# DEVELOPMENT OF A DATA INTEGRATE TOOL FOR CEMENT PLUG AND ABANDONMENT

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# ABSTRACT

With an increasing number of mature offshore/deep-water wells and progressively more strict regulatory requirements, plug and abandonment (P&A) is becoming a more complex issue and expensive, time-consuming initiative. It is necessary to understand the current status of well assessing the quality of the data available (pressure data, lithology data; sand, shale, cement range) therefore record keeping and data gathering are crucial throughout the wells' life cycle. Up to date, there is no specific tool develop to integrate different type of engineering and geological data in planning the cement plug location in P&A initiative. Objective from this study was show the utilization of data science method specifically by MS Access manipulation to integrate the data that is need to be analyse while planning for the best economically cement plug location. Method that was use in this study is explore and exploit the MS Access to create form to gather all the well data, subsurface lithology data of the well, the leak off test then later execute the calculation to verify the best depth of cement plug to be install in the well. The time needed to run the manual analysis without the develop tool was recorded and compare with time that was spend by using the study tool to run the data. In the previous manual method, different set of excel spreadsheet is created for different type of data and there is redundant data typed in the various number of spreadsheet to come up with the final pressure plot as the planning reference and user took about a week or five working days per well. MS Access use in the study was help to minimize the manual key-in, redundant data entry then later automatically plot the required graph in less than five working days for one well. The result from this study is, workflow established from this research can standardized the initial process to start a plug and abandon process, and accomplish accurate, precise initial data. In term of time spend, man-hour was saved by 60% and of course save the cost that involved in the data preparation effort with the usage of the integrate tool. P&A approval review also can be done easily if the result derived from the tool are accurate. In summary, the major goal to this study has develop an integrated tool that can merge different data from both engineer and geoscience input and later save the processing time in preparing the data for plug and abandonment process.

# ABSTRAK

Dengan meningkatnya bilangan sumur luar pesisir / perairan dalam dan keperluan pengawalseliaan yang semakin ketat, ‘Plug & Abandon’ (P&A) menjadi isu yang lebih kompleks dan inisiatif yang memakan masa serta mahal. Adalah perlu untuk memahami status semasa menilai dengan baik kualiti data yang ada (data tekanan, data litologi; pasir, serpih, julat simen) oleh itu penyimpanan rekod dan pengumpulan data sangat penting sepanjang kitaran hidup telaga. Sehingga kini, tidak ada kaedah khusus yang dikembangkan untuk menggabungkan berbagai jenis data kejuruteraan dan geologi dalam merancang lokasi palam simen sebelum aktiviti P&A. Kajian ini menunjukkan penggunaan kaedah sains data secara khusus dengan memanipulasi MS Access untuk mengintegrasikan data yang perlu dianalisis semasa merancang lokasi pemasangan simen terbaik. Kaedah yang digunakan dalam kajian ini adalah meneroka dan mengeksploitasi MS Access untuk membuat borang untuk mengumpulkan semua data sumur, data litologi permukaan bawah sumur, ujian kebocoran kemudian kemudian melakukan pengiraan untuk mengesahkan kedalaman terbaik dari plag simen yang akan ada pasang di telaga. Masa yang diperlukan untuk menjalankan analisis manual tanpa alat pengembangan dicatat dan dibandingkan dengan waktu yang dihabiskan dengan menggunakan alat kajian untuk menjalankan data. Dalam kaedah manual sebelumnya, beberapa salinan excel yang berbeza dibuat untuk jenis data yang berlainan dan ada data berlebihan yang diisi dalam berbagai jumlah fail untuk menghasilkan plot tekanan sebagai rujukan perancangan. MS Access dalam kajian ini membantu meminimumkan kemasukan data manual, berlebihan dan kemudian secara automatik merancang grafik yang diperlukan dalam masa kurang dari lima hari bekerja untuk satu telaga. Hasil dari kajian ini adalah, alur kerja yang dibuat dari penyelidikan ini dapat menyeragamkan proses awal untuk memulakan proses pemutus dan pengabaian, dan mencapai data awal yang tepat dan tepat. Dari segi masa, jam kerja dijimatkan sebanyak 60% dan tentu saja menjimatkan kos yang terlibat dalam usaha penyediaan data dengan penggunaan alat integrasi. Kajian kelulusan P&A juga dapat dilakukan dengan mudah sekiranya hasil yang diperoleh dari alat tersebut tepat. Ringkasnya, tujuan utama kajian ini adalah mengembangkan alat bersepadu yang dapat menggabungkan data yang berbeza dari input jurutera dan geosains dan kemudian menjimatkan masa pemprosesan dalam menyiapkan data untuk proses pemasangan dan pembuangan.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background

