Proving Reliability: A Matter of Philosophy

Combining reliability engineering principles with minimized downhole complexity accelerated technology adoption.

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Early history of intelligent well technology was somewhat checkered. The systems were generally complex and costly. Most used downhole electronics. Data was monitored and, in some cases, processed downhole and results were transmitted to the surface. Good data frequently was obtained but product reliability and longevity were not acceptable. This was especially true in high temperature operating environments where electronic systems historically had their highest failure rates.

The oil field is ripe with examples of early technology introductions where reliability was poor such as measurement-while-drilling, electronic gauges and steerable mud motors. Historically, new technology was tested in live wells time and again until the bugs could be worked out. This proved time consuming and costly, especially after failures and lost rig time. It was not unusual to take up to 10 years to progress to an acceptable level of reliability for new downhole technologies. Worse, this outdated philosophy slowed technology adoption and the realization of associated benefits that new technology brings. In essence, the problem became how to demonstrate downhole reliability without a proven downhole track record.

Permanent in-well monitoring systems must be reliable throughout the life of a well. Since the value of these systems is directly linked to their longevity, new and creative considerations were needed. Success would require downhole equipment to be simple and reliable. To this end, Weatherford, applying reliability-engineering principles from other industries, began addressing the reliability of these systems and increasing industry confidence that new systems would out perform their design life.

Design for reliability

It is generally accepted that 80% of product reliability is achieved in the design stage. This is partially accomplished using techniques such as failure mode effects and criticality analysis and fault tree analysis. These are proven techniques applied by qualified reliability engineers who help steer the entire design process. Also, in the case of designing in-well monitoring systems, it became clear that product reliability required the deployment of inherently reliable technologies. The application of all optical sensors realized the intuitive benefits of no moving parts downhole, no electronics and low component counts. The core approach was the use of simple technology in the harsh downhole environment and the placement of any complicated technology on the surface where it could be easily replaced and upgraded. Although this philosophy provided inherently reliable product design, it did not provide the design assurance necessary to fully convince an industry sceptical of applying the technology.

Test for assurance

The modern design engineer uses various tests to provide design assurance. In design validation or performance qualification testing, all components, subassemblies and complete systems are extensively tested under simulated field conditions to ensure design performance criteria are met or exceeded. Highly accelerated life testing techniques are then applied to identify the weak points in the product. Individual tests, such as temperature, pressure, shock, vibration and corrosion are run. Then, combined tests (i.e.: pressure and temperature cycling while vibrating) are conducted. All are intended to find the breaking point. All parameters are carefully recorded and, factored into any redesign of the product. The objective: a product whose final production specifications are well within its design destruct envelope. Often, the larger the margin between specification limits and destruct limits the better the reliability, durability and longevity of the product or system.

Manufacture for performance

To close the performance reliability loop, highly accelerated stress screening is conducted throughout the manufacturing process. At each step in manufacturing, the system and each of its components is screened. For example, a pressure/temperature (P/T) gauge that has a 10G rating is vibrated at 15G combined with 300°F (150°C) and applied 5,000psi pressure during the manufacturing process in order to screen-out failures. This process removes infant mortality failure risk.

The results of this philosophy in relation to new generation in-well monitoring systems are proving impressive. In Weatherford's case, each of their firsts performed straight-out-of-the-box on the first field installation. Expensive and time consuming, operator-funded, live-well reliability tests were eliminated. ●