Well Plugging & Abandonment

Oil & Gas Asset Decommissioning

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Well Plugging & Abandonment (P&A) is the process of removing tubing, completion equipment and casing that has been used as a conduit to bring hydrocarbon from downhole to the surface. It is one aspect of Oil & Gas (O&G) asset decommissioning.

When talking about offshore O&G asset decommissioning, most people will immediately think of the removal of the offshore platform and pipelines but few will be able to tell if well P&A has been completed because this is something that happens below the surface of the sea and below the sea floor. Before surface structures can be removed, downhole structures decommissioning need to be completed first and more importantly, to restore the environment to its natural state as much as practically possible.

The environment refers to not only land or sea areas but also to that below the sea floor. It is the responsibility of each O&G operator to ensure the environment is left with as little disturbance or changes as practically possible. Prior to any development, as part of the field development plan, environmental impact assessment (EIA) is conducted on the area to analyse the impact of drilling and producing of hydrocarbon operations on the environment and socio-economy of the people living in the area.

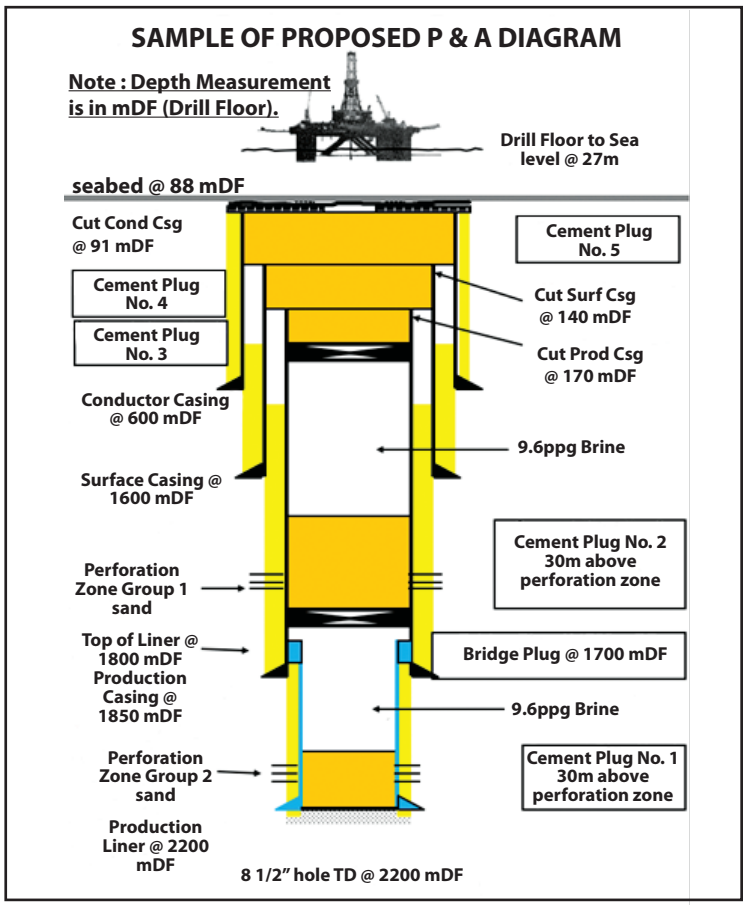

Figure 1: Sample of Proposed Plug and Abandonment Diagram

PPGUA RELATIONSHIP TO P&A

In Malaysia, the central reference for all upstream oil and gas operations is the PPGUA (PETRONAS Procedure and Guidelines for Upstream Activities). This is the ultimate reference for all O&G operators here and all requirements, which are based on international standard adapted for Malaysia's operations, must be met; for any exception, a waiver's approval from PETRONAS is required.

While this is the minimum requirement, many operators perform above and beyond these requirements, based on their company policies as well as needs for an individual well. Every well is unique, so it will require individual design as assessment. Volume 8 of the PPGUA is dedicated to "Drilling and Well Operations". Section 9 of Volume 8 laid out the "Plug and Abandonment of Well" requirements. If a P&A is found to be not properly executed within these requirements, PETRONAS reserves the right to ensure that the operator re-abandons the well again.

WHY P&A?

