



Innovative Drilling Fluid Mixing Technology Enhances Performance and Lowers Cost

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Executive summary



AquaShear™ drilling fluid mixing technologies are a significant enhancement to drilling fluid management because they improve drilling performance, reduce rig time, and lower cost. The technology is being applied in the Permian Basin to reduce the volume of additive products up to 20 percent per well and to cut the rig time associated with mixing and equipment maintenance by 50 percent.

Additive product volumes are reduced and more stable drilling fluid properties result because AquaShear mixers achieve near-instantaneous hydration, dispersion, mixing, blending, and shearing. Additional time and cost savings are gained by eliminating sludge at the bottom of tanks, so cleanout times and costs are lower.

Rig crews and mud engineers report high volumes of lost circulation materials can be mixed with no particle clogging, and there is no need to continuously adjust fluid properties to maintain viscosity levels for effective hole cleaning and high rates of penetration.

Operators who replace traditional agitators and mixers with rented AquaShear mixers are eliminating fisheyes, viscosity humps, and angel hair. The units optimize powdered mud additive yield and oil mud and packer fluid emulsions, and there is no loss of undissolved materials across the shakers.



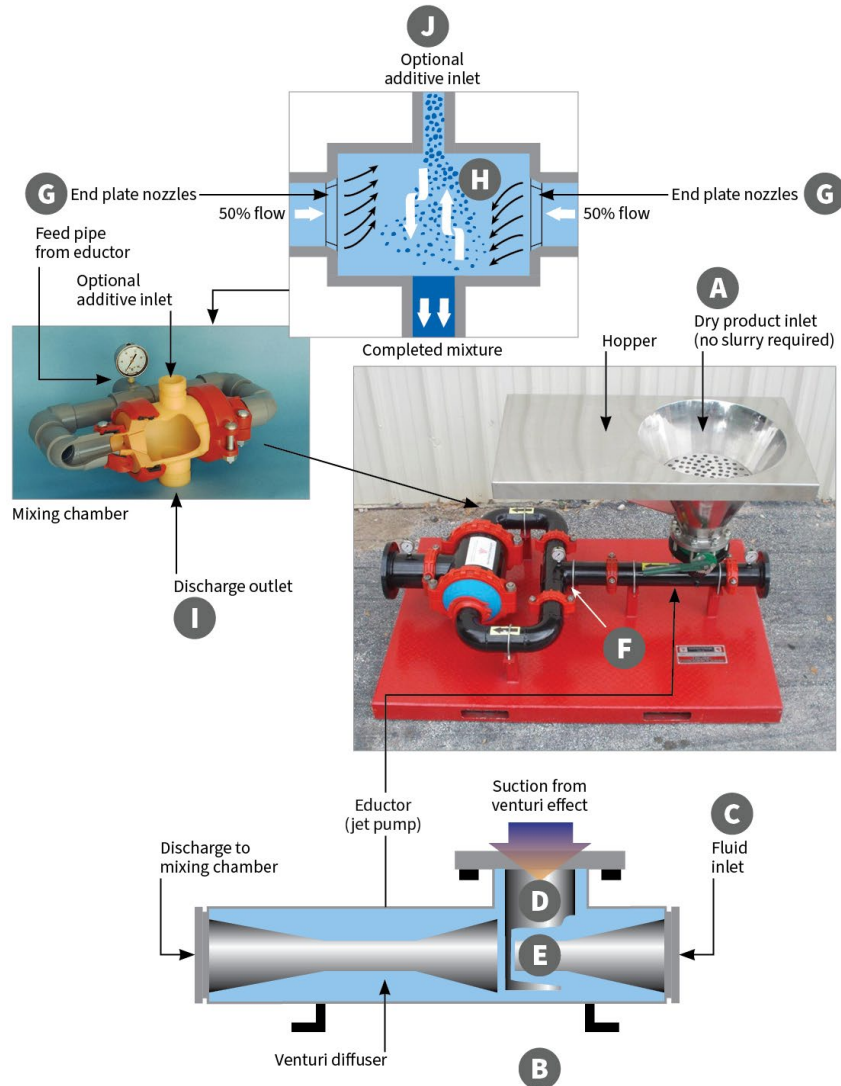
With no moving parts and 15 minutes of maintenance per month, this innovative technology is performing with high reliability and ease of use. Bottom line, operators and drilling contractors have proven lower mud cost per foot and higher drilling performance using AquaShear technology.

