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Three-Phase Flow Profile Determination of A Horizontal Well in Offshore by Tracer Technology

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Abstract

Over the past few years, the oil and gas industry has faced a situation of high fluctuations in hydrocarbon prices on the world market. In addition, the trend for the depletion of traditional hydrocarbon reservoirs and the search for new effective solutions for the management and control of field development using horizontal and multilateral wells is still relevant.

The most common method for horizontal wells testing is production logging tools (PLT) on coiled tubing (CT) or downhole tractor, which is associated with HSE risks and high cost, especially on offshore platforms, which limits the widespread use of this technology. The solution without such risks is the method of marker well monitoring, which allows obtaining information about the profile and composition of the inflow in a dynamic mode in horizontal wells without well intervention.

There are several types of tracer (marker) carriers and today we will consider an approach to placing marker monitoring systems as part of a completion for three-phase oil, water and gas monitoring.

Introduction

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Technical solution for placing markers in the downhole completion for three-phase monitoring

The process of placing markers in horizontal wells involves placing fluid flow indicators on the completion assembly and then running the assemblies into the well. Horizontal wells can be marked using sleeves containing tracers and placing them close to the inflow control devices (Figure 1).

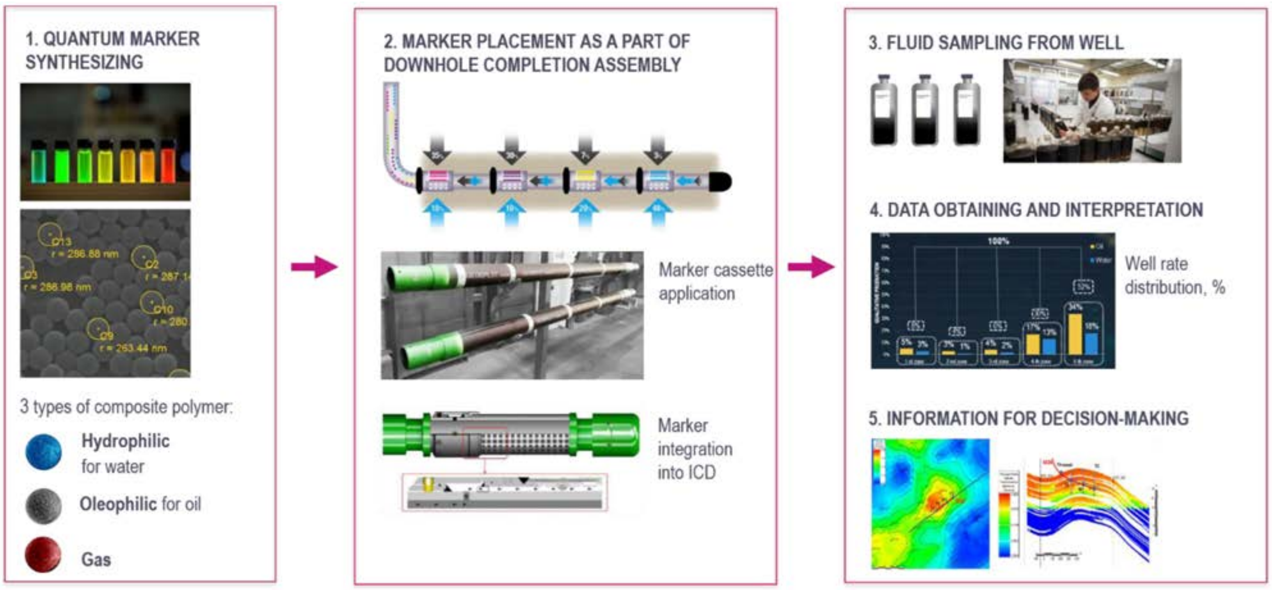

Figure 1—Marker based monitoring technology

After the well is put into operation, fluid samples are taken at the wellhead and analyzed in the laboratory to quantitatively distribute the markers of each code. Then the data is converted into the distribution of gas, water and oil production rates for each interval with visual display.

Quality check for Marker sleeve

A mandatory procedure is to check the strength of the sleeves by acceptance tests for resistance to external mechanical influences, including external torque, simulating pipe jamming during rotation during seating and a longitudinal displacement test with simulated pipe sticking. The sleeve's size can be different depending on the well requirements.

