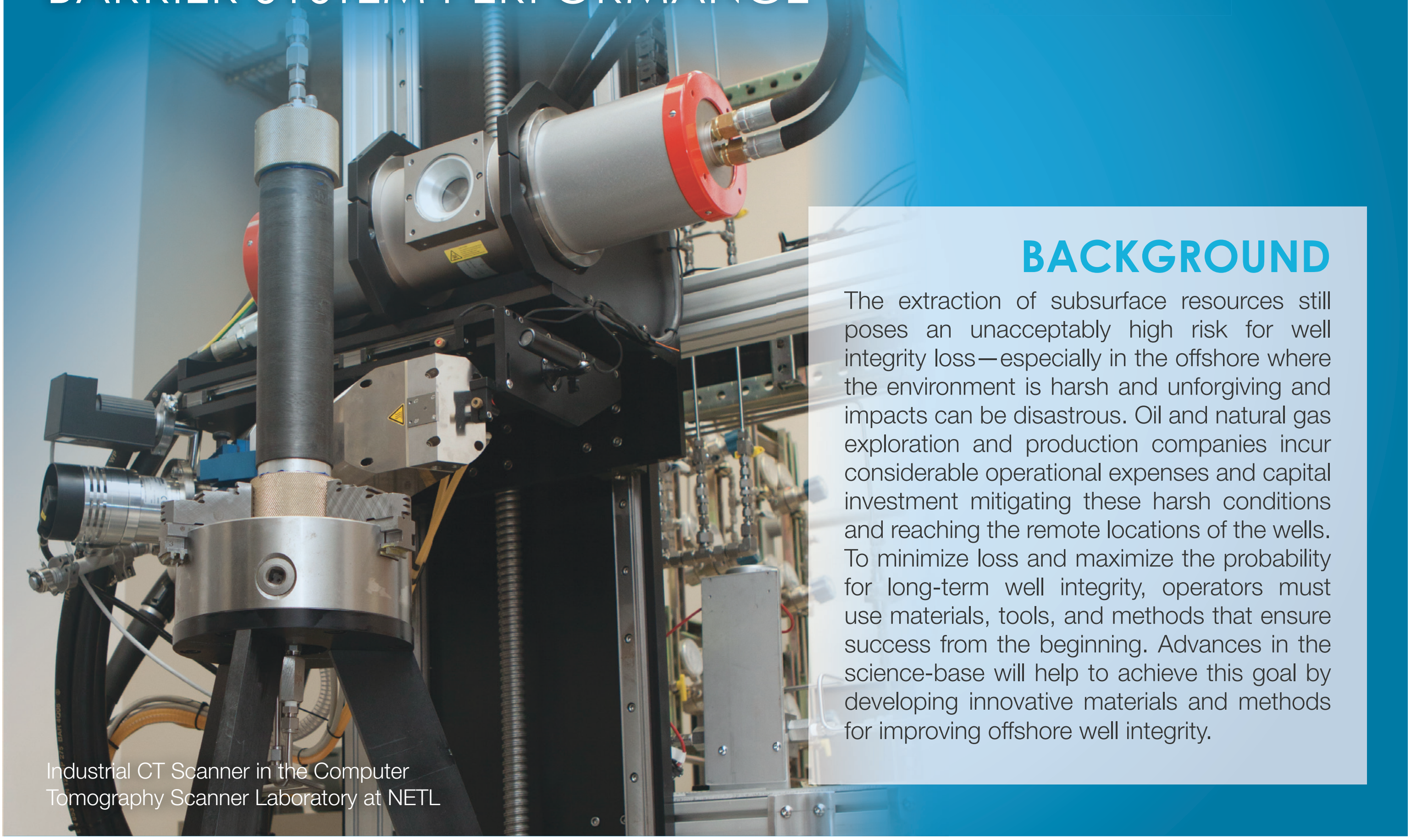
IMPROVING OFFSHORE WELL INTEGRITY

ADVANCED TOOLS AND METHODS TO EVALUATE BARRIER SYSTEM PERFORMANCE



Industrial CT Scanner in the Computer Tomography Scanner Laboratory at NETL

BACKGROUND

The extraction of subsurface resources still poses an unacceptably high risk for well integrity loss—especially in the offshore where the environment is harsh and unforgiving and impacts can be disastrous. Oil and natural gas exploration and production companies incur considerable operational expenses and capital investment mitigating these harsh conditions and reaching the remote locations of the wells. To minimize loss and maximize the probability for long-term well integrity, operators must use materials, tools, and methods that ensure success from the beginning. Advances in the science-base will help to achieve this goal by developing innovative materials and methods for improving offshore well integrity.