Advanced mixing methodology

The viscosity action of mud polymers depends on the molecular length of the hydrated polymer chains. Mechanical shearing devices can break these fragile chains, causing irretrievable viscosity loss. AquaShear mixing technology utilizes hydraulic rather than mechanical shear. Hydraulic shear occurs from the interaction of opposed counter-rotating fluid streams entering the cylindrical AquaShear mixing chamber through precisely sized and positioned nozzles in the plates of each end of the mixing chamber.

The result is more thorough mixing with virtually no product damage.

The process flow diagram below illustrates how this unique equipment works. Mixing begins [A] when product additives are introduced via a single or dual hopper to an integral high-efficiency eductor [B]. The eductor below the hopper acts like a jet pump to create strong suction from a venturi effect. The jet nozzle converts fluid entering at the fluid inlet [C] at high pressure to a high-velocity, low-pressure stream, causing a vacuum at the inlet of the suction chamber [D]. The driving jet



momentum maintains the flow of the dry product, and the dry product and fluid are mixed at the throat of the eductor [E].

The low-pressure stream causes a negative pressure or vacuum at the inlet of the suction chamber. This pulls and entrains the additive material into the flow of the moving fluid.

The driving jet momentum maintains the flow of the additive material. The two streams are mixed in the throat of the eductor [E]. The combined stream travels through the diffuser, accelerating the flow to a pressure that is greater than the additive pressure, but less than the motive fluid pressure.

After discharge from the diffuser in the eductor, a yoke [F] is used to create two equal streams. Each stream is directed into the AquaShear mixing chamber through end plates containing nozzles [G]. These nozzles are precisely spaced, sized, and angled for specific applications and flow rates. The opposing streams collide in the center of the mixing

chamber [H] and generate intensely concentrated turbulence. The result is instantaneous dispersion and wetting of each and every additive particle, ensuring a smooth and consistent mixture.

Instantaneous mixing of the additive at the point of maximum fluid turbulence within the mixing chamber prevents clogging of the nozzles and delivers high-viscosity drilling fluids. It is not necessary to form a slurry before introducing powders into the solvent liquid. Mixing is virtually instantaneous and confined to the region of maximum concentrated turbulence. Frictional losses are minimal, and power is efficiently utilized to produce concentrated turbulence.

The unique capability of the AquaShear mixer to instantly combine product additives with liquids delivers an energy-amplified mixture that requires zero retention time in the mixing chamber.

As the dispersed mixture moves immediately from the mixing chamber in a low-shear motion, kinetic energy is released, uncoiling molecules and producing a fully uniform blended drilling fluid through the discharge outlet [I]. In some configurations, the AquaShear mixer includes an optional additive inlet [J] that can be used with a bypass valve to allow LCM or other additives to be flowed directly through the eductor to the mixing chamber without plugging the nozzles.

The AquaShear mixing chamber is a proven, effective, and economical means of hydrating polymers, providing instantaneous dispersion and hydration of clays and creating tighter, more stable invert emulsions in oil-based/synthetic fluids.

A low-pressure (sub-atmosphere) zone occurs at the point of the introduction of the product additive, resulting in very limited to virtually no dust [D]. Frictional losses are minimal, and power is efficiently utilized to produce concentrated turbulence.

With no moving parts and simplified construction, the AquaShear mixer requires little maintenance, is easy to clean, and delivers important drilling fluid management benefits.

