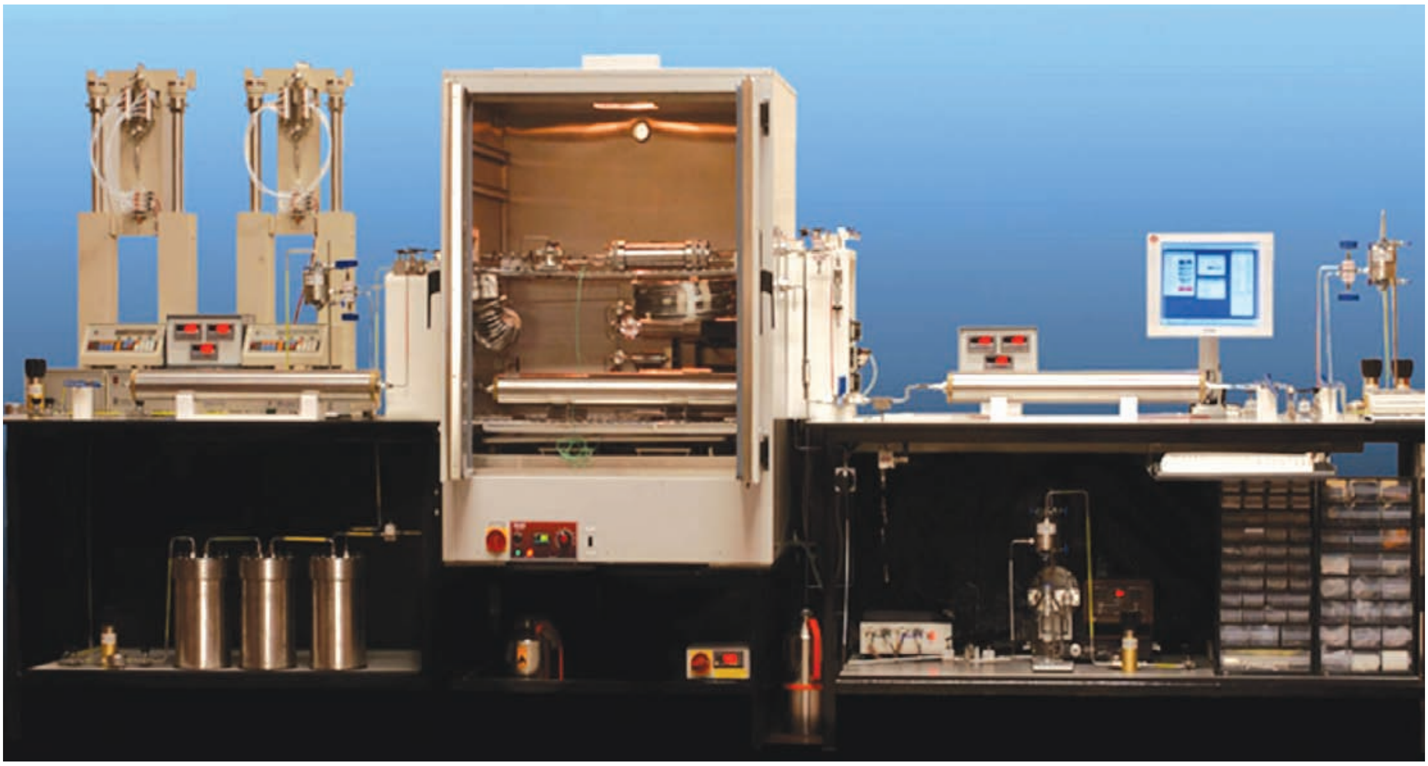
Cost effective risk reduction



In the current economic climate, and with rising costs associated with drilling, completing, and treating wells, laboratory testing is a cost-effective and low-risk route to gathering vital information to assist in operational decision-making.

Understanding areas which may create risk during the life of a well through laboratory analysis (and proper interpretation) can have short, medium and long-term benefits. This article will summarise some of the main arguments for laboratory testing, and discuss some of the areas where the results can be especially valuable.

Mechanisms which have an unfavourable economic impact can occur at any point, including drilling, completion, production, injection, treatment, stimulation, and workover. These mechanisms (formation damage) manifest themselves in numerous ways, but fundamentally involve interactions between the reservoir (rock and fluids) and introduced fluids and hardware. Drilling mud infiltration, poor mud-cake clean-up, fluid retention, fines mobilisation and pore blockage, fluid incompatibility and precipitation, emulsions / sludges, removal of cement, clay swelling, and sanding are all examples of mechanisms which can have an impact on productivity or injectivity.

Laboratory testing can be performed to identify these damaging mechanisms, and with the correct interpretation useful recommendations can be made on ways of avoiding or removing them. The testing therefore becomes part of the quality management 'Plan, Do, Study, Act' cycle: laboratory testing checks for problems or mechanisms, defines the options available for avoidance, tests the solutions for effectiveness, and provides feedback to aid in implementation.

