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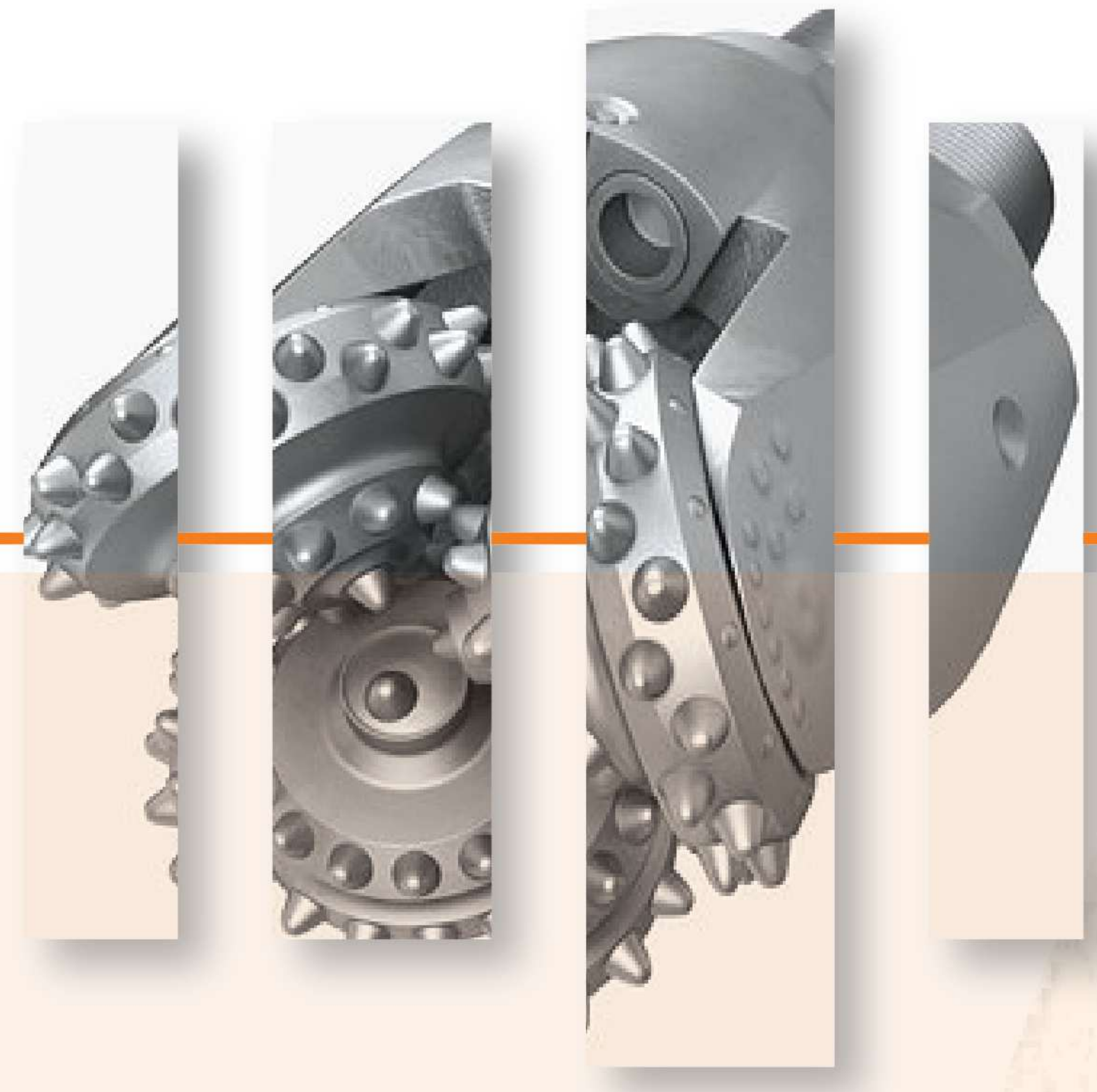
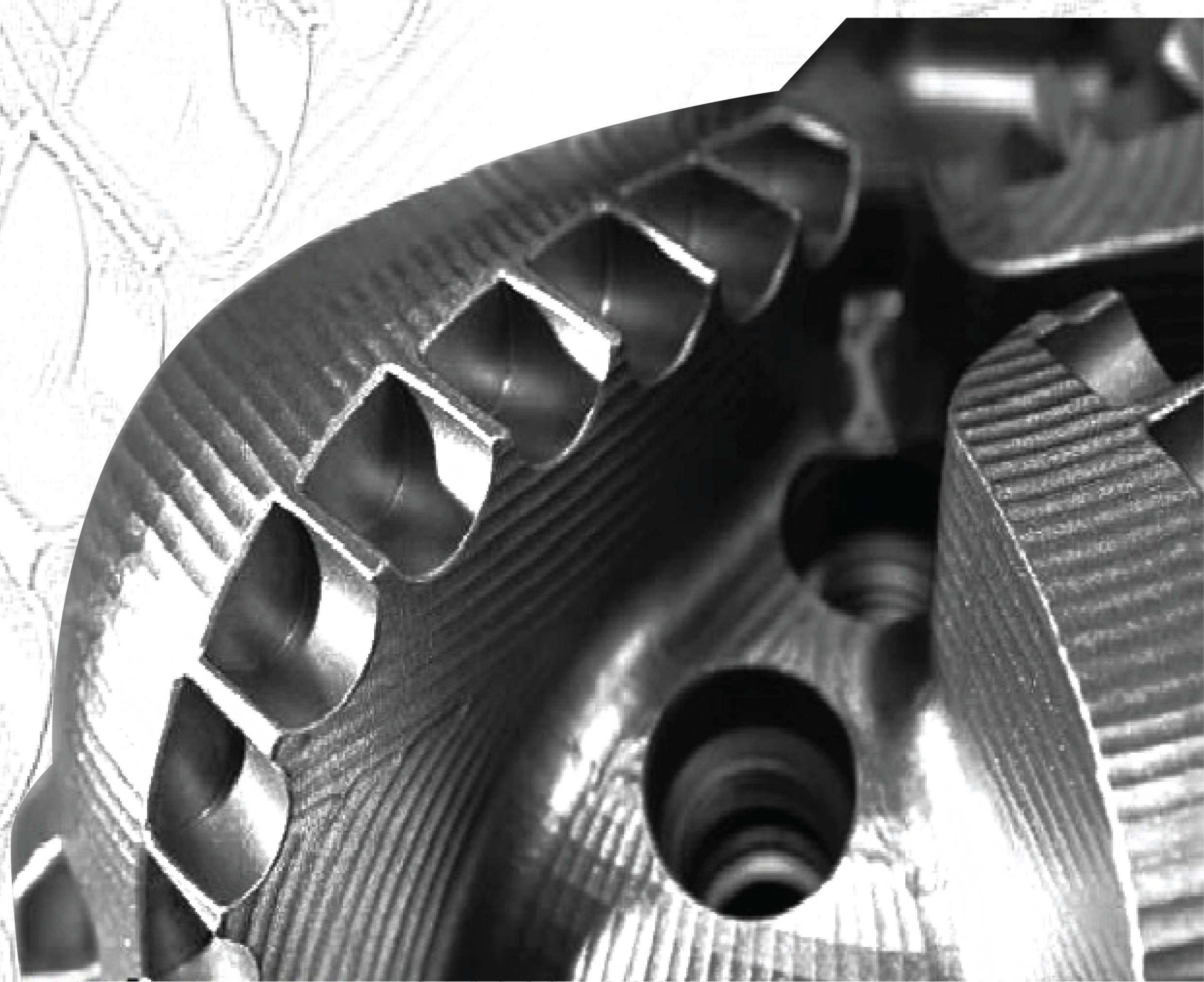