In oil and gas industry, there are five important stages involve in a well life cycle. The stages includes field exploration, development, operation, abandonment and reclamation. Each operator company that explore and develop an oil and gas field is responsible for managing well safety and facilities that associated. Life span of an oil or natural gas well is about 20 to 30 years. Known that the life span of a well is influence on the active years the well is in production. 'Active' is one of the six main life cycle categorizations of a well. Nonetheless, there are vast of growing new technologies in keeping the development to find new method to extend the life span of the well.

Millions of wells were drilled since the American's explorers launched the modern oil industry a century and a half ago. In the last 50 years, technology advances have progressively enhanced the chances that wells was find hydrocarbon, and of producing them profitably. Technology has also prolonged the oil and gas industry's horizons to areas where exploration was once impossible, such as the depths of the ocean. But in addition to the type of technology needed to produce oil for example from 8,000 metres below the seabed and later over 3,000 metres of sea, successful oil exploration be subject to on the alignment of a host of economic and geological variables. The explorer needs an enthusiasm for risk, access to funding, a great oil price to make exploration worthy and permission to operate and fortuitous geological measures to have arisen hundreds of millions of years earlier.

There are three geological elements necessary for the creation of an oil and gas field. First the source rock, second the reservoir rock, and thirdly the cap rock. After over millions of years, organic matter in the source rock is cooked into petroleum and natural gas. Then a mixture of oil, natural gas and water slowly migrates upwards over thousands of years through permeable layers of rock. An oilfield forms when the hydrocarbons store in a porous, permeable reservoir rock usually a sandstone or a carbonate with an impermeable layer above it, which avoids further upward migration. In oil and gas production, a well perforations through this impermeable seal, cap rock permitting oil and gas to flow to the surface. In some conditions, source rocks may also be reservoir rocks.

Explorers carry knowledge and risk capital to oil exploration, nonetheless seldom own, maintain or even maneuver the equipment. That and several other methodological responsibilities are usually outsourced to professional services companies. Step one in a well life cycle involve planning. It takes years to design an entire development, however a single well usually takes about 18 months, depending on where the well is located. Once all the study is complete and geologists find their site, the well must go through an extensive review and approval process. This process comprises getting the land lease, a spacing order, the permit for drilling and other. Before any exploration took place, yet, E&P companies must secure permission to work on the land and to agree with the proprietor of the mineral-extraction rights on who gets what in the occurrence of oil or gas being recovered. Ownership rules vary by country. For example, in the US and Canada, mineral rights may be in unrestricted or private hands. Everywhere else, including Malaysia, the state or country owns the oil and gas. In our country, the agreement term is known as Production Sharing Contract (PSC). Whoever the owner is, a contract is required to launch mechanisms for allocating up risks, costs and also rewards from any future production. The local environment is an essential part of the business plan too. The explorer wants to maximise its chances of financial success whereas minimizing the impact of its processes on the local environment and local groups.

No surveying practice can truly see oil and gas underground, however seismic and extra technologies can support earth scientists categorize rocks that are capable of holding oil or gas deposits. That can offer an explorer reasonable sureness that a discovery is potential before incurring the high costs of drilling. Seismic works by transfer pulses of sound energy into the ground then timing reflected wavelets, as they bounce back off layer after layer of rock. This information permits geoscientists to shape models of the subsurface and narrow down the pre-eminent spots for drilling. Another important data source is information from nearby wells and producing fields.

Wherever there has been no exploration, geophysicists be able to start to identify appropriate rocks by gauging their gravitational besides magnetic properties. Soft, sedimentary rocks able to hold hydrocarbons for example limestone, are fewer dense than heavy, igneous rocks. Practically, by utilizing the aviation field, airplanes measure the Earth's gravitational pull, searching for small differences caused by variations in the density of the underlying rocks. Variants in the Earth's magnetic pitch can provide beneficial data too, the less magnetic the better – sedimentary rocks are practically non-magnetic. Once a site is nominated and approved, drilling can begin. Before drilling, the operator must assess the economic case for a well, computing the chances of discovery commercial quantities of oil or gas, how rapidly a discovery would pay back the investment and the cost of a profit it would eventually make in light of the fundamental oil price. It takes a middling of 50 to 60 days to drill the well to its objective depth, which, with modern technology like horizontal drilling, could be up to two miles underground and up to two miles horizontally.