The test process of a dummy cartridge is shown in Figures 2 and 3 mounted on a branch pipe with an outer diameter of 140 mm. The sleeve was attached to the pipe body with standard locking screws with a torque of 33 ft lb (45 Nm). The test was carried out on a stand with a hydraulic wrench and automatic clamping.

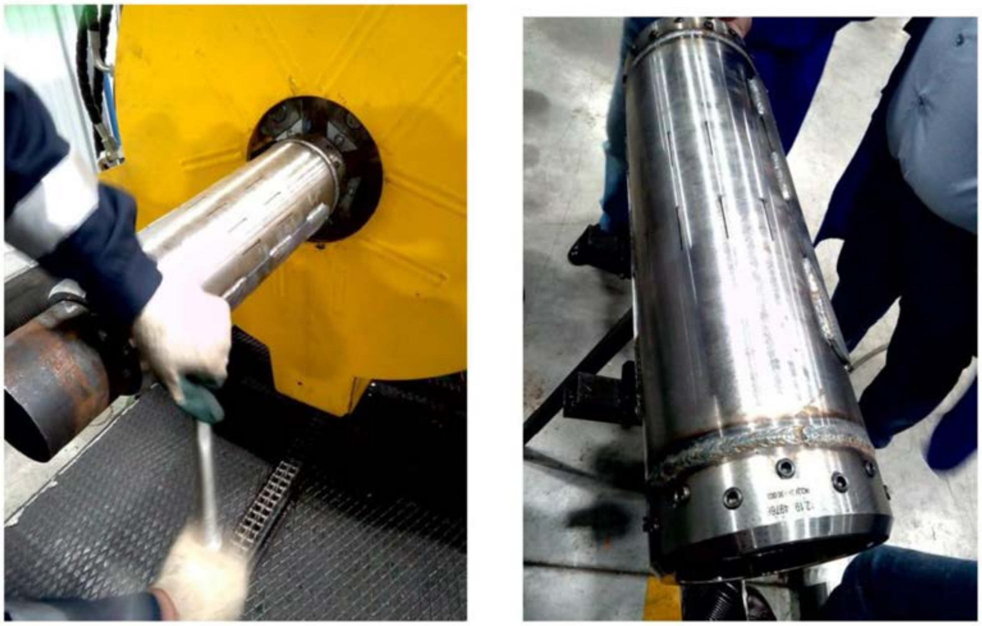

Figure 2—A torque test preparation for marker sleeve

Figure 3—Equipment for marker sleeve testing

The dummy marker sleeve was mounted on a hydraulic wrench attached to the body on one side and to the branch pipe on the other. The sleeve and branch pipe had opposite marks for visual control of sliding. An external forced torque was then applied to the sleeve and recorded continuously during testing (Figure 4).

