



MSF ACTIVATION DART: EFFICIENCY AND PROSPECTS IN OIL PRODUCTION

The sanctions imposed against Russia have had a significant impact on all sectors of its economy. The outflow of foreign companies combined with import restrictions has created challenges for many industries, including the oil and gas sector. Previously, a large share of technological solutions in oil production were provided by foreign service companies. However, after the introduction of sanctions, many of them left the Russian market: some by choice, while others failed to adapt to the new conditions. As a result, operators faced the need to seek new solutions and leverage domestic resources to sustain and develop production rates.

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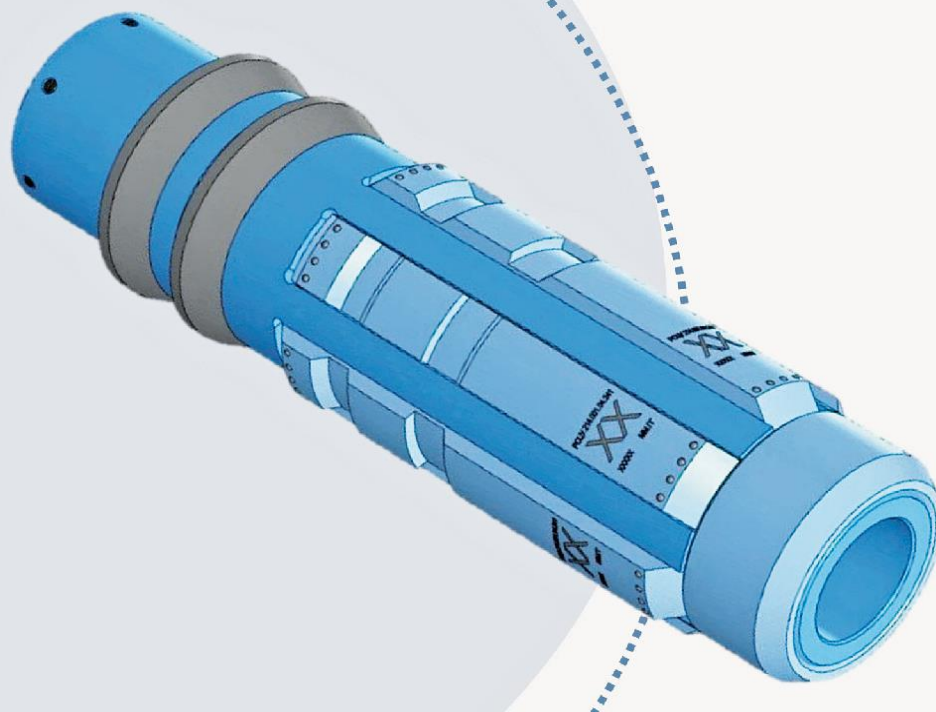




Figure 1. MSF ACTIVATION DART

In response to these challenges, a boom in import substitution was observed, enabling many manufacturers not only to survive but also to gain additional competitive advantages. TatProm-Holding Group is a prime example of an enterprise that has successfully adapted to these changes, offering innovative solutions to the market, which are essential for maintaining the resilience and development of the domestic oil and gas industry.

FROM A SMALL MANUFACTURER TO AN INDUSTRY FLAGSHIP

In October 2005, the company began manufacturing components and spare parts for oil and gas production equipment, laying the foundation for rapid growth. Since then, due to an innovative approach and continuous improvement, the company has evolved from a small manufacturer into one of the industry flagships.

TatProm-Holding Group offers a wide range of high-quality products, including liner hangers, packers, well screens, hydraulic fracturing (HF) equipment, and casing accessories. The company also focuses on manufacturing frac sleeves for multi-stage hydraulic fracturing (MSF), including equal-bore, hydraulic, ball-activated, and activation dart-driven sleeves, as well as burst-port frac sleeves set in the cemented hole and activated by a selective packer. The Group's innovative approach is most evident in the design of activation darts, which have had an essential role in enhancing hydrocarbon production efficiency and strengthened the Group's reputation as an innovator, thereby strengthening its market position. Its core business principle is to manufacture high-quality products that fully meet client needs. The company strictly adheres to industrial quality, environment, health, and safety standards, demonstrating a responsible

approach to business.