Bentonite Cements and the Capabilities of Bentonite Types from Arzesh Afarin Company

Common slurry cements used in drilling wells, with specific gravities ranging between 14 to 16 pounds per gallon, have a potential for water loss. When water loss occurs, the initial strength of the cement develops very quickly and excessively. Such cement, if placed behind the casing pipes, can cause fractures in the formations, especially in weak formations, particularly when a large amount of cement is used. The water loss characteristic in permeable formations leaves a thick layer of cement on the formations. Excessive water loss into the formations can lead to water entering formations with fluid potential, which can cause the clay in the formations to react with the water, leading to swelling and blocking some pores and reducing the permeability of the formations.

In such a situation, some bentonite is added to the slurry cement mixture to increase the consistency of the slurry cement. The recommended amount of bentonite in the cement mixture is up to %25 by weight, which is referred to as bentonite cement. According to the API definition, water loss occurs when the rate of water loss reaches 1000 cubic centimeters per minute. However, practical experience has shown that adding %25 bentonite reduces water loss to 100 cubic centimeters per minute.

The micronized bentonite products from Arzesh Afarin Company, with minimal water loss, controlling viscosity and swelling, perform best in drilling cement. Besides having suitable rheological properties, due to the natural origin of the product, it exhibits very high stability over the usage period of the well compared to activated bentonites.



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Types of Drilling Methods and the Role of Bentonite Grades from Arzesh Afarin Mining and Mineral Industries Co.

1. Manual Drilling System

In this system, drilling is carried out using human power without the use of mechanical energy.

2. Percussion Drilling System

Percussion or cable drilling was first used by the Chinese for drilling water wells. The drilling equipment consisted of a hard steel bit with a sharp edge attached to the end of a metal cable, which was lowered and raised by a crane to bore through the ground. Essentially, this method of well drilling is similar to using a crowbar to dig a hole and removing the soil with a bucket. In 1859, Colonel Drake used this method to drill the first oil well in the United States and the world in Pennsylvania. The primary advantage of using cable drilling is its low cost for shallow wells.

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The overall benefits of this method include:

• Low cost of rig transportation and relocation.

• Short setup time and consequently low cost of rig erection.

• High drilling speed in shallow wells, especially in hard formations compared to rotary drilling methods.

• Generally, rotary drilling systems are designed for wells with a diameter greater than four inches. Therefore, for wells with smaller diameters and depths, the percussion method is preferred.

• Simple construction and ease of repair and maintenance of its components.

However, there are significant drawbacks to this method, including:

• The most significant limitation is the drilling speed and well depth. For deep wells, the high time and cost make this method economically unfeasible. The deepest well drilled using this method reached 11,145 feet, which incurred a high cost.

• Inability to manage potential well blowouts due to the absence of drilling fluid.

• Lack of wellbore stability in loose formations due to the absence of drilling fluid.

• Frequent cable breaks, resulting in high time and cost.

Given these disadvantages and the inability to drill deep wells with this method, as well as the discovery of hydrocarbon reservoirs at greater depths, this method has become obsolete and was replaced by the rotary drilling method.

Percussion-Rotary Drilling System (HTD - Hole The Down)

In this method, drilling is achieved through the simultaneous application of impact and rotation to the drill bit using a drilling hammer and compressed air. In HTD, the piston or drilling hammer, which delivers the impact, is placed immediately after the bit and goes down the well with it. Since there is no intermediary between the drilling hammer and the bit, there is no energy loss through the drill pipe. This allows the machine to drill deeper and wider wells. Compressed air from the compressor, along with some foam and oil, enters the hammer, moving the piston inside, which then delivers continuous and efficient impacts to the bit. Additionally, the injected air and foam pass through the hammer and the bit neck to the bottom, pushing the cuttings upward. This method is used for wells with diameters between 4 to 9 inches. The required air pressure typically ranges between 100 to 250 psi, and the air speed for removing cuttings is about 4,000 feet per minute (1,200 meters per minute). The weight on the bit needed for this system usually depends on the bit diameter and rotation speed. Drill pipes have a longer lifespan in HTD drilling because the only energy they transmit is the weight on the bit, not the impact energy. Noise levels are also lower as the impact source is inside the well. Challenges arise in wells with cavities or shale where bit sticking may occur, causing the loss of the hammer. This method can be used in almost all geological formations except loose and collapsing grounds. The minimum well diameter that can be drilled with HTD is usually 4 inches.

Rotary Drilling System

In 1890, the first rotary drilling rig was introduced. In this method, drilling fluid continuously circulates to bring the cuttings to the surface. The first well drilled using rotary drilling reached oil in Texas in 1901 at a depth of 1,020 feet. Today, rotary drilling is the standard method for drilling oil and gas wells. In this system, the bit is connected to the drill pipe, and penetration into the rock and well drilling is achieved through bit rotation and downward force applied using heavy and thick pipes known as drill collars, placed above the bit. Power is typically provided by steam, diesel, gas, or electricity, and the crushed particles at the bottom are brought to the surface by circulating air, water, or drilling mud. The drilling cuttings are separated from the drilling fluid at the surface. In rotary drilling, bentonite is added to the drilling fluid as a viscosifier and to transport the cuttings and line the well walls. Depending on the depth, pressure, and formation type, various grades of drilling-grade bentonite from Arzesh Afarin Company are used in vertical rotary drilling.

