Project aims to qualify tubular connections

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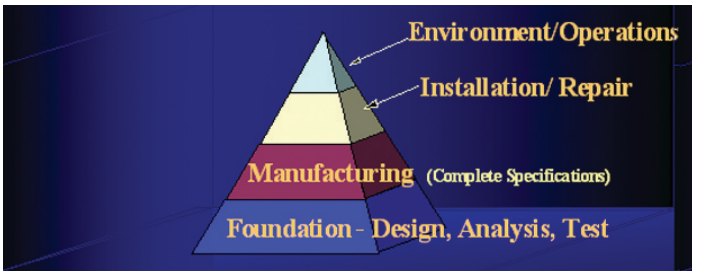
ENGINEERING OF CASING and tubing programs that are reliable and cost-effective is a fundamental responsibility of the drilling and completion community. With advances in steel and pipe manufacturing, reliability of tubing and casing is largely driven not by pipe-body performance but by the integrity and reliability of the connections. It is estimated that connection failures account for between 85% and 95% of all oilfield tubular failures.

When a production string is viewed as a high-order system in series, it's clear why connection failures can be so dominant. Specifically, a connection failure rate of 1 in 100,000 is required to achieve a casing string reliability of 99 percent. Add to this the variety of connection designs and their special handling requirements, as well as the extreme loads and temperatures involved, and it becomes evident that achieving connection reliability is not a simple task. As a result of the prevalence and consequences of failures, much attention has been centered on performance testing and test procedures for qualifying threaded connections. The joint industry initiative QUALCONN is a connection test database organized especially for rapid search, decision-making and application.

This recently completed JIP was launched as DEA Project 151.

Over the past 15 years or more, critical and high-value wells have driven the industry to invest significantly in modern qualification testing, resulting in more than $50 million in existing testing and an annual investment of $7 million. Implicit in this annual spending is the fact that connections are being tested constantly. There are many connections that have not been evaluated in a product line, yet many product lines have not seen modern reliability testing. Evaluation of the state of connection performance ratings and their verification in the industry show there is still substantial room for improvement.

Aspects of reliability & robust design



Robust technology considers design, manufacturing quality, installation and repair, as well as operations.

In many cases, performance is published only in the form of a tension and internal pressure ratings. The pressure rating is almost always indicated to be 100 percent of API pipe body performance. These simple performance ratings do not adequately define the connection's ability to perform downhole, where loads will include not just uniaxial tension or internal pressure but a wide variety of combined loads involving tension, internal pressure, external pressure, compression, bending and torque. Combined load ratings need to consider the effects of 2 or more of these loads acting simultaneously. These ratings also need to consider the effects of load sequencing. In view of the cost of tubular connections and the impact of their reliability (and limits thereof), there is substantial room and need for improved quantification of their full performance characteristics.

OPERATORS' CHALLENGE

Operating companies are faced with complicated, often highly stressed, components in series when dealing with tubulars. Tubing and casing connections are a complex combination of seals, threads and torque stops assembled in a compact form.

The compactness in diameter is required to reach depth objectives and then produce economically. Because of their complexity, connections development involves the Finite Element Analysis in the design phase and worst-case testing in the verification phase. Stress levels at makeup can often approach or exceed the material yield strength, and often the difference in pipe and connection stress state is great. Remarkably, typical well design methodologies do not address threaded connection performance in any detailed fashion. Testing has grown in sophistication and generally considers material, dimensional and load variability.

Each length of pipe includes a field end and mill end assembly for a threaded and coupled string. Assuming 40-ft lengths of pipe, a 10,000-ft string will include 250 lengths of pipe and 500 assemblies. Reliability of a system of components in series can be approximated as part reliability to the power of the number of components in series. For the 10,000-ft string just presented, with a connection reliability of 99%, the string reliability is 0.66%. Yes, a string reliability less than 1%, or a probability of failure of 99.34%. Connection reliability must be very high to achieve reasonable string reliability. To achieve a string reliability of 99%, the reliability of an assembly must be 99.999%, or 1 failure in 100,000, for a 20,000-ft string. In order for operators to achieve reliability, robust design and test methods are applied.

