

# Successful Implementation of Ultra High Temperature MWD for HPHT drilling environment in the Gulf of Thailand

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## Abstract

Nowadays in Gulf of Thailand, hundreds of wells per year being drilled for gas production, where the reservoirs are at static temperature over 200 °C, safe and economic production from these Ultra HPHT (High Pressure High Temperature) fields is crucial to deliver on gas contracts that support the region's economic activities. With conventional technologies, the operational limit of equipment used to drill these wells, such as Measurement While Drilling (MWD) and Logging While Drilling (LWD) tools, is 175 °C. If those conventional electronic components, elastomers, and sensors in these tools are exposed to high temperature, the reliability of the tool is significantly decreased, and therefore it requires extensive time consuming maintenance.

New technologies have been developed and qualified during the last decade that enable electronics, sensors, and elastomers to operate in these HPHT environments with the same level of reliability as that in what is nowadays considered "normal environmental conditions." A new MWD tool has been designed utilizing these novel technologies. The tool can operate reliably at 200 °C and 207 MPa.

Schlumberger, in collaboration with PTT Exploration and Production Plc. (PTTEP), brought Ultra HPHT MWD technology for trial in Gulf of Thailand to drill wells without the need to stop operation due to temperature limitations. Average time savings of 17.2 hours per well have been achieved.

Although this new technology has been successfully trialed and utilized in Gulf of Thailand for PTTEP, to have it fully implemented in day to day MWD operations is crucial to bring real economic value to the operators.

## Introduction

With current ventures focused on drilling deeper and exploiting new reservoirs, offshore drilling in the Gulf of Thailand increasingly challenges drilling operation with temperatures above 200 °C. Hundreds of wells need to be drilled per year in this environment to fulfill long term gas contracts. High efficiency is required in such a high volume operation.

Existing commercial MWD and LWD technologies are only capable of operating up to 175 °C, with inherent decrease in reliability at the higher temperatures. In the Ultra HPHT projects, the Bottom Hole Assembly (BHA), which includes an MWD tool for directional and inclination measurements in real time, will be pulled out of the hole once the circulating temperature approaches 175 °C. Then a new BHA without measurement tools will be used to continue drilling to total depth. This "blind" drilling section could be several hundred meters long, introducing risks associated with well control and well collision.

The main limiting factors in having MWD/LWD tools operating in these Ultra HPHT environments are the downhole electronic components. Industry research studies show that plastic encapsulated components have a life expectancy of approximately 1,000 hours at 150 °C ; this drops to less than 100 hours at 175 °C (Fig. 1). Ceramic encapsulated components last longer at 175 °C, but they are bigger and heavier than their plastic counterparts. Since space is restricted in these tools, the best compromise yields a mix of both ceramic and plastic-

encapsulated components.

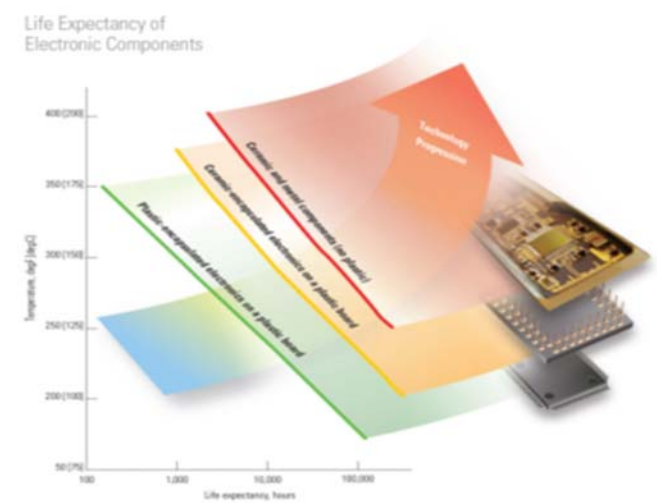


Fig. 1 Life Expectancy of Electronic Components

To find a solution to this industry-wide problem, significant effort was made over the last decade to develop custom electronics that can withstand high downhole temperatures. The newly developed MWD tool equipped with these novel electronics components was deployed in Ultra HPHT wells. In these wells, the real time measurements were necessary to drill the sections with operating temperatures above 175 °C. It allowed to minimize drilling risks, enable proper well placement and improve drilling efficiency by eliminating one run.

### Innovation Features

The HPHT MWD (Fig. 2) was designed and built with the objective to not just “survive” at high temperature but to perform reliably drilling multiple wells. The tool electronics can be mounted on either a 6 ¾-in. or 4 ¾-in. collar and fitted with flow kits to address different operational conditions. For this project, proprietary technology was developed to ensure reliable operation at 200 °C and 207 MPa and lay the foundation for future high-temperature

developments.