Directional Drilling

Directional drilling is a type of drilling where the well path is deviated from the vertical according to a pre-designed plan to reach the target area. This method is also known as slant, inclined, or guided drilling. It is used when the target is laterally offset from the starting point on the surface. Given the high costs of oil and gas production, directional drilling has become a necessity. The primary feature of this method is enabling producers to tap into reservoirs that would not be economically viable by any other method. Advances in mud motors and sophisticated positioning devices have significantly contributed to the development of this industry. These advanced devices, which guide the motors, provide accurate positioning data, crucial for successful directional drilling.

Applications of Directional Drilling:

- **Deviation from the Initial Path:** The initial method for directional drilling was to bypass or avoid in-well obstructions. Nowadays, slight deviations are common, especially when unexpected geological structures are encountered. If vertical wells deviate from their path, they can also be considered as directional drilling.
- **Correcting Entry Depth into the Reservoir:** This is particularly relevant in fields with significant formation dips, where initial seismic interpretations might lead to incorrect depth predictions. Directional drilling allows for adjustments, ensuring entry into the oil-bearing section rather than water zones.
- **Accessing Inaccessible Locations:** Some reservoirs are located beneath urban areas, mountains, or other inaccessible places. Directional drilling allows access from a distance, avoiding the need to disturb these sensitive areas.

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In directional drilling, due to the reduced influence of gravity, higher viscosity and lower density drilling fluids are needed to ensure proper cuttings removal. High-yield bentonite grades from Arzesh Afarin Company, designed to consider pressure and angle calculations, are ideal for horizontal drilling, increasing viscosity while maintaining low density.

- **Salt Dome Drilling:** Sometimes, oil reservoirs are found beneath hard salt domes. Drilling through these formations is challenging, and directional drilling provides an alternative by starting the well outside the salt dome.
- **Faults:** Vertical wells sometimes encounter faults which cause deviations. Directional wells can avoid faults, reducing risks of geological disturbances.

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Bentonite Products from Arzesh Afarin Mining and Mineral Industries Co.

The high-yield grades 1 to 3 from Arzesh Afarin are used as viscosity agents in water-based and oil-based drilling fluids.

High Yield Grade 1 contains the mineral Bidellite as its main phase. This mineral increases the positive charge in the aluminosilicate networks, enhancing the absorption and retention of sodium cations between the layers. As a result, the increased cation capacity leads to more extensive bonding and a greater expansion of the aluminosilicate layers, thereby enhances viscosity to approximately 70 Pa at a shear stress of 600 RPM. Additionally, due to stronger bonds in the aluminosilicate network, water loss is minimized.

As mentioned, in directional drilling systems where the influence of compressive forces is minimal, a high-viscosity agent without added weight is required. Therefore, bentonite must have maximum viscosity, and high-yield grades can be effectively used as the primary component of the drilling fluid.

Regarding wellbore wall coverage, which is a crucial function of the fluid, bentonite with high water absorption and swelling capacity performs well as an expansion agent. It ensures the sealing of the wellbore walls and reinforces the walls in less cohesive layers, preventing collapse. Additionally, on the basis of calculating the formation fluid pressures and balancing them with drilling fluid pressure, it prevents formation fluids from leaking into the well.

Under formation pressure, the membrane formed by the drilling fluid must be able to retain the fluid phase between the aluminosilicate networks. This is crucial because fluid intrusion into formation pores can lead to wellbore failure. According to API Standard 13A, the volume of fluid loss is measured under specific conditions using a filter press, with a maximum acceptable volume of 16 ml. Bentonite grades from Arzesh Afarin exhibit fluid loss of less than 16 ml, as presented in the tables.

Moreover, Arzesh Afarin's bentonite products, with swelling indices between 15 and 30 and fluid loss below 16 ml, effectively perform sealing and protection of the wellbore.

Thus, in drilling operations where other clays such as Attapulgite and Sepiolite are used as primary materials, Arzesh Afarin's bentonite products with lower swelling indices can be used as a smoothing control agent.