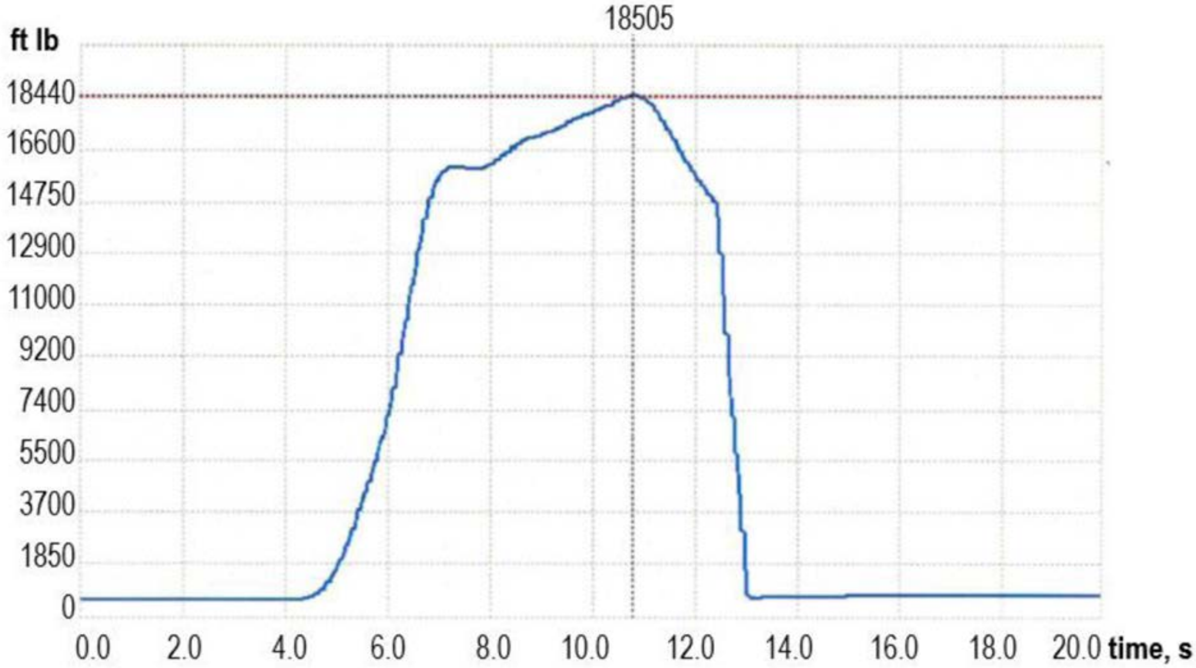

Figure 4—Chart for external torque

As a result of the test, no displacement of marks and traces of sliding was found. Then a visual and defectoscopic inspection was carried out. The sleeve design has been proven to remain intact and non-slip at a maximum torque of 18505 ft lb (25.09 kNm) to meet customer target requirements.

The principle of marking the well

The wide coding ability of quantum markers-reporters (used as indicators of oil, water and gas inflow) makes it possible to significantly improve the information content of the data obtained by marking each sleeve or inflow control devices (ICDs) with a unique code. Thus, it becomes possible to obtain an inflow profile both for a different section of horizontal well and for each sleeve (code) or ICD within one interval.

Monitoring technology for ICD and Packer

To monitor the operation of each ICD, it is necessary to install a set of tracer sleeves with marker indicators of unique signatures, which make it possible to obtain an inflow profile with a clear identification of the source of water breakthrough (Figure 5).

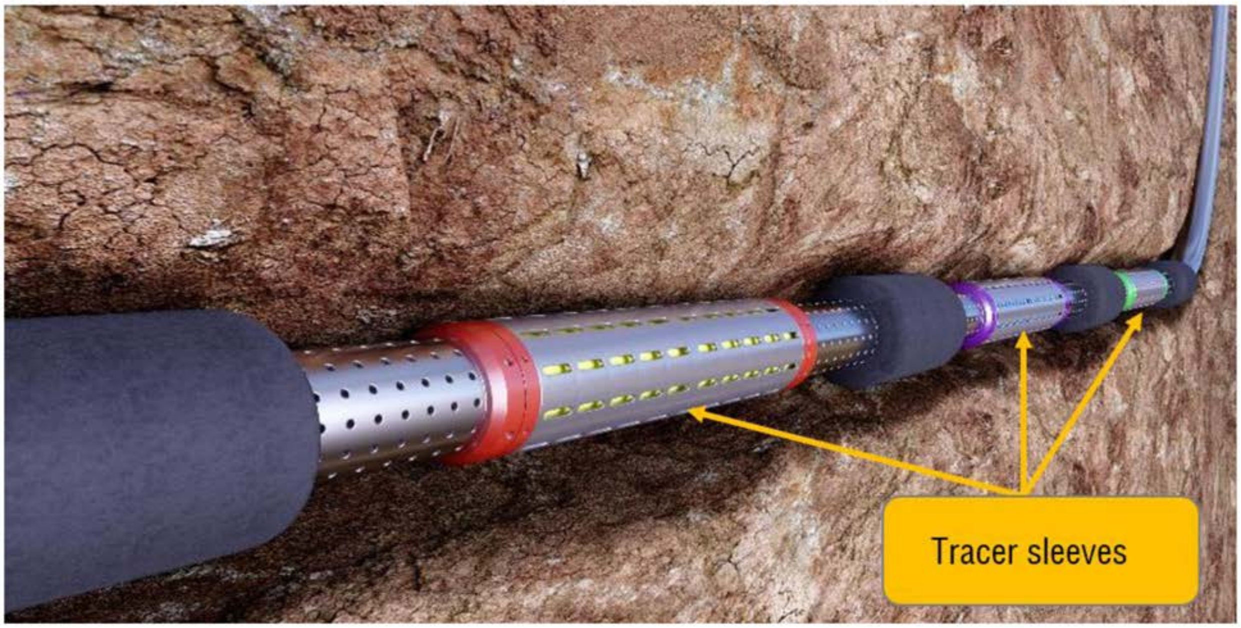

Figure 5—Tracer sleeves for inflow profile determination

In addition, the system can be equipped with marker sleeves, which are installed in between packers to ensure its integrity (Figure 6). If the packer leaks, appropriate markers will be found in the borehole fluid samples. Then some actions will be required to isolate this zone.