An area is empty for the drilling pad, water supply is customary by laying a water pipeline or tunnelling a well and a spare pit is dug and lined with plastic to hold excess mud and also cuttings from the well. Rig equipment is then mounted, the most noticeable of which is the derrick, the metal framework that backings the weight of the drilling apparatus. The deeper the well, the denser the load and the superior and tougher the derrick needs to be. A well bored to discover a new oil or gas reservoir is termed a wildcat or exploratory well. The well that ascertains a new field is termed the discovery well for that field and succeeding wells drilled to regulate the field's size and boundaries are known as step-out, delineation or appraisal wells. Developmental wells are drilled in a verified producing area and wells drilled between producing wells in a recognized field to upsurge production are named infill wells. Dry wells contain no oil or gas, or hydrocarbons in insufficient hole is drilled well below the freshwater aquifer. Steel casings and high-grade protecting concrete are then further to protect the underground water. Once this is accomplished, the drilling can proceed to the target depth. Drilling is the single way of actually verifying that an oil or gas field or reservoir occurs deep below the surface. Drilling a well is a 24/7 procedure, with crews occupied in shifts. The procedure can preceding for weeks – dependent on the hole's depth, the rig's control and the hardness of the rocks. Most wells are drilled using rotary drilling rigs. A sharp-toothed drill bit is connected to the surface by the drill string, lengths of drill pipe screwed together end to end. Machinery at the surface makes the drill string rotate. As it does so, the rotating drill bit at the end of it cuts, grinds, scrapes and crushes rock at the bottom of the well. Drill bits and the well's diameter decrease in size the deeper the hole gets. At the surface, the diameter potency be about 60 centimetres, associated with perhaps just 15 in the pay zone – the section of producing rock. In utmost wells, drilling ends periodically so that the well can be ruled with carbon steel casing. A special fluid called drilling mud is continuously circulated around the hole, washing out cuttings and keeping the drill bit in contact with uncut rock. The mud too cools and lubricates the bit, make available to the drill string thru buoyancy and counters the natural pressures of fluids in the rocks round the well, which would otherwise make it cave in.

Geologists and engineers cannot straightly inspect subterranean rock formations, but have distinctive tools to do it for them. In wireline logging, sondes are lowered down the hole on an electrical cable or the wireline. Data concerning to physical properties in or nearby the well are then transferred to the surface alongside the wireline, and logged in contradic of depth or time or both. Sondes can take numerous measurements. Electrical resistivity is one, oil and gas are more resistive than the salty water that fills most deeply buried rocks. Acoustic, radioactive and nuclear magnetic resonance tools also produce data on the possible content of a rock layer. Core samples, in which cylinders of rock are regained from the well for analysis, also deliver vital information. Mud logs possess track of the chemistry of cuttings carry away out of the hole. Wireline tools are suitable in vertical wells because, thanks to gravity, it's relatively easy to lower them in and pull them out. But the emergence of directional and horizontal wells has resulted in the development of logging while drilling and measurement while drilling tools usually referred to as LWD and MWD tools, in which sensors are located just above the drill bit and transmit data to surface by fluid pulse telemetry (pulses are sent through the medium of the drilling mud and decoded at surface) or are recovered later when the equipment is brought to surface.

If a drill bit stops drilling effectively, the drilling crew lifts the drill string out of the hole a process known as tripping pipe and replaces the drill bit or makes other adjustments. If scrap or debris enter in the way of drilling, they must be distant from the hole. Items left in a wellbore that impede the continuation of operations broken drill bits, drill pipe or logging tools, for example are called fish. Removing them is known as fishing. During drilling, a safety device called a blow-out preventer, or BOP, seals off the well if pressure from inside the formation threatens to build up and cause oil and gas to emission out of the well in a hazardous, wild manner. Pressure can then be calmed in a controlled way. Drilling a vertical well in a perfectly straight line is difficult: when the drill bit encounters a different type of rock, it tends to deflect slightly or dogleg. But utmost wells in the US these days, and many more round the world, aren't upright. They're designed not to be straight. In guiding drilling, exceptional power tools build angles into the wellbore, mingling up vertical and curved segments, and building in variations in azimuth. Horizontal wells, a type of directional well, able to deviate by 90 degrees from the vertical and, from that point, even start to drill upwards. Extended reach wells have lateral sections stretching up to around 12 kilometres.