MSF ACTIVATION DART

The multistage hydraulic fracturing (MSF) activation dart (*Fig. 1*) is an innovative solution designed to reliably activate the target frac sleeve. The dart is pumped down to the frac sleeve during displacement of the previous stage or immediately prior to conducting multi-stage hydraulic fracturing operations. Each MSF activation dart has a unique activating mechanism that is actuated exclusively when contacting a corresponding frac sleeve having a suitable profile. After that, the activation dart latches onto the frac sleeve and deploys, creating an axial thrust that opens the frac sleeve for the next stage of hydraulic fracturing.

An activation dart is part of an equal-bore frac sleeve assembly, which enables achieving an optimal liner cross-section without the need to mill out catching baffles. Since the product elements are made from custom-selected soluble materials, they do not require additional millout operations in the well after hydraulic fracturing. Thus, there is no need for running equipment on coiled tubing and logging cable, which simplifies the process and reduces costs. TatProm-Holding offers MSF activation darts in two configurations: soluble darts made from a magnesium alloy and aluminum darts requiring millout.

Both options offer effective solutions, ensuring operational safety and ease of use. Soluble and millable darts offer identical functionality, differing only in the base material. These alternatives allow clients to select the optimal solution based on their specific requirements and preferences.

Technical specifications and advantages of the technology are as follows:

- pumping down to the target frac sleeve: the activation dart is efficiently delivered to the frac sleeve;
- unique activating mechanism: activation occurs only in the target frac sleeve;
- dissolvable materials: no need for subsequent millout operations in the well;
- no need for CT or wireline: lower operational costs and simpler fracturing jobs;
- custom-selected materials: optimally tailored to specific well conditions (pressure, temperature, fluid composition).

- Further advantages include:
 - equal-bore completion assembly: smoother passage of the liner during well interventions and workover operations.
 - unlimited number of stages: enables MSF operations with virtually any number of stages;
 - compatibility with various liner completions: suitable for a wide range of well designs;
 - fully dissolvable activation darts: facilitate post-frac cleanup;
 - accelerated dissolution: achieved by injecting acid, if required.
 - application in high-paraffin crude production: workover crews can be used as a cheaper solution instead of expensive CT services.

ENHANCING HF EFFICIENCY WITH EQUAL-BORE LINERS

In the modern oil production industry, key factors are cost reduction and process efficiency enhancement. In the face of these challenges, the industry saw extensive implementation of equal-bore liners, which offer solutions to a number of problems associated with conventional hydraulic fracturing methods and the production of high-paraffin crude oil.

Conventional HF methods are characterized by a limited number of fracturing stages and require additional interventions, such as catching baffle mill-outs, which leads to a longer operational time and higher costs. In contrast, equal-bore liners improve fluid distribution, reduce the risk of clogging, help save time and resources, enhance process control, and minimize environmental impact.

The advantages of equal-bore liners include the following:

- improved HF efficiency: achieved through uniform distribution of the fracturing fluid, leading to more effective reservoir fracturing;
- cost reduction: achieved due to optimized material consumption and shorter time of operations.

increased well productivity and extended life: achieved due to a more uniform pressure distribution and a reduced risk of clogging.

- innovative production methods: involve the use of equal-bore liners in thermal fracturing and other advanced enhanced oil recovery (EOR) techniques.
- The production of high-paraffin crude oil poses a particular challenge due to the risk of equipment clogging and increased oil viscosity. Equal-bore liners can help resolve these issues by reducing the need for custom-tailored chemical additives and simplifying maintenance.

Overall, equal-bore liners represent a significant advancement in oil production, providing more economical and efficient solutions to modern technological and environmental challenges.

