanently P&A the well by 2020. Therefore, a preliminary study was carried out to find out the status and condition of the well. All the information has been summarized in Appendix B. Based on the provided information in Appendixes B and C, and supplementary information for each part, answer the questions.

- a. Write the P&A code system based on the provided information in Appendixes B and C. Briefly write your reasons for the selected code. **(2p)**

- b. List a general operational sequence for all the three P&A phases. **(5p)**
- c. In order to N/D the XMT and N/U the BOP, primary and secondary well barrier envelopes shall be established. List the primary and secondary well barrier elements for each envelope. **(5p)**
- d. As shown in Appendix B, the well has been completed with control lines. Since NORSOK D-010 does not accept control line as a part of permanent barriers, the tubing shall be removed. The operator asks you to remove the production tubing with coiled tubing. Based on the provided information in Appendix B and following information, is it possible to do the tubing removal with coiled tubing unit? State any assumptions. **(10p)**

Additional information:

The coiled tubing injector pulling capacity: 100,000 lbs.

Coiled tubing yield strength: 100,000 psi.

Coiled tubing OD: 2.375 in.

Coiled tubing thickness: 0.175 in.

Buoyancy factor of the fluid: 0.87

Tubing data: 5 ½" 17 lb/ft L80

- e. The initial reservoir pressure estimated to be 2915 psi and the current reservoir pressure is below the bubble point. The reservoir is supported by an active aquifer. Additional information: Oil gradient = 0.32 psi/ft, Gas gradient = 0.1 psi/ft and the formation fracture gradient is 14.5 ppg.

Calculate the minimum setting depth for the primary and secondary permanent barriers and suggest an interval setting depth with respect to pore pressure and formation fracture gradient curve given in Appendix B. **(5p)**