In terms of risk, the greater level of understanding can not only reduce risk, but add value to the planning process, as it is significantly cheaper to experiment in the laboratory than the field. A key aspect of laboratory testing is that it is direct measurement, whereas models are indirect or derived measurements; test data can therefore be used as inputs which consequently supplement or improve models. In addition, independent testing is key in the 'calibration' of vendor recommendations on fluids and hardware, allowing comparison across vendors, fields, and operators.

Testing to examine wellbore operations typically consists of preparing core samples to representative wellbore conditions, and simulating the operational sequences under consideration. Care must be taken throughout the process, to avoid any impact of the equipment or procedures on the outcome of testing. Equipment must not corrode, even when flowing strong acid under HPHT conditions; the techniques used to prepare the samples (cutting, cleaning, drying, saturation, permeability measurement) must not create artefacts; and the conditions and sequence tested must be representative in terms of the fluids and hardware being considered, exposure times, temperatures, pressures, overbalances and underbalances.

Expert consultants assist with the test design (e.g. mud cake development, horizontal versus vertical core holder orientation, wellbore operational sequence to be evaluated) so that the required objectives are met and also to ensure that test results are not misleading. The output data from testing typically includes permeability measurements, filtrate loss volumes, production/injection plots, and sample photographs, which are all used in aiding conclusions.

After having performed a well-designed and executed test it is, however, just as (if not more) important to understand the results fully. Relying upon permeability alone creates a high risk, as in short core samples it is common for both pore restricting (e.g. drilling mud infiltration, scale precipitation, fluid retention) and pore-enlarging (e.g. clay fines removal, cement removal, saturation change) mechanisms to be seen. The combination of these can lead to increases, decreases, or no overall change in permeability, even though there are a number of mechanisms which could potentially cause problems in the field.

For example, in short core samples it is relatively easy to mobilise and remove high surface area clays, which will increase permeability, where in the field increased transit distance and concentration as the particles move towards a smaller volume in the near-wellbore area can lead to significant reduction in pore space. To reduce risk and increase understanding of results, interpretative geological analysis including scanning electron microscopy (SEM), x-ray diffraction (XRD), thin section, and innovative techniques such as cryogenic SEM are all used to examine samples before and after testing to understand the impact of the sequence tested. These short core flood tests are informative and generate the inputs required to enable up-scaling for lateral simulation.

Laboratory testing is performed by operators worldwide to help them in decision-making during exploration, development, treatment / workover, production, injection, and at any other point in the lifetime of a well where there is an opportunity to avoid or remediate damaging mechanisms. Operators should consider testing as a vital part of the "best practice" in selecting fluids and hardware, and as such the many types of tests being performed reflects upon the wide range of operations being performed worldwide, with each test being customised to the operator's specific needs. Some areas where there have been recent innovations in laboratory testing at Corex include:

Heavy oil

With the current (and future) emphasis on non-conventional reserves, traditional testing techniques can struggle to adequately represent heavy oil reservoirs. Specialist sample preparation techniques have allowed the core samples to be prepared in a manner that does not impact on their integrity, for example avoiding removal of oil cement which can create unconsolidated and unrepresentative samples. Improvements and innovations in geological techniques have also allowed for visualisation of pore-lining and pore-filling fluids without impacting on the integrity of the samples.

HPHT

High pressure, high temperature (HPHT) reservoirs, particularly tight gas, have also historically proved challenging to perform representative testing upon. Useful testing is especially vital in these fields, as any damaging mechanism can have a significant impact on permeability, and therefore the economic viability of a field. Identifying and avoiding damage before it occurs is essential in HPHT testing, and the testing needs to be performed at meaningful temperatures and pressures; the main innovation here is the design of equipment at Corex that allows wellbore operational testing to be carried out at temperatures of over 200ºC including (if required) humidification of gas at reservoir temperature.

SRA of injection operations and production drawdown operations

Scale Risk Assessment (SRA) which can range from prediction to squeeze design, Corex independently-evaluate scale formation and inhibitor selection. Utilising state of the art laboratory equipment and methodologies in combination with expert post test geological sample evaluation, scale inhibitor chemicals are evaluated for formation damage mechanisms. Inhibition life time is measured in the laboratory and optimised for field squeeze application

High-rate gas

On the other end of the spectrum to tight gas is high-rate gas, which has also posed problems in the past in terms of accurate control and measurement of rate over a large range of pressures. Corex have recently designed equipment that refines this to a level never before seen in reservoir conditions testing.

Assessment for Halite rich reservoirs and well operations

Specialist Cryogenic SEM analysis techniques and preparation as well as integration with modelling criteria will assist in the assessment of well operations for Halite rich injection or production intervals. Full wellbore fluid sequences are simulated under reservoir conditions (pressure and temperature) to closely mimic those of the reservoir in question, thus accurate representation. Damage mechanisms (such as precipitation or dissolution) can be identified which will specifically address the changes in equilibrium experienced with Halite-rich intervals.

These examples of 'challenging' scenarios help demonstrate that, if the tests and equipment are properly designed and implemented, and results are fully interpreted, independent laboratory testing can significantly reduce risk in operational decisions. Analytical testing can therefore be used as a tool to reduce risk and add value to the decision-making process by supplying information (direct measurement) which can be used to increase understanding or continually improve models (indirect measurement) which already exist.

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