Application of RAPID technology for well drilling

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Abstract. The article is devoted to multilateral drilling, it provides a brief history, relevance of application, development prospects, advantages. The history of the emergence and development of the unified international classification of multilateral wells the TAML is also described in detail. The article summarizes the characteristics of the six difficulty levels of the TAML Classification System. The use of advanced RAPID brand joints is described and analyzed in detail. Various designs of joints of the Rapid brand are considered. The authors also propose the construction of a multilateral well using a connector of the Rapid X type.

1. Introduction
Russia's share in world oil production from 2000 to 2015 increased from 8.9 to 12.4 %. Today, Russia, along with Saudi Arabia and the United States, determines the dynamics of prices in the oil market. Russia is the main supplier of petroleum products and oil to the European market, while there is an increase in oil supplies to the countries of the Asia-Pacific region. In 2016, Russia set a new production record, there were 547 million tons of oil and gas condensate produced exceeding the level of production in 2015 by 1.3 %. The highest level of oil production is observed at Rosneft [1, 2].

At the same time, the use of technology for drilling multilateral wells is promising. The technology of drilling multilateral wells is not new, but also it cannot be considered sufficiently mature and developed in the oil industry. Nowadays there are a lot of wells built using this technology in the world. The technology of multi-hole drilling is used almost everywhere, and its further development has many perspectives [3].

Despite the fact that the technology for constructing multilateral wells was first patented in the USA in 1929, this method of drilling wells continues to evolve to date. For the first time, the successful application of multilateral drilling technology was carried out in Bashkoria in 1953.

The advantages of this drilling method are the following: increased coefficient of coverage of the reservoir, reduced overall costs for drilling and completion, increasing productivity, providing a more effective oil flow, ensuring increased oil recovery. The volume of oil production in the world is significantly increasing due to the construction of multilateral wells. Since sometimes there is a lack of technical ability to drill new wells from the surface, or the implementation of a new project requires too high economic costs [4].

A multilateral well drilled in a good location can be much more efficient than several wells constructed using traditional technologies. Since in this case the efficiency increases, construction costs are reduced, and the volume of oil coming from the reservoir increases. Proper application of multilateral drilling technology causes more efficient field development [5].
Drilling multilateral wells can be effective for developing fields with depleted reserves or when operating formations with low reservoir pressure.

2. Methods and materials

The beginning of the development of the terminology and classification of multilateral drilling was laid in 1997. In March 1997, Eric Diggin (Shell spokesman) was invited to convene an international forum called Technology Advancement – Multi-Laterals (TAML) held by a non-profit organization. During the forum experts from leading world oil companies (BP, Statoil, Norsk Hydro, Esso UK, Mobil, Exxon, Phillips, Texaco, Total, Maersk, Chevron, Shell International E&P, Shell Oil and Shell UK Expro) shared their experience in drilling horizontally branched wells, and also developed a unified approach and determined the further direction of technology development for drilling multilateral wells.

In 1998, the unified international classification of multilateral wells (The TAML Classification System), as part of a Joint Industry Project (JIP), was developed and published in terms of complexity and functionality.

A meeting of TAML members was organized in Calgary in November 2002, the goals of the organization, which was transformed into a non-profit based on membership, were adjusted, and created an opportunity for new members to join. The classification has been changed, taking into account the latest developments in the field of this technology.

The term Multi-Lateral Technology is widely used in English-language publications. It extends to the entire set of applicable technologies for drilling various types of multilateral wells. As for Russian papers, there are different terms used to describe different types of wells and sidetracks.

Nowadays, according to the accepted classification of Technology Advancement - Multi-Laterals (TAML), there are 6 difficulty levels for drilling multilateral wells. Difficulty levels increase in accordance with increasing level number.

The first level of difficulty is characterized by drilling the main trunk with lateral branches without casing fastening. In this case, the properties of the rocks are of great importance, since the joint strength and isolation of the layers depend on them.

At the second level of complexity, the main trunk is cased and cemented, and the lateral trunk is either equipped with a shank or has an open bottom.

The third level of complexity is characterized by a cased and cemented main trunk, while the lateral trunk is cased without cementing; fixing at the branch point is acceptable.

The main and side trunks are cased and cemented, and a shank in the fourth difficulty level is installed in the side trunk.

At the fifth level of complexity, casing and cementing of the main and side shafts are also carried out, the fastening of technological equipment is performed using a packer. The joints of the main trunk with the lateral sections are one of the most important elements for drilling multilateral wells. The fifth level involves a hermetically sealed joint, either cemented or not.

And the most difficult sixth level is distinguished by the presence of a downhole branching on the main trunk, and the equipment is fixed for the possibility of separate production. In this case, the joint is sealed [6].

Currently, a complete TAML classification (TAML Classification System) has been developed, which includes the second part and is called Functionality classification. This classification provides: descriptions of wells and intersection points of shafts (joints); Unified coding of multilateral wells.

The technology of drilling multilateral wells has evolved gradually. Wells drilled since 1953 belong to TAML grades 1 and 2. The widespread use of multilateral wells has contributed to the development and complexity of the technology. Shell in 1993 in the Canadian province of Alberta drilled the first well, which corresponded to the third level of complexity. The first multilateral well of the fourth difficulty level was drilled there in 1994. In 1995, BP drilled the first multilateral well of the fifth complexity in the Gulf of Mexico, USA.

