Weatherford sensors track vibration to increase ROP, temperature change for early kick detection

By Jerry Greenberg, contributing editor

WEATHERFORD'S NEWEST tool in its Hostile Environment Logging (HEL) MWD system is its True Vibration Monitor (TVM) sensor, which is focused on providing pertinent downhole information to monitor bit and BHA vibration, primarily lateral and axial vibration, as well as rpm.

Drilling is all about moving energy from the rig floor to the bit. If the driller is getting the maximum amount of energy, the drilling process is optimized and obtaining the most footage possible. Any time vibration occurs in the drill string as a result of torque or drag, for example, the bit is being robbed of energy and rate of penetration (ROP) suffers. With TVM, the company is better able to identify what is happening downhole and to suggest changes in operating parameters that will maximize weight on bit (WOB), rpm, etc., to optimize the energy transfer to the bit.

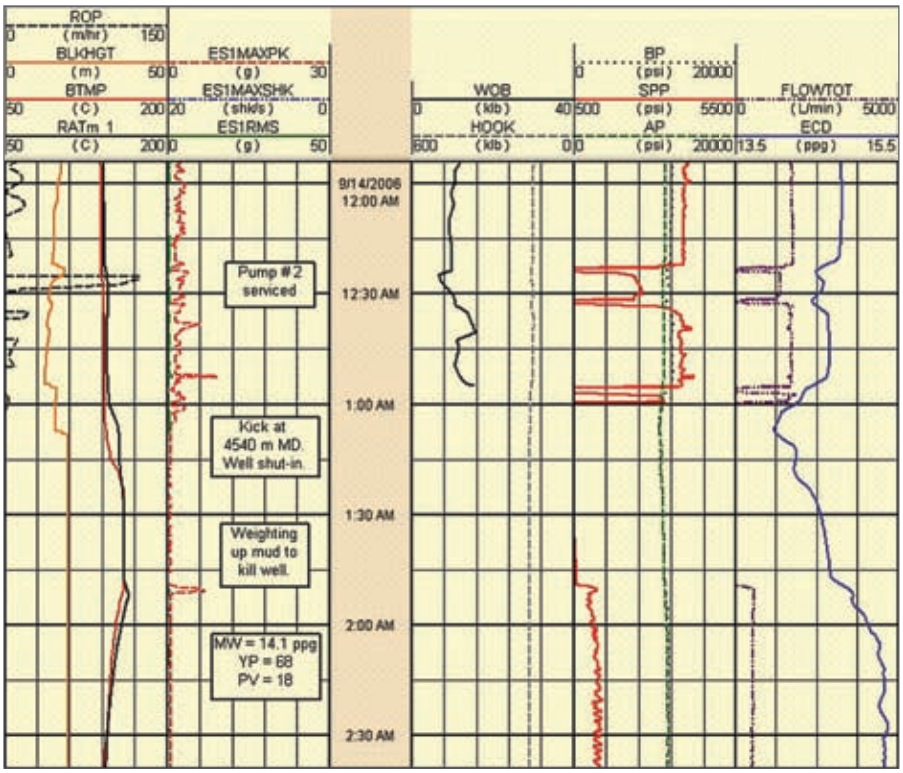
The TVM can provide real-time data that alert the driller when excessive shock or vibration is occurring and allows rig personnel to vary drilling parameters to reduce vibration without sacrificing ROP, although in certain cases it may be recommended that ROP be reduced in order to eliminate vibration.

The company also recently introduced its Rapid Annular Temperature (RAT) sensor that provides quick temperature change indications that could result in early kick detection.

CRITICAL VIBRATION DATA

The TVM sensor is a downhole drilling mechanics tool that provides critical data in real-time and recorded formats. The tool is equipped with six orthogonally arranged accelerometers and two magnetometers arranged on two axes to provide high-resolution vibration and shock data in both high- and low-vibration environments. The magnetometers provide downhole rpm of the drill collar.

The TVM can be mounted on the same insert as the company's gamma ray inserts that are run in the HEL tools, the resistivity tool or in a standalone format for recorded data only. Since the TVM's electronics are mounted on the same insert as the gamma ray inserts, the tool is not any longer than the HEL MWD system, at about 25 ft.



The Rapid Annular Temperature sensor is a small plug that is inserted into the tool column's communications port on the exterior of the collar where tools are plugged to read and program the tools.

The tool uses a comprehensive system of wellsite-programmable real-time triggers to signal when vibration data should be transmitted to the surface to alert rig personnel of potentially damaging conditions. The accelerometers are amounted orthogonally on a block, and the block is mounted directly to the insert, allowing for accurate measurement of the acceleration forces acting on the insert. Downhole processing is performed to ensure that the most accurate data is transmitted in real time from the available accelerometer data.

The magnetometers provide the actual rpm of the drill collar while drilling, providing critical information about stick-slip vibration. The tool also records all pertinent accelerometer and magnetometer data for later analysis.

"With the downhole rpm combined with the accelerometer and magnetometer data, we can tell what type of vibrations are occurring downhole, whether it is whirl or stick-slip," said **Barry Schneider**, global optimization specialist, drilling services, for Weatherford. "We will know what parameters to change to alleviate the vibration.

"At that point it would be up to the driller to do what he needs to alleviate the vibration."

The tool is available in 4 ¾-in,. 6 ¾-in., 8-in., 8 ¼-in. and 9 ½-in, all with a maximum operating temperature of 180°C (356°F). Tool sizes between 4 ¾-in. and 8-in. have maximum operating pressures of 30,000 psi while the remaining tools sizes have operating pressures of up to 25,000 psi.