Provides instantaneous dispersion and full hydration of clays

AquaShear mixers provide better surface wetting of colloidal materials independent of particle shape and eliminate the need for product settling in the mixing tank. The well-dispersed mixture moves immediately from the mixing chamber, providing a uniform, blended product. With its thorough mixing and even distribution of additives, it speeds up the treatment process and provides full utilization of expensive additives.

Creates a tighter, more stable invert emulsion in oil-based/synthetic fluids

The high shear rate mixing immediately disperses invert emulsions into fine particles in the continuous phase. The AquaShear counter-rotational motion and superior agitation deliver smaller droplets and a more stable emulsion.

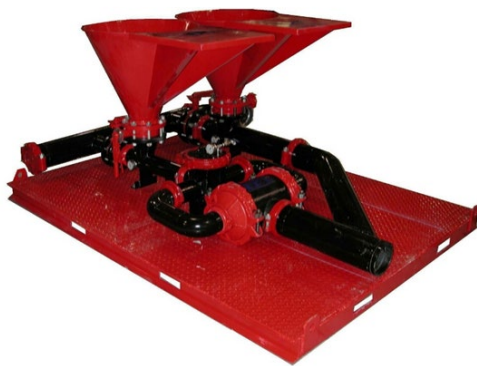
Eliminates fisheyes, viscosity humps, and angel hair

Hydration, dispersion, mixing, blending, and shearing of additives occur at the point of introduction before fisheyes, viscosity humps, and angel hair occur. Particle dispersion and wetting occur almost instantaneously. There is no need for a separate function or cycle to create proper mixing.

Significantly reduces mixing time, product usage, and cleanup

Superior dispersion capabilities prevent micro agglomeration to reduce mixing time, product usage, and sludge buildup in tank bottoms.