There are lots of reasons for drilling horizontally. Directional wells can navigate round underground hazards. They can reduce surface influence because several wells can be drilled from one point. They can reduce costs by enabling offshore deposits to be drilled after land making costly platforms avoidable. And a single horizontal well can bump into multiple reservoirs and substitute the requirement for dozens of vertical wells. Drilling from time to time stops with the aim of the well can be lined with steel casing, which is then cemented into place. Casing hollow, heat-treated pipe frequently fabricated from carbon steel provides the hole mechanical maintenance and helps inhibit the formation wall from caving into the wellbore. It also guards freshwater formations by preventing fluids inside the well from seeping out of it. Sections of casing are secured together, pull down into the hole and cemented in position by graceful cement down the centre of the casing string and then up into the breach the annulus between the newly inserted casing and the bare sides of the hole. There are diverse types of casing for unlike phases of the well conductor casing, surface casing and also intermediate casing. Also, if a commercial conclusion is taken to produce from the well, most production zones are also arranged with production casing or production liner. If the producing zone in a producing well is not cased, the completion is identified as a barefoot or open-hole completion. Like the hole itself, casing strings cut in diameter the deeper it gets.

A drill stem test is a temporary completion that identifies the types of fluids in the well, their flowrate, the producing zone's permeability and the pressure of the reservoir. Collectively, those data specify the well's production ability and may consequence in a completion. It's done by connecting a measurement device to the bottom of the drill stem and lowering the apparatus down into the formation. At the bottom of the well, the instrument processes the flow of oil or gas for a quantified amount of time, usually an hour. Once the well is bored, oil and natural gas must to be released for extraction. If a well is to convert to a producer, it undertakes completion. The completion procedure means the setting up of the equipment in the well to expedite the flow of oil and natural gas safely and competently out of the well. Completion apparatus includes production tubing, a tubular inserted into the well that assists as the outlet for the hydrocarbons. At the top of the well, the drilling rig is substituted with a Christmas tree, an association of valves, spools and instruments that panels the flow of fluids out of the well. Completions diverge in complexity and may integrate technologies to avert sand from fluid into the well and triggering damage or to lift the flow of oil and gas to the surface.

From the time when 1940s, producers have castoff a technique named hydraulic fracturing, or fracking, to generate or re-create small fractures in the rock formation to encourage production. Fracking practises a high-pressure water mixture comprising of a 99.5% mix of water and sand and also 0.5% of chemical additives that are agents can help reduce friction and avoid corrosion, and are found in numerous household products. This method opens tight rock formations to permit the oil and natural gas resources to move up to the surface. This technique combined with other modern expertise, is unlocking more energy resources than ever previously putting the U.S. atop of energy producing republics. Once the well is accomplished, oil and natural gas are all set to be produced and composed. If desired, a pump jack is positioned at the wellhead, and acts mechanically to pull liquid oil up and about the wellbore. Most wells produce oil, natural gas and saltwater. These three properties are pumped and then separated above the surface. Tanks hold and transport the oil and natural gas resources through pipelines that expand across the country providing communities' energy.

Oil and gas production of one well can preceding up to 20-30 years. Production is the lengthiest segment in the well's lifespan and may last for years or even more. Over time, production declines and, eventually, was too low to continue to operate the field. But, during a field's productive lifecycle, the operator observers well performance and intercedes occasionally to execute maintenance and conservations, and attempt to stem the degree of decline. Different stages of production are identified as primary, secondary and tertiary recovery. Oil and natural gas in a reservoir is certainly under pressure and may need no reinforcement to flow to the surface where otherwise primary recovery happens when hydrocarbons flow unexpectedly. In some wells, nonetheless, there is inadequate pressure or the oil is excessively viscous to flow freely. Several technologies, such as electrical submersible pumps, can be utilized to acquire the hydrocarbons moving. Even in reservoirs that are highly pressured when production starts, the operator was ultimately need to intervene to keep up the flow rate. During secondary recovery, gas or water are introduced into the reservoir to displace oil and drive it to the surface. Tertiary recovery, or enriched oil recovery, comprises the injection of steam, gas, chemicals or microbes to adjust the properties of the hydrocarbons in the reservoir, and cause them easier to extract. In unconventional wells, drilling is complemented by hydraulic fracturing, which opens up passageways in the impermeable rock through which fluids in the rock may flow into a wellbore.