ROBUST DESIGN

Robust design provides a method for designing products that are minimally impacted by external factors, such as environment, use or manufacturing variability.

Robust design is a process for optimization. A technique to help with this is the Signal-to-Noise (S/N) Ratio. Signal-to-Noise (S/N) Ratio is the mathematical formula used to calculate the design robustness. The larger the S/N ratio, the more robust the performance. The Sig-

nal-to-Noise ratio gives a sense of how close the design is to the optimum performance of a product or process. For connectors, "signal" relates to performance, and "noise" relates to dimensional, material and assembly variability.

"Variability in product function is the enemy of quality." Dr Taguchi relates this deviation from ideal to a concept called Noise. Robust testing methods such as ISO 13679 verify that the connector meets or exceeds performance requirements regardless of "noise". The objective of connection robust design is not to simply improve reliability but to make the probability of failure statistically insignificant.

QUALCONN

QUALCONN is an integrated reliability test database for casing and tubing connections that addresses design engineering, purchasing, quality, operations, installation and management needs. QUALCONN brings the resources of major threaders and the global user community to your fingertips. This equates to over $50 million in modern qualification testing over the past 15 years and roughly $7 million annually in robust connection testing. By applying QUALCONN, a strategy can be implemented that includes the use of competitively bid, proven robust connectors to meet demanding schedule and lifecycle cost objectives.

The foundation of the QUALCONN is the newly developed industry test standard ISO 13679 (Petroleum and Natural Gas Industries – Testing procedure for casing and tubing connections – Recommended Practice).

This test specification applies the principals of worst-case reliability analysis in testing, which considers the impact on desired performance of expected (i.e. reasonable) variations in part parameters. Worst-case analysis evaluates product performance with all parts at their worst value and is the most robust technique. It is the easiest approach and ensures specified performance at performance parameter extremes (i.e. dimensional and mechanical properties). This approach considers product specifications, inspection methods, quality procedures, process control and makeup parameter variability.

Typical well design methodologies do not address threaded connection performance in detail. Rather, a safety factor is

applied to pipe body ratings. In contrast, modern test standards specifically address connection performance and robustness. Performance limits are validated and specifications developed to ensure performance over the complete connection performance envelope. The majority of $50 million of modern connection qualification testing have been performed under the direction of operators, which will provide the performance basis for the QUALCONN for well design and subsequent field operations.

The procurement portion of the program issues the proper connection specifications to ensure that operators run the robust connection. This includes drawing numbers and assembly specifications to ensure that the procured string conforms to test requirements.

Using QUALCONN connections can be properly run to ensure reliability and performance in the field. Well designers will have access to verified connection performance envelopes overlaid against the traditional pipe von Mises ellipse. QUALCONN is compatible with **Landmark Graphics** (StressCheck™ / WELLCAT™) and **Schlumberger** (TDAS™) well design software.

The JIP's goal is to minimize costly failures, increase performance, improve delivery and minimize supplier and user lifecycle cost by qualifying engineered tubular connections using industry standard methodology. Qualification of connections enables manufacturers to supply reliable, field-ready tubing and casing strings.

For more on DEA JIPs and activities, go to www.dea.main.com.

2006 DEA Workshop

The 2006 DEA Workshop will be held on 20-21 June at the Moody Gardens Hotel in Galveston, Texas. The theme is "We have problems: Who has solutions?"

The workshop will seek to identify practical solutions to new challenges in drilling that have arisen as the pressure to drill the un-drillable increases.

Session topics will include: drilling solutions, modeling and simulations, HPHT, downhole tools and operations, monobore applications - casing and coiled tube drilling, rotary steerable systems and drilling equipment.

Keynote speakers will be J. Ford Brett of PetroSkills-OGCI and Dr Stephen Holditch of Texas A&M University. Mr Brett will review what history says about the kinds of problems the industry will likely face in the near future and what actions it could take. Dr Holditch will review hydraulic-fracture technology and discuss how it has affected the exploration and development of tight gas plays.

To register and for a complete program, visit IADC's Web site at www.iadc.org/conferences/EW6_Program.html.