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Methane Hydrate; Deep Water Drilling Hazard

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Methane hydrate is a crystallized concentration of methane and water that occurs under specific pressure and temperature conditions. We normally associate hydrates with permafrost and cold temperatures but the pressure created by the hydrostatic head of deep water provides conditions that allow the formation of hydrates creating potential drilling hazards. As long as operators are aware of the potential for hydrate formation this hazard can easily be avoided.

Methane hydrate is stable at 0°C at pressures above 2500kpa but it is also stable at 4°C and pressures above 5000kpa. As water cools it becomes more dense to its maximum density at 4°C resulting in deep water temperature of 4°C, and at 500m depth the hydrostatic pressure reaches 5000kpa providing the conditions at which hydrates will form if methane mixes with water. If hydrates are exposed to temperature and pressure conditions outside the temperature and pressure regime at which they are stable; the concentrated volume of methane virtually explodes into its equivalent gaseous volume creating a potential hazard to offshore drilling.

Methane hydrates pose a dangerous drilling hazard in shallow water if they are encountered during the drilling of the conductor pipe before the installation of the BOP. Conditions for the formation of shallow methane hydrate accumulations are found in the Canadian Beaufort Sea, which is underlain by up to 600m of permafrost that creates sufficiently low near sea floor temperature conditions for hydrates to form. Fortunately, shallow hydrate accumulations are easily recognized by their high acoustic impedance relative to the near sea floor sediments, but since these acoustic properties are similar to ice it is not possible to differentiate between local ice features and hydrate pockets. Because of the inherent risk, no attempt is made to distinguish between small ice features and hydrate pockets and all near surface features exhibiting anomalous high amplitude properties are simply avoided by moving the location to a position free of any such high amplitude anomalies.

Methane hydrates found in deep water areas do not present the same drilling hazard as hydrates found in cold shallow waters because the pressure from the deep water maintains the necessary stable environment to prevent the decomposition of hydrates into methane gas. However the 4°C temperature of deep water and the high pressure exerted by the large water column create a potential hazard from the formation of hydrates if natural gas is introduced to seawater at these temperatures and pressures.

The Macondo Well blowout in the Gulf of Mexico was a harsh reminder about the formation of hydrates when methane is mixed with 4°C water at high pressure. The first attempt to capture the oil flowing from the well using an inverted funnel capture device was thwarted by the formation of methane hydrates plugging the device. The initial attempts at a “top kill” through the kill line of the BOP may have also been

affected by the formation of hydrates from the water in the kill mud mixing with the gas flowing out of the well forming a plug that prevented the kill mud from pushing the oil back down the hole. The problem with hydrates was clearly recognized and addressed when the well was eventually killed by the top kill after the well had been successfully shut in using a valve assembly to replace the broken riser. To prevent the kill line from "hydrating off" the kill mud was oil based avoiding hydrate formation and the resultant successful top kill operation.

Conclusions

As long as methane hydrates are recognized as potential drilling hazards they are easily dealt with and pose no threat; but if operations take place at water depths where methane hydrates can form and their existence is not anticipated there can be very serious consequences. All the necessary information about hydrates is readily available and as long as the hazard is recognized it is a simple matter to deal with hydrate formation in deep water drilling operations. Any drilling operations in water depths greater than 500m face this potential drilling hazard from methane hydrate formation, and it is incumbent on both operators and government regulatory agencies to properly address this hazard with appropriate regulations and procedures.