Well P&A is not only conducted during decommissioning but also during exploration and development stages. During exploration, when the well has been tested and all information required have been gathered, P&A of the well is conducted before the area is left. During development, if somehow the well is found to be "dry", and unusable for any development functions (such as producing, testing or sidetracking) in the near future, then the well shall be P&A. Another instance for P&A requirement is when a well is no longer producing economically. There are many other instances where P&A may be required; the idea is to ensure the hole is

sealed completely according to the provisions before the well can be abandoned. Other instances which may lead to P&A of a well or a portion of the hole, are accidental sidetrack, drilling into a wrong location and a stuck pipe. Before any well or part of the hole is P&A, detailed reasons and P&A design with justification are required for submission to PETRONAS for approval. Upon completion of P&A work, another complete report is required to be submitted to PETRONAS. This is to ensure that every hole made for the purpose of hydrocarbon exploration and development is accounted for and referenced for future records and studies.

The request for approval submission has to at least include the proposed P&A programme and diagram. The information required include well depth, all perforated intervals including those that have been plugged, casing and tubing depths and description, estimated tops of cement in each casing annulus, subsurface equipment and depths, plug types, locations and lengths, types and density of fluids left in hole, perforating and casing cutting plans, casing removal depths and reservoir strata as well as subsurface pressures of all known potential. The list may seem extensive but the information is crucial for future reference.

A GOOD BALANCE

It is important that we restore the environment to its natural state as much as possible. Although we know that this will never be entirely possible, professionally we must ensure there is minimum impact on the environment. This is a question of how much can be done and at what cost. A good balance between what is possible and what is feasible, from the environmental and financial perspectives, must be considered.

Engineering work can determine and recommend this balance and PPGUA ensures that this balance is practiced by all operators tapping into our natural resources. PPGUA has gone through a few revision cycles to meet international environmental protection requirements and be in-line with the guidelines with major multi-national O&G operators.

THREE PRINCIPLES

We must abide by 3 principles when permanent abandonment is conducted on a well or a portion of the open hole. The first is to provide downhole isolation between hydrocarbon zones. The second is to protect freshwater aquifers and the third is to prevent migration of formation fluids through the wellbore. Downhole isolation between hydrocarbon zones is important because each formation layer can actually be differently pressured due to the naturally formed formation movement. Leaving the different layers to communicate with each other will impact the pressure maintenance of the area. Freshwater aquifers need to be protected to ensure there is no contamination. Migration of formation fluids through the wellbore must not be allowed, because this will allow mixing of formation fluids from the different formations. In practice, for permanent abandonment of a well or portion of the hole, we must ensure the following: Isolation of zones in open hole, isolation of open hole, plugging of perforated zone and plugging casing stub. Isolation of zones in open hole, regardless of whether it is hydrocarbon bearing or not, is to ensure there is no communication between zones when the well is abandoned.

For offshore operations, decommissioning operations include clearing the area of any structure above the sea surface, above the sea floor and below the sea floor. P&A operations involve removing as much material as we can from the downhole.

Figure 1 shows a sample of a proposed P&A diagram for an exploration well. Upon obtaining all the information from the process of coring, logging and production testing, the well is evaluated for P&A.

Once this is decided, a programme is prepared and approval to P&A is obtained. After the hole is cleaned, cement plug # 1 is placed at the bottom of the well to seal off the perforation zone for Group 2 sand. The cement plug is extended up to 30m above the perforation zone to ensure the zone is ultimately sealed off. Then a bridge plug or a mechanical seal is placed below the Group 1 sand perforation zone. This bridge plug acts as a barrier to leakage from Group 2 sand and as a holder to the cement plug # 2 which also extends 30m above the perforation zone. On top of these sealing elements, the hole is also protected with liner (casing which does not go up to the surface) and casing.

In the O&G industry, two or more barriers are usually required to ensure safety of the operations. The hole is never left empty but instead, is filled with fluids which weigh more than the formation pressure. In this case, brine is used.

The process is repeated for the rest of other cement plugs.

Whenever possible, the casing is cut and retrieved from the hole to ensure that minimum materials are left in the hole. It is not possible to retrieve most parts of the casing because this is cemented on the outside to provide support during drilling operations to ensure that the inadequately supported formation does not cave in.

Well P&A has many other complexities such as additional procedure/approval if radioactive source is accidentally left in hole, temporary abandonment or well suspension, unplanned sidetracking requirement etc. However, the principle of P&A is the always the same, that the environment be restored to its natural state as much as practically possible. Once all the wells from a platform have been P&A and completely secured, surface equipment decommissioning can proceed.

Engineering is not just about making money; it is also about recommending the most optimised solution to a problem while ensuring safety, sustainability and operational excellence in the most professional way governed by engineering ethics.

Author's Biodata

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