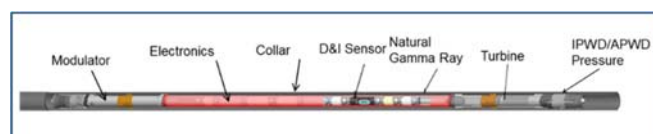


Fig. 2 HPHT MWD schematic

The electronics are made of fully proprietary Multi Chip Modules (MCM) and are powered by a downhole turbine. A downhole mud pulse modulator enables real-time transmission above 6 bits per second of data acquired by Ultra HPHT sensors. These sensors provide directional and inclination surveys and gamma ray for well placement, formation evaluation, and geological correlation, as well as annular and internal pressure while drilling (APWD/IPWD) and shock and vibration measurements for risk mitigation and drilling optimization.

The components are qualified by following proprietary mission profiles that validate reliable operation. Such profiles subject electronics and sensors to the following:

- ✚ 2000 hours at 200 °C, -40 °C/205 °C cycles, 10 hours on plateau
- ✚ More than 1000 shocks (500 g) at 200 °C and aging in oven farm
- ✚ Electrical connectors qualification
- ✚ Highly accelerated life tests (HALT), 60 °C/min (up and down), -40 °C/200 °C cycles, cycling and with vibration 2 days per MCM

The final assembly undergoes pressure and temperature well tests at 200 °C + 221 MPa, roll tests, and a functional flow loop test to verify functioning under flow conditions.

Maturity of the product was evaluated by using the four-axis methodology commonly used in reliability assessment:

- ✚ Performance: validation of the system level functions up 200 °C in the laboratory

- ✚ Durability: over 35,000 hours above 200 °C and 2,000,000 shocks at high temperature accumulated on the electronics
- ✚ Robustness: verified by HALT testing and by pushing duration of qualifications up to 2,000 hours at 210 °C
- ✚ Variability: assessed on multiple batches of MCMs on four complete tools.

The HPHT MWD had been deployed to operational location with Standard Work Instruction from both shop and field aspect to uniform the operation, some of key controls have ensured outstanding service is delivered:

- ✚ Standard maintenance work shop with humidity control and nitrogen (N2) filling facilities
- ✚ Standardized maintenance standard and well trained maintenance technician
- ✚ Standard work instruction for field engineers to program and configure tool at rig site
- ✚ Periodical internal workshop to field engineer and operation support center for eliminating human errors, as well as field feedback meeting with sustaining team for continuously develop and improve tool reliability

### Impact on Thailand E&P Industry

The HPHT MWD tool was deployed in Thailand in 42 high-temperature wells in 2015 with nearly 3,000 hours below rotary table. The maximum real time circulating temperature during operation was 197 °C on one of the recent wells. From service quality performance point of view, only one trip out of 42 runs were caused by tool. In overall HPHT MWD average operation efficiency 2015 to date is 99.2%. It proved the new technology works and operationally fit for Ultra HT factory drilling.

The HPHT MWD tool not only innovated the new way of drilling deeper and hotter but also improves safety and efficiency of operations in Ultra HPHT wells from below aspects:

- ✚ An average of 17.2 hours' trip had been saved on each well compare to conventional way to drill an Ultra HT well

- ✚ HPHT MWD allows operators to drill without stopping to circulate or slowing down drilling speed for cooling down which was about 1 hour per well.
- ✚ Reduced the risk of tool overheating and reliability related tool failures while operating at limit of specification.
- ✚ Eliminate cost from conventional HPHT well survey by using High Temperature Electronic Multishot survey. at TD

### Why this project should win the award?

PTTEP innovate drilling operation through selection and implementation of the Ultra HPHT MWD technology has proved to bring real economic value to E&P industry for the Kingdom of Thailand. Conservative estimation of rig time cost saving benefit from this project is **over 7 million \$US in year 2015**. Detail of value estimation and other benefit as follow;

Cost saving from elimination of one drill pipe tripping time for changing of BHA, 42 wells has been drilling in 2015 with average 17.2 hours saving per trip and cost of drilling rig operations at 10,000 \$US per hour

Saving over 7.2 Million \$US

Cost saving from elimination of requirements to cooling down for conventional MWD, 42 wells with average 1 hour required per well for cooling down circulation at 10,000 \$US per hour

Saving 420,000 \$US

Long term benefit from this project will help PTTEP to be able to continue provide reliable energy supply more efficiently to the Kingdom of Thailand

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