Once an oilfield no longer holds sufficient hydrocarbons to validate the continuation of production operations, the operator fills in wells, pull to pieces and removes equipment from the site, and restores the area. Typically, about a third of reserves are economically recoverable and accumulative recovery factors is one of the industry's foremost aims. After the years of producing energy, a well finally touches retirement. Operators get rid of tubing, fill the wellbore and casing by concrete, cut the casing off well underneath the surface, weld a cap onto the top and protect it with soil, returning the landscape to its natural form. Energy production is a widespread process that takes decades of hard work, preparation and execution, all to produce the energy means the world needs. Oil and other liquids are detached from natural gas at the wellsite and stowed in nearby tanks before being conveyed to a refinery by various means, such as pipelines, lorries and ships. Natural gas is typically processed adjacent to the point of production to remove natural gas liquids and other impurities. This verdures methane, which can then be piped to markets or to liquefaction plants. Alternatively, natural gas may be inserted back into the ground to help maintain reservoir pressure.

An abandoned well is lastingly shut down, wellhead removed, plugged, and considered safe and protected by regulators. After well abandonment, the site is remediated and cultivated. Companies evaluate the occurrence of soil contamination, produce a report specifying how pollution was mitigated, and confirm the site has been remediated in agreement with provincial requirements. Once an oil or natural gas well is no more productive, the operating company is requisite to remove equipment and reclaim the site. A well site is retrieval certified after it is remediated and cultivated to current regulatory standards. When a reservoir is not productive, it is stated that there was issue in decommissioning the offshore structures because the shelf is exceeding. This issue was faced around the globe. The definition of decommissioning is currently not define internationally nor and in the national legislation. In the other hand, there is three word that can create the model and process to decommissioning. Moreover, decommissioning always link with the word abandonment, disposal and removal.

The Department for Business Energy and Industrial Strategy UK, 2011 mention in the publication of UK Petroleum Act 1998 and the Decommissioning Guidelines that the abandonment programme is referred to the decommissioning programme generally in the Petroleum Act. 2011 Department for Business Energy and Industrial Strategy UK, 2014a Government of USA, 2008 Petroleum Institute of Thailand , 2015a Petroleum Safety

Authority (Norway), 2008 PETRONAS and 2015 Techera and Chandler listed down the requirement in legislation classified decommissioning as the final step in the life cycle of the industrial facility, decommissioning also identified as the stage to close down the facility of industrial via methods, this method minimise the cost financially, this including human life and well-being cost and to the environment. 2018 AER indicate the P&A programme success as if it covered and protect the non-saline ground water. Techera and Chandler, (2015), offshore production facilities if specifically referred in the industrial facility. Substructure secured to the seabed, pipeline network, and topside structure above the seabed made up the offshore facilities.

The decommissioning procedure thus involves the plugging and abandonment of wells, subtraction partially or totally, of the platform and related amenities on the platform, and clearance any “above mudline” structures or equipment from the seafloor. Myseth et al., 2017: Oil & Gas UK, 2016 indicated that P&A as it is often called to be run to an offshore or onshore well that is not anymore produce oil or gas cautiously. In the upcoming years, estimated thousands of wells was eternally plugged and abandon. There are study specified that a well was abandon when it starts to produce sand, H2S and CO2. Ferg et al., 2011; Scanlon et al., 2011 wrote the major cost that took place for each operation of P&A is the well conditions, and very time-consuming. Oil & Gas UK (2016) anticipated in the next decade, average cost of P&A per well in a mature area like North Sea is projected around £5–15 million. Crosswise an entire field, subsea wells is a key area, these wells is set up at either one or more subsea model. A current drilling rig be able to plug a platform well. A well can also plugged by a snubbing equipment. Devoted vessels, high spread rates conventionally semi-sub are required for subsea wells.