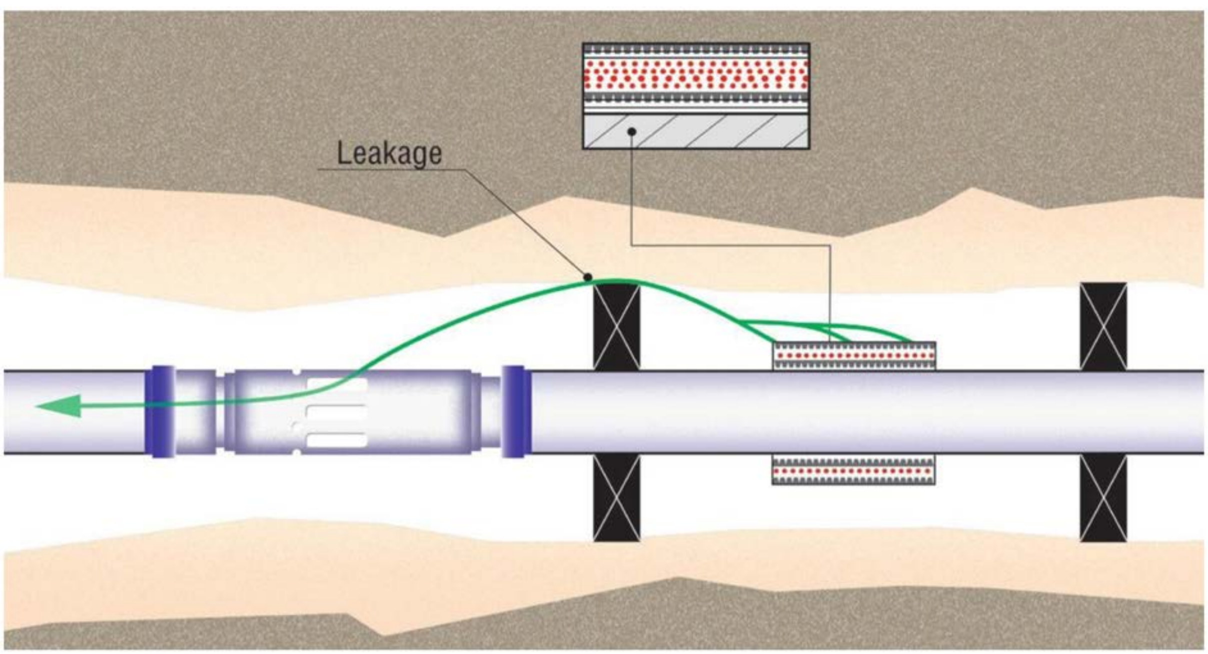

Figure 6—Identification of packer leakage in horizontal well without well intervention

An example of 9 interval diagnostics of a horizontal well with ICD is shown in Figure 7 and packer leakage monitoring in Figure 8. All sleeves include various types of matrix:

– Hydrophilic matrix - to monitor water inflow profile;
– Gas matrix - to monitor the gas inflow profile;
– Oleophilic matrix - to monitor the hydrocarbon fluid inflow profile.