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Bentonite grades of Arzesh Afarin Company

Chemical Analysis (OCMA)

SiO_2	Al_2O_3	Na_2O	MgO	K_2O	TiO_2	MnO	CaO	P_2O_5	Fe_2O_3	SO_3	LOI
60.7	14.34	3.26	4.04	0.56	0.66	0.02	0.8	0.08	2.56	0.07	12.1

Physical Analysis (OCMA)

Parameters	unit	Result
Viscometer dial reading at 600 rpm	r/min	43
Viscometer dial reading at 300rpm	r/min	37
Plastic viscosity (PV) = R600-R300	CP	6
Yield point (YP) = R300-PV	$\frac{lb}{100ft^2}$	31
YP/PV Ratio	$\frac{lb/100ft^2}{cp}$	5.16
Fluid Loss	ml	13.50
Moisture Content	%	8.5
Residue > 75micrometers	wt. %	2.5

Chemical Analysis (High Yield 1)

SiO_2	Al_2O_3	Na_2O	MgO	K_2O	TiO_2	MnO	CaO	P_2O_5	Fe_2O_3	SO_3	LOI
62.98	14.72	1.93	5.11	0.25	0.71	0.02	0.98	0.12	3.37	0.02	9.67

Physical Analysis (High Yield 1)

Parameters	unit	Result
Viscometer dial reading at 600 rpm	r/min	60-70
Viscometer dial reading at 300rpm	r/min	55-65
Plastic viscosity (PV) = R600-R300	CP	6-10
Yield point (YP) = R300-PV	$\frac{lb}{100ft^2}$	20-30
YP/PV Ratio	$\frac{lb/100ft^2}{cp}$	6-10
Fluid Loss	ml	15.10
Moisture Content	%	9
Water Absorption porous plate Method	wt. %	580-650
Distribution 325 mesh	wt. %	max 2.5

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Chemical Analysis (High Yield 2)

SiO_2	Al_2O_3	Na_2O	MgO	K_2O	TiO_2	MnO	CaO	P_2O_5	Fe_2O_3	SO_3	LOI
50.51	16.15	1.72	3.8	0.82	0.78	0.03	1.99	0.08	5.54	0.01	18

Physical Analysis (High Yield 2)

Parameters	unit	Result
Viscometer dial reading at 600 rpm	r/min	50-60
Viscometer dial reading at 300rpm	r/min	45-55
Plastic viscosity (PV) = R600-R300	CP	6-10
Yield point (YP) = R300-PV	$\frac{lb}{100ft^2}$	43
YP/PV Ratio	$\frac{lb/100ft^2}{CP}$	6-10
Fluid Loss	ml	15.10
Moisture Content	%	9
Water Absorption porous plate Method	wt. %	580-650
Distribution 325 mesh	wt. %	max 2.5

Chemical Analysis (High Yield 3)

SiO_2	Al_2O_3	Na_2O	MgO	K_2O	TiO_2	MnO	CaO	P_2O_5	Fe_2O_3	SO_3	LOI
60.02	11.49	1.5	3.73	0.14	0.55	0.03	0.81	0.06	3.73	0.01	16

Physical Analysis (High Yield 3)

Parameters	unit	Result
Viscometer dial reading at 600 rpm	r/min	40-50
Viscometer dial reading at 300rpm	r/min	35-45
Plastic viscosity (PV) = R600-R300	CP	6-10
Yield point (YP) = R300-PV	$\frac{lb}{100ft^2}$	20-30
YP/PV Ratio	$\frac{lb/100ft^2}{CP}$	6-10
Fluid Loss	ml	15.10
Moisture Content	%	9
Water Absorption porous plate Method	wt. %	580-650
Distribution 325 mesh	wt. %	max 2.5

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Chemical Analysis (API)

SiO_2	Al_2O_3	Na_2O	MgO	K_2O	TiO_2	MnO	CaO	P_2O_5	Fe_2O_3	SO_3	LOI
60.7	14.3	3.26	4.04	0.56	0.66	0.02	0.8	0.08	2.56	0.07	12.1

Physical Analysis (API)

Parameters	unit	Result
Viscometer dial reading at 600 rpm	r/min	Min 30
Viscometer dial reading at 300rpm	r/min	Min 25
Plastic viscosity (PV) = R600-R300	CP	9
Yield point (YP) = R300-PV	$\frac{lb}{100ft^2}$	27
YP/PV Ratio	$\frac{lb / 100ft^2}{CP}$	3.00
Fluid Loss	ml	14
Moisture Content	%	8.5
Residue > 75micrometers	wt. %	2.5

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