Kaiser and Dodson (2007) and Kaiser and Liu (2014) estimated the costs of different phases of the decommissioning operations in the Gulf of Mexico centred on regression models. Moeinikia et al. (2014a,b, 2015a,b,c) established a probabilistic method to evaluate cost-and time for P&A of subsea wells using a Monte-Carlo simulation methodology. They presented that the implementation of rigless plug and abandon technologies by changing operations starting a rig to lighter vessels results to significant cost and duration savings in subsea multiwell campaigns. Øia and Spieler (2015) and Aarlott (2016) initiate the statistics on the total number of wells to be plugged and abandoned in Norway and predicted total costs for P&A on the Norwegian Continental Shelf. They also determine that there is possible for cost-savings when execute operations with a vessel instead of a rig. Saasen et al., 2013; Sørheim et al., 2011; Valdal, 2013 shows another example is riser less well interpolation (RLWI) vessel as a straight forward parts of plug and abandonment operation can reduce a total rig time. Period and cost-estimation of P&A operations have been the concentrate for several authors. With an increasing number of mature offshore/deep-water wells and progressively more strict regulatory requirements, plug and abandonment (P&A) is becoming a more complex issue and expensive, time-consuming initiative. When a well grasps the end of its lifetime, it must be enduringly plugged and abandoned. Such plug and abandonment (P&A) operations usually consist of placing several cement plugs in the wellbore to isolate the reservoir and other fluid-bearing formations.

Permanent P&A of wells has been an important topic for several years (Calvert and Smith, 1994; Jordan and Head, 1995; Barclay et al., 2001), but there has been an increased focus in current years which is possibly due to the huge number of old offshore wells in developed areas such as the North Sea and Gulf of Mexico (Liversidge et al., 2006; Saasen et al., 2013; Rassenfoss, 2014; Davison et al., 2017). Operators are now informally talking about an upcoming "P&A wave" of wells that need to be permanently plugged. Depending on well conditions, P&A operations can however be quite time-consuming and thus very costly. Moreover, offshore wells are considerably costlier to abandon than onshore wells (Oil & Gas UK, 2015a). The North Sea for instance, nearly two thousand wells are intended to be permanently plugged and abandoned in the forthcoming decade. Up to £3 billion respectively year is estimated to be spent on decommissioning activities in the North Sea throughout the upcoming years, where about 50% of these expenditures are on well P&A operations alone (Oil & Gas UK, 2016). Furthermore, an essential aspect of P&A is to ensure well integrity after abandonment (King and Valencia, 2014). In earlier years, not too much emphasis was put on ensuring that wells were properly plugged since regulations covering P&A operations were vague and inadequate (NPC, 2011). More than a few old, plugged and abandoned wells are consequently leaking (Watson and Bachu, 2009; Vielstädte et al., 2015, Kaiser, 2017). Catalysed by the 2010 Macondo accident and subsequent serious oil spill, changes in technology and regulatory regimes have caused the industry to make some significant shifts in their attitude towards P&A in recent years (Smith and Shu, 2013). The focus of P&A operations is now on environmental issues such as preventing leakages, in addition to cost-efficiency.

The national Malaysian oil company, Petroleum Nasional Berhad (PETRONAS), has ownership of all offshore and onshore oil and gas in Malaysia. PETRONAS regulates abandonment of oil and gas wells through the Production Sharing Contracts (PSC) and the guidelines for wells P&A as set out in the PETRONAS Procedures and Guidelines for Upstream Activities (PETRONAS, 2013). During the term of the PSC, the operators are responsible for carrying out the abandonment activities of all the petroleum facilities under the PSC. This commitment ceases if the field is surrendered on the expiry or expiry of the PSC. The operators must obtain the approval of PETRONAS before commencing any P&A activities. The operations must be conducted in accordance with the abandonment work programme and budget approved by PETRONAS. The work programme and budget has to describe in detail the abandonment plan.