Achieving the high-temperature and high-pressure capability is partly due to the type of electronics used to make the board as well as the board's design. But it is also more than the board's architecture that makes it so robust, especially when it comes to the high-pressure capability, which is due mainly to the tool's seal design and the different type of O-rings.

He notes that the tool's other electronics are also rated to the same temperature and pressure specifications.

TOOL CONFIGURATION

The tool can be configured to record samples for time ranges of 1-30 seconds for the accelerometer data and 5-60 seconds for the rpm. Regardless of the record rate configured, the tool's electronics will measure the sensors about 1,000 times/sec. Real-time thresholds for shock, vibration and rpm can be configured during tool programming to control when the tool will transmit the data to the surface via mud pulse telemetry to help optimize real-time data bandwidth.

The company's field engineer has two options when programming the tool for real-time data transmission: triggered and loop. With triggered data transmission, a threshold is set for each variable. As long as the measurement from the tool exceeds one of the thresholds of the trigger, the data will continue to be transmitted to surface.

In the loop mode, the tool will continuously transmit vibration data to the surface at predetermined intervals, regardless of vibration severity. A typical download for the tool would contain a combination of trigger and loop mode data to ensure that optimal real-time data is available for the current rig activity and vibration levels encountered.

IDENTIFYING BIT BOUNCE

The TVM had been under development for about a year before it was commercialized in October 2007 and has, since mid-February 2008, been utilized in about half a dozen wells, mainly offshore. Its first commercial well was in the Gulf of Mexico. The company had 12 TVM inserts available in the US last February in varying sizes, with another eight internationally. The company is adding to that inventory daily, according to Mr Schneider.

The company is still building its database regarding the TVM but it already has provided several examples of bit bounce. "I have seen instances where the TVM has been able to identify issues of high bit bounce caused by repeated issues with swivel packing going out, and top drive issues," Mr Schneider said. "These are all things we can see and alert the rig crew about before they begin damaging rig components."

A lot of redundancy was built into the tool's sensors due to the amount of data the tool collects and transmits to the surface. "We have a lot of repetitive sensors in the tool," Mr Schneider explained, "and we didn't do that lightly. We did that because we wanted to make sure that were are going to provide accurate data at all vibration levels.

"Even if one set of our equipment fails, there are backups in place downhole that will automatically pick it up."

Some operators prefer to utilize the TVM tool only for certain wellbore sections that are known to cause problems. For example, one operator with a large drilling program in the Middle East uses the TVM primarily in the 12 ¼-in. hole section, which is the section that was causing the most vibration issues. However, Mr Schneider would prefer to use the tool for the entire well, and for good reason.

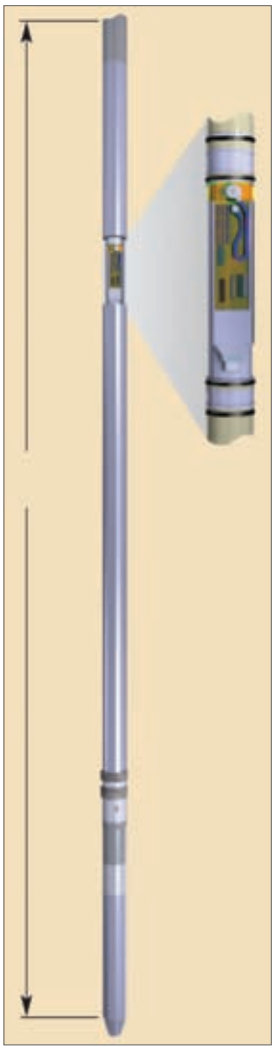
"You never know when certain issues appear," he explained. "Vibration is not something that is only formation related, it could be in your drilling parameters. You could drill 10 wells in a field with no problems but then you make one minor change to the BHA and you can begin having all sorts of problems."

MEASURING TEMPERATURE CHANGE QUICKER

One problem with LWD systems, according to Mr Schneider, is that all of the electronics are mounted in the collars. The temperature sensors are thermally decoupled and inside the tool string. To measure temperature changes in the mud columns, the mud has to warm the drill collars, the inserts and then the temperature sensor itself. This could take 5-10 minutes, and when an uncontrolled influx is moving up the well, that can be the difference between alleviating a well control situation and beginning to evacuate the rig.

The Rapid Annular Temperature (RAT) sensor is a small plug that is inserted into the tool column's communications port on the exterior of the collar where tools are plugged to read and program the tools. Usually a simple solid beryllium copper plug is screwed into the tool to protect the communications port. Rapid temperature measurements can be compared with relatively static internal tool temperatures to forewarn of wellbore kicks.

"RAT is inserted and seats on the same pins in the communication port that is used to read and program the tool. It is thermally decoupled from the rest of the collar and has a temperature sensor inside," Mr Schneider said. "We can see small changes in the annulus temperature extremely fast.



The TVM sensor's three-axis vibration data allow for identification of axial and lateral vibration.

"In several cases in India and in the Gulf of Mexico it has allowed us to recognize a kick or a fluid influx by that temperature change before the electronics would register the change."

Usually the best temperature measurement is in the pressure tools because they bring a small amount of mud to the transducers in order to provide an accurate temperature measurement to correctly calculate the pressure. "The transducers are extremely accurate but you have a certain amount of column mud and a certain amount of steel that has to warm up to see that temperature," Mr Schneider explained. "From our studies, (RAT) will respond about 5-10 minutes faster."

In both India and the Gulf of Mexico, the company measured as much as a 5-10 degree temperature change in a matter of a couple of minutes with RAT, alerting the crew to a well control event. RAT can provide temperature measurements in borehole pressures up to 30,000 psi and temperatures to 180°C (356°F), the same specifications as the TVM. The sensor can operate in all mud types.