NETL

NATIONAL ENERGY TECHNOLOGY LABORATORY

OVERVIEW

The objective of this U.S. Department of Energy (DOE), the Office of Fossil Energy (FE), and the National Energy Technology Laboratory (NETL) project is to improve well integrity by conducting research focused on the critical barrier system stability in a well. The barrier system consists of the casing-cement-rock interfaces and is designed to provide mechanical support, act as a hydrologic barrier, and prevent corrosion of the well system. Improving this system requires studying the performance of materials along critical interfaces (e.g., the corrosion-resistance of a casing-cement interface) in addition to full-system performance.

CAPABILITIES

This project leverages existing competencies across the NETL sites and expands capabilities to tackle the issue of well integrity using a combination of laboratory experiments and computer-based simulations. The project brings together NETL's corrosion science and engineering experts, geoscientists, and petroleum engineers with external collaborators to address aspects of this problem.

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A diverse set of NETL's laboratory capabilities are contributing to this project. Corrosion experiments within the High Pressure Immersion and Reactive Transport Laboratory (HiPIRT lab) and at an external collaborator's lab at The Pennsylvania State University will study how cement protects the casing when subject to corrosive subsurface environments under environmental static and flow-assisted conditions. The borehole simulator apparatus, housed in HiPIRT lab, will be used to study how drilling fluid materials and methods can be improved to ensure a well-conditioned borehole, which is critical for establishing a quality bond between casing and rock.

Capabilities at NETL's Computer Tomography Scanner Laboratory are being expanded to address the issue of geomechanical failure of well systems. A novel testing apparatus is under construction that will simulate a host of subsurface conditions that impart stresses onto a well system. Understanding these stresses is important because they sometimes have disastrous results. These experiments will be used to verify a numerical model for well system stress analysis that is being developed. This model will be freely shared and developed into a tool that operators, service companies, and regulators can use to study the stress distribution around well systems.

BENEFITS

This work advances the DOE/FE/NETL mission of ensuring the safe, efficient, and economic use of our fossil energy resources. Because of the project, the public will benefit from advances in the science-base for understanding well system barrier performance, open-source tools that stakeholders can use to simulate key processes that affect offshore well integrity, and innovative materials that can be used to reduce the risk of well integrity loss in the barrier system.

Figure 1. Borehole Simulator Apparatus.

ACCOMPLISHMENTS

To date, corrosion experiments have shown that electrochemical testing can simulate corrosion over the long term. Further, they have confirmed that when a casing is properly protected by cement, the high pH pore fluids prevent most forms of acid attack on casing. However, if carbon dioxide/hydrogen sulfide (CO_2/H_2S) pore solutions reach the casing surface, corrosion degradation starts.

The borehole simulator apparatus has been designed and constructed and baseline testing is expected to start in the Summer 2017 (Figure 1). This apparatus will allow NETL to study the buildup and removal of mud filter cake on a borehole wall to develop more robust models for filtrate performance.

Proof-of-concept experiments for the scaled well system have been completed. The apparatus successfully imaged mechanical failure of cement and casing after a fluid pressure was applied to the inside of a "casing." This will allow us to gain a better understanding of mechanical failure of wells when subject to cyclic loading.

Simple analytic numerical models have been developed to estimate the stress and strain distribution in a well system under different wellbore orientations and different tectonic stress fields. The results compare well with more advanced finite element models being developed, which are needed to more accurately simulate changes to the system due to temperature and pressure cycling and materials performance issues like corrosion.

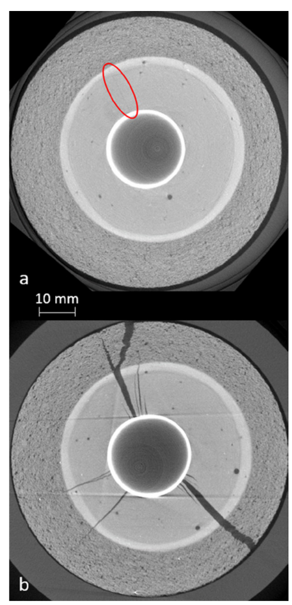

Figure 2. Two X-ray computed tomography (CT) images of a scaled well system subject to internal pressurization. (a) At 3,000 psi the cement has begun to fail (red oval). (b) At 4,500 psi, internal confining pressure the cement and rock have failed catastrophically.

For additional information, we invite you to visit https://edx.netl.doe.gov/offshore

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