Cement is at present used in wells as the crucial material for abandonment purposes since it is initiate to have similar properties to the rock that it is changing. However, given its operational restrictions, alternative materials, which compromise significant advantages above cement, are being suggested and developed by the industry.  These substances, however, still don't replace cement. That's because - when equated with cement that has been castoff for hundred years or so - uncertainty with regards to long-term integrity of the substitute materials acts as disincentive for their use.  The legislation, as reviewed last week, also play a role in the incentive to use cement for P&As; some countries refer only to cement as abandonment material in their legislation, although some others ask for an abandonment material to be “equivalent to cement."

| Type | Material | Examples |
|---|---|---|
| A | Cements / ceramics (setting) | Portland cement, pozzolanic cements, slag, phosphate cements, hardening ceramics, geopolymers |
| B | Grouts (non-setting) | Sand or clay mixtures, bentonite pellets, barite plugs, calcium carbonate and other inert particle mixtures |
| C | Thermosetting polymers and composites | Resins, epoxy, polyester, vinylesters, including fibre reinforcements |
| D | Thermoplastic polymers and composites | Polyethylene, polypropylene, polyamide, PTFE, PEEK, PPS, PVDF and polycarbonate, including fibre reinforcements |
| E | Elastomeric polymers and composites | Natural rubber, neoprene, nitrile, EPDM, FKM, FFKM, silicone rubber, polyurethane, PUE and swelling rubbers, including fibre reinforcements |
| F | Formation | Claystone, shale, salt. |
| G | Gels | polymer gels, polysaccharides, starches, silicate-based gels, clay-based gels, diesel / clay mixtures |
| H | Glass | |
| I | Metals | Steel, other alloys such as bismuth-based materials |
| J | Modified in-situ materials | Barrier materials formed from casing and / or formation through thermal or chemical modification. |

Figure 1.1: Material types for permanent barriers (source, Oil & Gas UK)

The UKOG guideline for qualification of materials then defines (see table above) a list of materials that offer characteristics that meet all the functional requirements for permanent barriers that we reviewed above. I was give we a summary:

•Very low permeability – to prevent flow of fluids through the bulk material

•Provide an interface seal; the material seals along the interface with adjacent materials such as steel pipe or rock; risks of shrinkage and de-bonding are considered.

•The barrier material must endure at the intended position and depth in the well.

•Long-term integrity; the material doesn't deteriorate over time; risks of cracks and de-bonding over time are considered.

•Resistance to downhole fluids (i.e. CO2, H2S, hydrocarbons, brine) at foreseeable pressures and temperatures.

•Mechanical properties suitable to accommodate loads at foreseeable temperatures and pressures.

## 1.2 Problem Statement

It is necessary to understand the current status of well assessing the quality of the data available including pressure data, lithology data (sand, shale, etc.), cement range and therefore record keeping and data gathering are crucial throughout the wells' life cycle. This is a challenge that is face by the different companies, especially regarding temporary abandoned wells and old wells whose information was lost over the years. The design of the P&A operation and how it was conducted highly dependent on many parameters to ensure the operation was pursued properly. A right planning and design was lead to high quality of cement seal of P&A. in the other hand, the right depth of cement is the factor to seal a gas sand perfectly. Time spend to analyse these data is equal to the money spend for the effort to dealing with each professional to get the final design. Each component of the initial preparation (cap rock analysis, wellbore sketch, pressure plot) required more than one day per data to be prepared.

Each data have their own graph plotted and unit. Difficult to provide a ready to use information in a short period from these several sources. At this point of time, we haven't sealed any wellbore, but the money have been spent. Decommissioning is an activity to restore a previously producing site to a safe and environmentally stable condition which comprise, well abandonment to prepare a well to be closed permanently usually after logs have determined that there is insufficient hydrocarbon to make production activities commercially viable, or after production operations have drained the reservoir. Upstream Facilities Decommissioning is to permanently make safe the facilities such as wellhead platform & clean petroleum product (WHP & CPP) and Subsea Tree, Floating Production Storage and Offloading vessel (FPSO/FSO) and Vent platforms at the end of production lifecycle or when there is insufficient hydrocarbon to make production activities commercially viable.

Decommissioning is a rapidly evolving market sector in the oil and gas business, with foremost potential and risks. It is a commitment to ensure proper Decommissioning efforts to minimize impact to our environment. The significant business driver for decommissioning is cost controlling where opportunities to capture value span from late-life asset management to final decommissioning over collaboration, innovative technology and reclaim / repurpose opportunities. Focus areas: Value engineering, Innovative removal method, Collaboration across stakeholders i.e. authorities, operators and OGSE players.

