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Using Ultrasonic Techniques to Accurately Examine Seal Surface Contact Stress in Premium Connections

Kirk Hamilton, SPE, Brian Wagg, SPE, and Tim Roth, C-FER Technologies Inc.

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Abstract

One of the most important functions of a tubular connection is sealability. This is especially the case for premium connections which are commonly used in the demanding conditions of HPHT and Thermal Well applications. Sealability therefore also is one of the most important criteria used during connection qualification in which the capability of the connection is verified for the characteristics of the application. During qualification tests it has been found that breakdown in connection sealability can be traced to damage on the primary seal surface, which can eventually develop into a leak-path.

Ultrasonic inspection technology can be used to provide a means to obtain non-intrusive measurements of contact stress between two mating metal surfaces separated by a thin lubricating film. While the technology has a wide scope of potential applications in this respect, the technology has been specifically developed to measure seal surface contact stresses inside oilfield tubular premium connections.

This application of ultrasonic technology has been used numerous times during connection qualification programs to assess the quality of the contact stress band in premium connections. During these analyses the technology has been able to detect scratches, galling, pock-marks, and other types of seal surface damage in a wide array of premium connection designs. Most of these flaws cannot be detected on the torque-turn curves generated during connection makeup. Moreover, mechanical separation of mating premium connection seal surfaces under tensile and compressive loads has been observed using this technology.

This paper will cover the basic concepts of premium connection design, as well as some of the issues that can affect the sealability of premium connections. As well, this paper will include an overview of the use of ultrasonic technology as a technique to assess the contact stress along the metal-to-metal seal band of a premium connection, and methods used to monitor changes in the contact stress profile induced by many installation and service loads.

Introduction

Well design and construction methods continue to evolve at a rapid pace. Resources thought unrecoverable only a few years ago are now being targeted by operators; however, the extreme environments where many of these resources are located pose unprecedented operational and technical challenges. In addition, more stringent policies protecting worker safety and the environment compound the importance of ensuring that all well components are capable of performing safely and reliably in these very hostile environments.

As a result, wellbore integrity management systems have become important components in current well design for many operators. These systems incorporate a combination of operational, organizational, and technical solutions to minimize the risk of uncontrolled releases of formation fluids throughout the life cycle of a well[1]. One of the wellbore envelope elements in downhole tubular strings where leaks may form during the service life of a well is at the interface of either threaded and coupled or integral connections.

Critical well designs incorporate premium connections, which generally offer better sealability compared to standard API connections. However, the sealing systems in premium connections can be damaged either during make-up or as a result of exposure to the service environment. Current connection make-up acceptance criteria are based primarily on make-up torques[2,3,4] (shoulder and final), which may not be directly associated with connection seal integrity and overall sealability. There are methods to perform pressure testing on connections during installation[5]; however pressure testing can be very time-consuming and may not replicate the loading conditions the connections will experience over their service life. Furthermore short-term pressure testing may not detect features on the premium connection seal surface that could develop into leak paths over time.