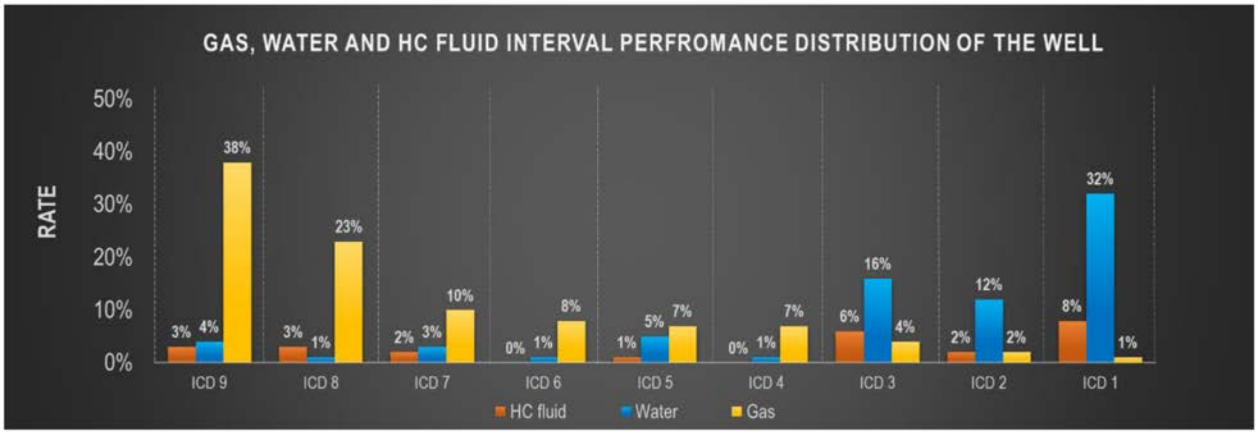

Figure 7—The diagnostics of a horizontal well with ICD

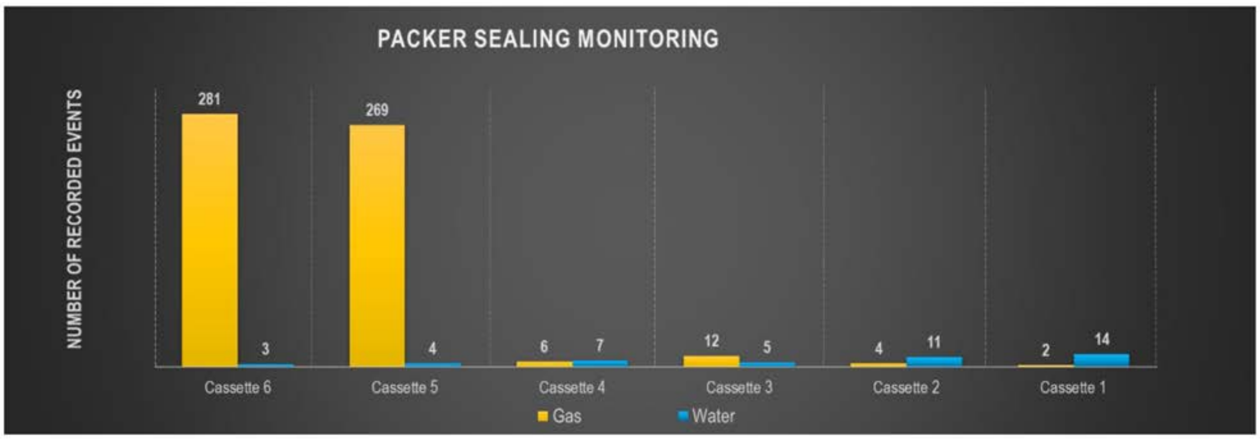

Figure 8—Packer leakage monitoring

Marker diagnostics allow updating information on the inflow and migration of various types of fluid with a frequency of up to 1 time per month. Based on the results of marker diagnostics, the inflow of water through ICD # 1, 2, 3 (Figure 7) and gas migration through packers # 5 and 6 (Figure 8) were detected. The results demonstrate a higher information content compared to traditional approaches and allow more efficient control of the ICD.

Three-phase monitoring sampling without changing existing piping

For minimal interference in the technological chain during gas sampling, a special mobile device was developed. This solution is based on the experience of using marker diagnostics in offshore projects and is built into the existing wellhead equipment.

Formation fluid samples are usually taken through a sampling valve, and a gas sample with markers in a three-phase gas-liquid mixture flow requires a new approach.

The technological scheme of the developed gas sampler used in one of the fields was tested in various conditions and shown in Figure 9. External view is at Figure 10 shows a photo and model of the gas sampler.