Decommissioning in Malaysia presents an interesting growth opportunity. Activities are to intensify as considerable assets have been operating beyond 40 years. The oil and gas industry continues to transform as economic, technological and environmental factors drive changes across the value chain. Digital advancement is one of the key factors underpinning our business transformation. PETRONAS is fully embracing this disruption head-on, as it recognizes that going digital is not just about technology, but about culture and mindset. It is about being outcome-driven and about being obsessed with serving customers. Thus, our key objective is to remove customer frictions and serve even the latent, unmet needs of our customers, whether they are internal or external. “PETRONAS is on a journey to orchestrate digital transformation across the organization. Our ultimate aim is to make digital entrenched in the way we work. We aim to be a data-driven organization, fundamentally changing the way we work to deliver new value. Our digital projects span across the value chain, from wells to plants, to customer-facing businesses” Wan Shamilah Saidi Chief Digital Officer Petronas.

Being an aging field, many wells in Malaysia that were developed in early field life are currently depleted and watered out, making wells and some platforms inactive. As these unproducing assets require maintenance for safety requirements, there are plans to decommission and abandon unproducing assets to reduce operating expenditure. In previous practices for well abandonment, well abandonment process consists of securing and restoring entire wellbore to original condition. As full well abandonment process requires long duration, which translate to huge abandonment expenditure, operators worldwide have adopted well abandonment optimization, with cap rock restoration method in well abandonment. The main difference in cap rock restoration method and traditional method is shifting of isolation focus from reservoir level to cap rock level1, resulting in time and cost saving in well abandonment.

### 1.3 Solution


Table 1.1: Solution road map

Roadmap above shows the proposed material that was used to create the tool. Final drilling and completion Report - Basic reservoir/geological information; final wellbore sketch or completion illustration showing all downhole apparatuses (with their I.D., O.D., length, depth of installation) and description of wellhead and Christmas tree; form and density of fluid left in the hole; Perforated breaks; initial production test outcomes including itemized pressure, fluid/gas flow rates and interval of test; List of wireline logs and its clarification (cored intervals should also be shown); Casing size, type, grades, weights, depth set in MD and TVD. Programme outlining operational steps and barrier verification (testing). It shall also take in description for plug types, downhole placement technique and downhole cement slurry support (to prevent slurry slumping). Current status and proposed P&A well schematic complete with descriptions for the following details: Well depth; All perforated intervals including those that have been plugged; Casing and tubing depths and explanation; Projected tops of cement in separately 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; Reservoir strata, subsurface pressures of all known potential reservoirs and estimated pressures; and Cement bond evaluation log result, if recorded.

## 1.4 Hypothesis

Workflow established from this research can standardized the initial process to start a plug and abandon process. Accurate and precise initial data achieved. Man-hour can be saved up with the integrate tool. 5 different data can be plotted into single application. Approval review can be done easily if the result derived from the tool are accurate. This paper will chronicle well abandonment optimization through data workflow optimization and integrated assessment for well abandonment proposal.

## 1.5 Research Objectives

This study main objective is to develop a workflow that can standardized the data preparation prior to ant P&A operations offshore and onshore. On the other hand, the major goal to this study is to develop an integrated tool that can merge different data from both engineer and geoscience input. These data include leak of test data, fracture gradient, water gradient, casing shoe depth, proposed cement depth, and the lithology data specifically on the cap rock analysis and gas sand exact location in the reservoir. In summary as per below:

1) To develop an analytic tool to integrate pressure excel spreadsheets and cap rock analysis and well sketch.

2) To create and document a workflow in preparing the data for plug and abandonment process.

## 1.6 Scope of Study

1) Workflow established from this research can standardized the initial process. Accurate and precise initial data achieved.
2) Developing automation tool to integrate plug and abandonment data preparation.

## 1.7 Conclusion

Time save with the tool can be diverted to more productive effort. Work that needed weeks to be done can be completed within hours. Time save with the tool can be diverted to more productive effort. Work that needed weeks to be done can be completed within hours. Embracing Industry 4.0. Taking the advantages of the data intelligence to solve oil and gas problem.

Well abandonment studies implemented integrated assessment approach, with the focus of decreasing the time and cost related to well abandonment without threatening safety requirements. As results, recommended abandonment intervals are considerably reduced compared to what has been planned initially. With simplified well abandonment strategy, fit-for-purpose rig is used, and well abandonment operation budget is reduced with reduction in rig day rate.

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