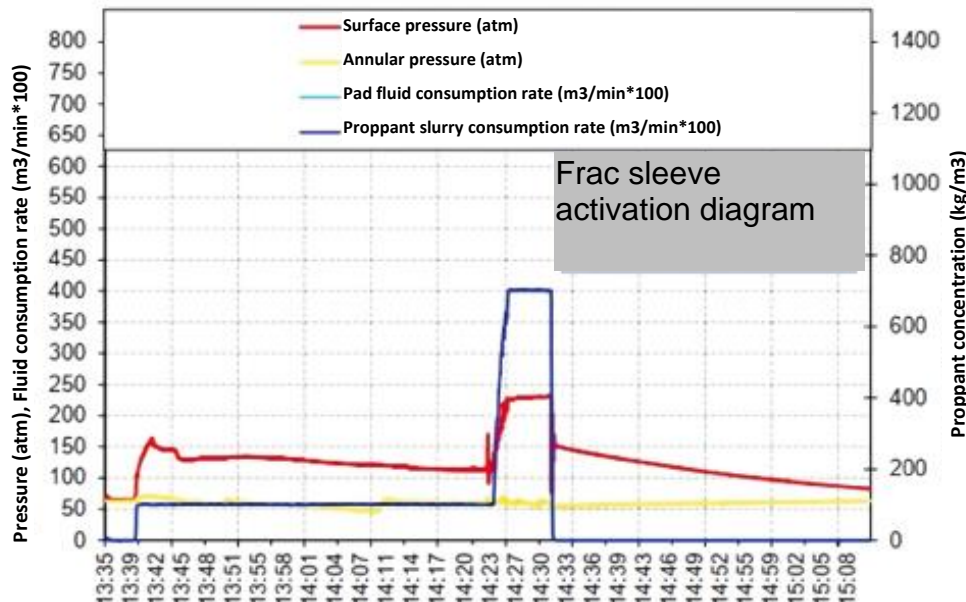
IMPORT SUBSTITUTION: A SUCCESS CASE FROM TATPROM-HOLDING

In February 2022, TatProm-Holding Group received a Terms of Reference (TOR) for the development of frac sleeves activated by dissolvable activation darts.

As noted previously, the advantage of this technology lies in the use of specially-designed dissolvable darts having a unique profile for frac sleeve activation, which ensures that the liner remains equal-bore after well interventions.

According to the terms of reference, frac sleeves had to be equal-bore, reclosable after initial activation by the activation dart, and meet all standard performance requirements for conventional ball-activated frac sleeves.

Figure 2. A frac sleeve is activated with an activation dart



Following data analysis and identification of key characteristics, two design concepts were developed. In the first concept, the latch mechanism is placed within the frac sleeve's inner pipe, while in the second one – within the activation dart body.

It took 5 months to develop design documentation and a further six months to produce pilot samples and test tools.

By April 2023, a series of tests were completed, including:

- wear tests:
- the darts were pumped through simulated tubing and casing strings for a cumulative distance of 4 km;
- tests to determine the maximum activation dart pump-down rate in the casing, subject to smooth passage through ports (without clinging) and subsequent latching in the target frac sleeve;
- hydraulic pressure testing: frac sleeves with dissolvable activation darts were pressure tested to 68.9 MPa at 120 °C;
- dart and frac ball dissolution rate tests;
- reclosability tests: multiple frac sleeve open/close cycles were performed after the dart dissolution, with the sleeve's sealing integrity in the closed position checked after each cycle.

Following successful pilot testing, the team commenced the candidate well selection process for the field trial. Finally, they selected a new well with a three-string casing design, featuring a 178 mm production casing and a 114 mm liner equipped with a nine-stage fracturing completion assembly. The two final stages were activated with dissolvable activation darts. A total of 100 tonnes of proppant was pumped per stage (Fig. 2–3).

- The completion assembly with frac sleeves activated by dissolvable darts fully proved its operational reliability under field conditions. The dart dissolution time was within 10 days (the actual time till flow initiation). The dissolution time for the dissolvable activation dart, specified by TatProm-Holding Group, was a minimum of 8 days.
- The equipment activation and hydraulic fracturing operations were carried out as per design, without any non-conformances. The hole reaming operations were also completed without trouble. When reaming the interval where the completion elements had been set, no dissolution by-products, component fragments, or rubber cuttings were detected.

It was not immediately possible to achieve the required results, as the design underwent several iterations based on preliminary testing. The team had to abandon the initial concept utilizing sliding latch mechanism inside the frac sleeve due to design complexity and inconsistent hydraulic performance.

The final design, involving dissolvable darts with "floating" latch mechanisms, successfully passed the validation procedure, and a pilot batch was manufactured. During subsequent field tests, all the product's specified performance characteristics were confirmed. TatProm-Holding Group's experience demonstrates that innovation and adaptation to the changing environment are key drivers for successful business development in the modern era.

Amidst economic and political challenges, the company has not only demonstrated a case of successful adaptation but also introduced advanced solutions to the market, which significantly enhance efficiency, streamline operations, and reduce costs in oil production, making its offering particularly valuable.

The process of developing and implementing the dissolvable activation dart showcased the company's high level of engineering expertise and its ability to rapidly upgrade products. After rigorous testing and validation of these state-of-the-art solutions, the production of a pilot product batch commenced, demonstrating the company's readiness to scale up and deploy innovations across the industry. Simultaneously with managing current challenges, the company's experts are paving the way for the sustainable development of the domestic oil and gas sector by delivering high-quality and highly efficient solutions for its clients.

Figure 3. Main HF – 100 tonnes