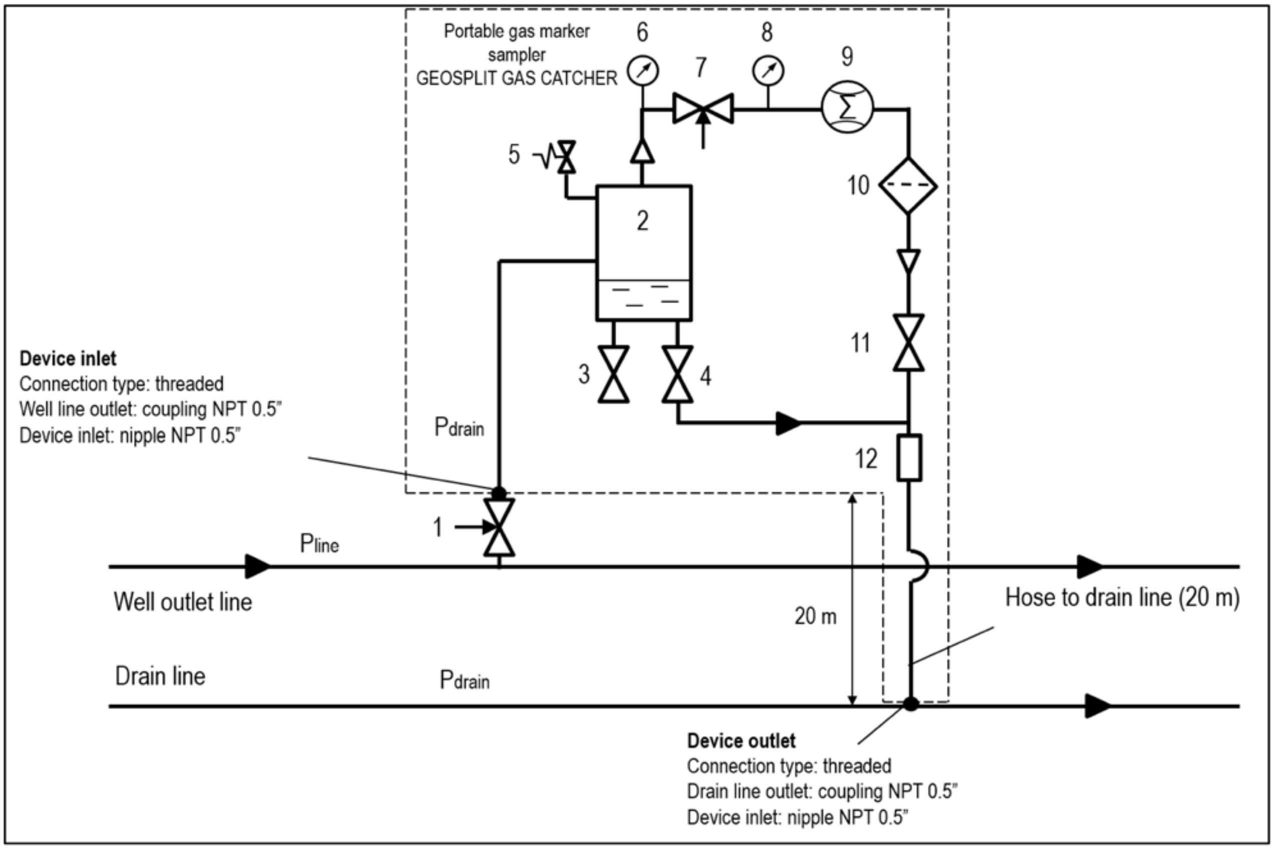

Figure 9—The technological scheme of the developed gas sampler: 1 - control valve; 2 - separator; 3, 11 - process valves; 4 - drain cock; 5 - pressure relief valve; 6, 8 - pressure gauges; 7 - gas valve; 9 - gas flow meter-counter; 10 - filtering device; 12 - check valve.