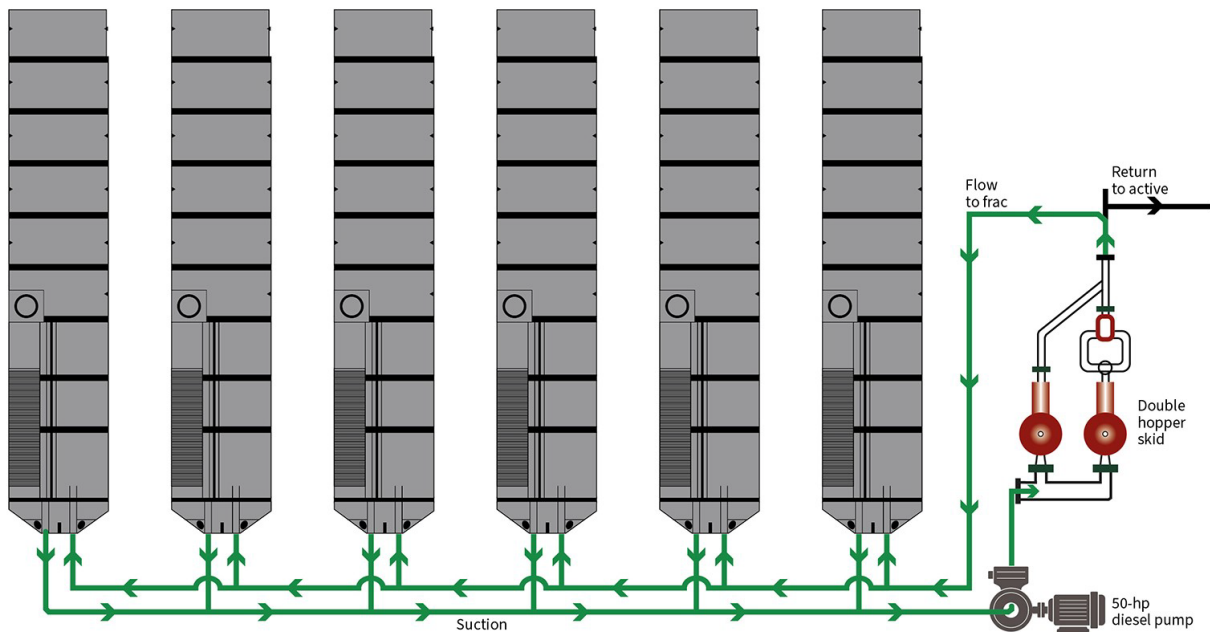
Equipment details



Single-shear hopper units excel at hydrating/suspending water- and oil-base mud products to ensure full yield of the product at addition, rather than circulating to achieve the desired rheological properties of the fluid. The addition of products and pre-hydrated mud from surface to TD is optimized, and unhydrated product is eliminated at the bottom of tanks to reduce product consumption and decrease pit, shaker, and basket strainer cleanout times.

Dual-hopper AquaShear units include an additional 6-in. high-capacity feeder for applications with high volumes of lost circulation materials.

The integration of AquaShear mixers and tanks creates a premix station for building mud on location. The equipment transfers mud to the active system or to storage tanks. This flow loop is beneficial after building the fluid to maintain mud quality and prevent falling out of the fluid system.



Field deployment

Prior to installation, experienced JST field technicians provide a comprehensive, onsite evaluation of the rig's drilling fluid management system. The modular AquaShear mixer design is easy to customize to optimize performance in both benign and extremely challenging drilling conditions.

At the time of installation, onsite safety, operations, and maintenance training for the rig crew and mud engineers is provided to ensure maximum economic benefits from the technology.

With its simplicity of design and no-moving-parts construction, AquaShear mixers require no special expertise and can be easily operated by rig personnel.

Verbatim testimonials from drilling engineers



The AquaShear unit reduced mixing time from 2 hours per 300-bbl batch to 30 minutes. It is simple, reliable, and performs as promised.

...

Drilling mud costs were reduced by an average of 27 percent as a result of improved dispersion and hydration of all drilling fluid components. The total elimination of fisheyes and shake blinding enhanced drilling efficiency.

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Mud mixing efficiencies improved dramatically with weight material and LCM added while the unit was in bypass mode. In normal operations, we achieved maximum dispersion and hydration.

...

After the AquaShear unit was installed our mud cost per foot was 52% less—cut in half.

...

During drilling, there was no sign of any loss of undissolved materials across the shakers. The equipment is very cost-effective and recommended when powered mud additives are used or with systems requiring shear to form emulsions such as oil muds or packer fluids.

...

We used the AquaShear unit at our mixing plant to quickly add 800, 50-lb sacks of barite to a kill fluid that was needed on a well taking a high-pressure kick. The time saved was significant, and there was no hopper plugging whatsoever.

...

During our field trial, mixing times were substantially reduced, and fisheyes were eliminated. No viscosity hump was seen in the active pit, and the fluid properties demanded by the mud program were easy to maintain. The AquaShear unit improves mixing, reduces waste, and minimizes screen blinding.

...

We conducted a series of tests on a horizontal well to compare the AquaShear unit to the standard pump and mixer used on the rig. Viscosity, rheology, API fluid loss, and HPHT fluid loss were measured on low- to high-solid muds, water- and oil-based muds, and LCM pills. In every comparison test, it outperformed the standard system on the rig.

...

Savings from the AquaShear mixer was 27.5%. Proper mixing clearly reduced mud bills in our operations, as evidenced by the reduction of leftover chemicals found at the bottom of each pit.

...

The AquaShear unit mixed completion fluids in 15 minutes as compared to the alternative system time of 90 minutes. There was no loss of material, and it improved dispersion, hydration, and yield. On one well, a blended LCM pill was mixed in half the time. The unit is worm proof, and materials and rig time savings are significant.

For more information



AquaShear drilling fluid mixing technologies with single- and dual-hopper feeders are a significant enhancement to JST's ZNPT Drilling Performance Packages because they lower the total cost of operations and reduce nonproductive time (NPT) and invisible lost time (ILT).

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