Drilling in deeper formations and in high pressure and high temperature (HPHT) environments is a new frontier for the oil industry. Fifty years ago, no one would have imagined drilling in more than 10,000 feet of water depth like we do today. However, more issues need to be researched, tested, and studied in order to maintain a good drilling efficiency as deeper depths are drilled. One of these issues is the great effect that drilling at HPHT conditions has on the behavior of drilling fluids. The goal of this research was to study fluid loss properties of water based mud and its effect on permeability under HPHT dynamic conditions utilizing advanced laboratory equipment that allows for wide ranges of pressure and temperature. Filtration tests were performed at both ambient and HPHT conditions. After several laboratory evaluations of fluid loss additives available in the market, Polysal HT was found to be the most effective in reducing the fluid loss of the water based mud for both static and dynamic tests at HPHT conditions. It is economically designed to be saturated in salt and other brine system. An additive that encapsulates particles with protective polymer coating as colloid. Drilling fluid stabilizer especially in drilling hydratable shale and a remarkable effectiveness in wide range make up water (high saline and high hardness). The fluid loss behavior of the mud and the characteristics of the filter cake produce dare the basic factors that need to be considered when determining mud treatment. A detailed workflow of experiments using equipment from OFITE HPHT Fluid Apparatus with differential pressure of 500 psi under 230 °F with 2.5” filter paper (30 minutes) as well as OFITE Permeable Plugging Tester with 1,200 psi differential pressure @ 230 °F using a ceramic disc were conducted. Also tests were conducted using the Low Temperature- Low Pressure API Filter Press at 100 psi @77 °F with 3.5” filter paper for the purpose of comparison. Drilling fluid behavior should be studied and researched in order to get better drilling efficiency and less fluid losses. This topic has been for years the subject of research and many laboratory studies. Most of these studies focused on the methods and parameters involved in the study of drilling fluid characteristics. Mud can act unexpectedly under HPHT conditions and testing its properties at these conditions produces results that
differ from those obtained from testing under static conditions. Drilling fluids’ interaction with the spacer fluid is also critical. Krueger found out that the API filter loss tests (standard and high pressure) shouldn’t be considered accurate when testing for the losses in mud that has viscosity reducers under dynamic conditions. He also studied the quantities of dynamic fluid loss in water based muds when adding substances to the drilling fluid such as CMC, starch, polyacrylate, and viscosity reducers. He found that—in dynamic system—starch and viscosity reducers were the most useful additives. However, when using API fluid test, the results deduced that CMC, starch and polyacrylate were the most beneficial additives. So he deduced that industry was paying so much on the API filter loss test (standard or at high temperature high pressure) expecting it to be accurate, instead of focusing on the dynamic filtration tests (at HPHT) whose results were more accurate since their conditions were very similar to the reservoir conditions. This is an experimental study of the impact of having HPHT reservoirs on the drilling fluids loss. Three different cases will be studied at different conditions. An API Filtration and fluid loss equipment will be used in order to test the mud capacity to withhold its filtrates under the HTHP as well as from static to dynamic condition. Experiment #1 consist of low pressure, low temperature conditions. The second one is at HTHP using static model. Finally, the last experiment will also be at HTHP conditions but using a dynamic model. Fluid loss models (beyond the conventional such as viscosity, gel strength, yield point and so forth) will then be compiled. The Polysal HT, a modified starch that serve as the fluid loss control additive along with Bentonite and Polypac UL will generally do the job. Roodhart stated that the commonly used 30 minutes API filtration test was inadequate especially in dynamic conditions. Also, he concluded that the range for fluid data testing (1,000 psi [7-MPa] differential) was lacking and deficient. Shadravan and Amani investigated the HPHT challenges in drilling and completions. Lee et al. researched the rheological properties of an extreme HPHT drilling fluids. Amani et al. compared the rheological properties of oil based and water based drilling fluids under HPHT conditions. Shadravan et al. looked at the possibility of fluid loss in underbalanced situations. Bland et al. mentioned that there were many parameters that need to be taken into consideration while designing and monitoring drilling fluids for HPHT conditions. These parameters included pressure and temperature effects on hydraulic calculations (while drilling under HPHT conditions at large depths, mud is subjected to high pressures and temperatures for long period of time) and PVT behavior of the base fluid (where the usual conditions considered by industry in fluid PVT measurements ranged from 15 psi per 750 °F to 20,000 psi/350 °F, but this range was exceeded while drilling under HPHT conditions). In addition, drilling efficiency was affected greatly by HPHT conditions where the use of additives like barite to increase the mud weight for such conditions caused lower drilling efficiency where the percentage of dispersed solids increased. This has many disadvantages (like decreasing hydraulic and cutting efficiency) during drilling high compressive formations under HPHT conditions. Elkatatny and Nasr-El-Din studied the formation of filter cake under static and dynamic conditions. They deduced that the same filtrate quantity was formed during dynamic and static conditions. However, dynamic conditions’ spurt volume exceeded that under static conditions and when the filtration process reached an end, the part of the filtrate near to the drilling fluid had zero porosity and permeability. Further results by the CT scan proved that ceramic disk properties (like permeability and porosity) varied significantly during filtration and this should be taken into account during filter cake calculation. Properties of water based drilling fluids under HPHT dynamic testing conditions that can be measured include spurt loss, quality of plugging, total fluid loss, and cake formation thickness. Crespo et al. looked at some fluid loss related problems such as formation fracture, lost circulation, and well-control problems as a result of surge and swab pressures for yield-power-law drilling fluids. As the results show, permeability is proportional to the flow rate per unit cross sectional area. This can be translated into pore throats in subsurface rock. Therefore, the greater the pore size through which the fluid is going to flow at a constant flow rate, the higher the capacity of the fluid to flow and therefore its permeability. It can be deduced that as the concentration of the Polysal HT increased, less and less filtrate was lost into the formations. Same results were obtained from the low temperature low pressure API test where smaller filtrate volume was obtained as the concentration of the used Polysal HT increased. Thus, water based mud under HTHP conditions undergoes many changes in its main parameters like spurt loss, fluid loss, and filter cake thickness. Fluid loss control additives are therefore required in order to handle these changes and maintain the required properties of the used drilling fluid where Polysal HT was the required additive in this case. Dynamic as well as static API filtration tests should
be performed before choosing the best additive. Numerous trials have been set up to test the fluid loss effectivity of the mud used in drilling but a very limited resources targeted the HTHP course due to its collaborative safety and productivity concerns, they call it “Drilling in the Dark” (a time to time check of properties).