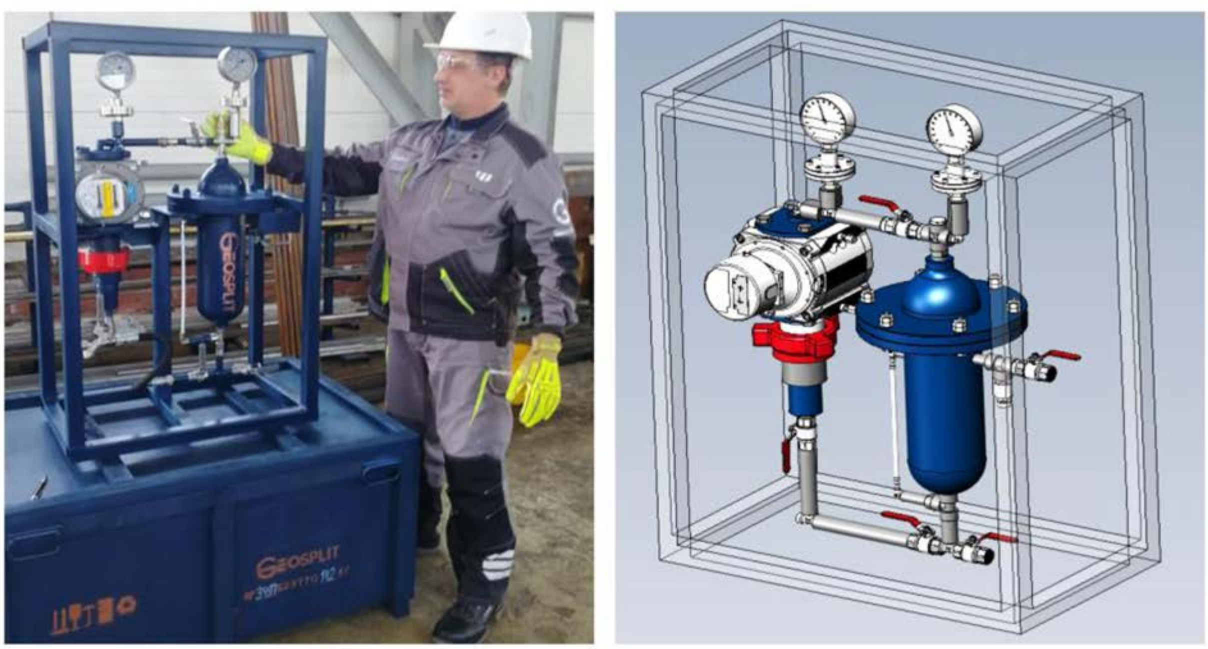

Figure 10—Gas marker sampler

The gas sampler must be connected to the wellhead gas line of the well. The input of the device is connected to a sampler, which is installed on the output line of the well under survey. The output of the device is connected to the drain (flare) line with a flexible sleeve. A control needle valve (1) is located at the inlet of the device. It is used to adjust the flow of formation fluid and control the pressure in the separator by pressure gauge (6). The control needle valve (1) is cracked opened during survey and the gas-fluid formation mixture is fed to the device inlet from the outlet line of the well. The separation of the gas and fluid phases is carried out in the separator (2), after which the gas phase enters the filtration device (10), where a membrane that traps gas markers is installed. Also, the gas flow rate is recorded in the gas line using a flow meter-counter (9), after which the gas flow is sent to the drainage line. When the separator is periodically filled with the fluid, it also drains into the drain line through the drain valve (4). The device is equipped with a check valve (12) to prevent overflows from the drain line, as well as a pressure relief valve (5) in case of emergency overpressure in the system.

At the end of the sampling, the inlet valve is closed, the fluid accumulated in the separator is discharged into the drainage line, the filter element is removed and transported to the laboratory for gas marker identification and analyses.

The mobile gas sampler allows to perform gas sampling quickly and without the involvement of additional equipment and is certified for connection to the gas line.

Conclusion

The method of three-phase monitoring of oil, water and gas wells considered in this paper allows for a more frequent analysis of the inflow profile and updating the current state of the well operation. In comparison with a traditional method this technology eliminates the risk of equipment getting stuck. The solution involves the installation of sleeves next to each ICD with a set of marker indicators of unique signatures, which makes it possible to obtain an inflow profile in a quantitative form with a unique identification of the source of water or gas breakthrough and thereby significantly improve the information content of diagnostics.

The method also includes the technology of identifying water inflow through specific ICDs of a horizontal well and gas migration through a leaking packer.

To simplify gas sampling, a new sampling technology has been developed and tested in an offshore project. It completely excludes interference with existing connections, their re-arrangement and the use of welding. There is no loss of production time on the platform. Thus, it was possible to achieve maximum safety of work, which is significantly important for offshore projects.

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