There are multilateral wells are being drilled by foreign companies Schlumberger, Weatherford, Halliburton, Baker Hughes in Russia.
3. Results
Great importance is attached to the mechanical and hydraulic tightness of the joints of the main trunk with side bends. Reliability and durability are ensured by the use of advanced RAPID articulations. There are several different varieties of such joints (Figure 1).

Modern technologies allow us to build more complex and productive wells. Using a Rapid joint, we can drill an additional wellbore in the opposite direction from the main one and turn it into another multilateral well, and then casing it. Thus, modern connectors build two wells, having an extensive system of sidetracks, from one well. That allows you to include in the work all the layers and deposits, isolated from each other, both simultaneously and separately. It will also save a huge amount of material resources and reduce the impact on the environment. Various designs of Rapid articulations have been developed and are currently in use.

The Rapid Tie Back brand system used for drilling side branches provides factory-made cutouts in the casing, which are internally closed by a drillable pipe. This technology is characterized by a short period of time required for its installation. The system has up to four lateral shafts located at an angle of ninety degrees to the main trunk. This system can be installed above the reservoir. In this case, the rate of climb of the angle of inclination of the well and the amount of lateral deviation are reduced. Installing the Rapid Tie Back system inside the reservoir allows you to drill inclined wells at large angles using equipment with small radii. The advantages of the technology is that it provides a quick exit from the casing string, with no metal chips, lower risk of subjecting the casing string to destruction. This technology can be used when drilling deposits with heavy oil, as well as in low permeability formations.

The Rapid Access multi-trunk well drilling system provides for cutting oriented side windows in the casing when mounting joints with sidetracks. In this case, there is a nozzle with a special groove used (a casing dividing sleeve), the use of which allows you to drill a well without a preliminary orientation of the cut windows. The use of several bushings allows you to collect several lateral joints, while the reservoir is opened by several wells, which allows you to get a greater effect when developing fields. The separation sleeve is an important element which causes a long-term field development planning and reservoir management. It also allows repeated access through an articulation into a horizontal well by installing an oriented deflecting wedge. This open-hole joint technology can be used for drilling shale and stable compacted rocks.

![Figure 1](image-url)  
**Figure 1.** Typical designs of multilaterals, the sidetracks of which can be cased and not cased: 1 – shoe BK 114.3; 2 – filter FS 114.45*30*6000-Y-E-OTTM; 3 – casing OTTM 114.3*8.6”E”; 4 – swelling packer (elastomer); 5 – centralizers TZTZH-114/146-200; 6 – head of the PCH shank (distance from the main trunk 5–10 m)
Rapid Connect and Rapid Exclude articulations developed on the basis of Rapid Access represent a structural connection between the casing and side shanks. It allows selective entry into the main well and branches. Lateral branches are cased, but only the main well is cemented. Joint designs provide mechanical integrity in the conditions of loose, unstable, fragile and weakly cemented rocks.

The multi-well Rapid X connection, corresponding to the fifth level of complexity according to the TAML classification, allows for the modernization of multi-hole horizontal wells. The articulation is distinguished by the presence of a continuous fixing rail, which provides extremely high joint strength. Selective descent is carried out in both trunks on the cable, coiled tubing and drill pipes. It is possible to install several TAML 5 levels in one trunk on top of each other; selective access will still work. Using the joint allows you to maintain tightness with internal and external pressure drops up to 17000 kPa. There is also the possibility of combining the Rapid X joint with inflow control valves, downhole pressure and temperature sensors. The ability to monitor inflow control remains. The joint is fully retrieved. There is no need to orient the casing during the descent. Rapid X can be used in wells that require control of sand removal, water and gas breakthroughs, and there is a need to increase the drainage area of the reservoir. The joint is applicable in compaction wells in developed fields with a limited number of slots both new or old, oil or gas, production or injection. Also, formations with non-uniform pressure and flow regimes can be drilled with similar technology, layered and fractured, divided into blocks. The advantage of the technology is the reduction of risks during drilling, saving time and costs due to the simplicity of operations.

The success of drilling horizontal sections of multilateral wells is influenced by the shape of the well profile, the length of BHA hard part, the intensity of the set of curvature in the interval of cuts.

Figure 2 shows the design of the multilateral well proposed by the authors, the Rapid X type connector is used in the construction of the well. The well has two sidetracks. The side trunks are cased. One to nine additional trunks depart from each side trunk.

![Figure 2. Proposed Well Design](image)

4. Conclusion
Multilateral drilling as an effective technology increases the productivity of long-developed oil fields and develops new oil-fields with maximum efficiency.

The use of technology for multilateral well construction has following advantages: economic costs are reduced, the extracted volume of oil is increased, the use of several available well increases the
reservoir development area. Further, there is a more accurate assessment of oil reserves made. Drilling multilateral well develops small-volume and peripheral satellite deposits which can be used in difficult geological and technical conditions. The use of multi-hole drilling technology reduces negative impact on the environment, since there will be less wells and therefore the disposal of drilling mud and cuttings will be carried out in smaller sizes. The use of multi-hole drilling technology is also considered effective when drilling on offshore platforms with a limited number of wells [7–10].

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