SEPARATION SOLUTIONS

HDD Solids Control Principals

and Buyer's Guide

2018 – Revision E

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Principles of HDD Solids Control

Relative to the use of drilling fluids within the oil & gas industry, the use of drilling fluids within the horizontal directional drilling ("HDD") industry, is new. As the use of HDD technology did not become mainstream until the 1980's, it took another decade before drillers started to consider the use of basic drilling fluids. Even today, the amount of research and development aimed at HDD drilling fluids is considered a rounding error in the oligopoly of drilling fluid manufacturers. However, the trends strongly suggest that the future of HDD drilling will follow a similar evolutionary cycle as experienced by the traditional oil & gas industry. As such, it is only a matter of time before customized and highly engineered drilling fluids make their way into day-to-day HDD operations.

Couple the evolution of drilling fluids with the escalating cost of waste management and disposal, the economic practicality of utilizing drilling fluids, is dependent on the ability to recover and recycle. Though the cost of barite and bentonite continue to be commoditized, additives continue to become more and more expensive. Add the escalating cost of qualified talent, HDD rig operators are left with a critical challenge; making profits, when the cost of business is increasing.

Note – In addressing the economics of drilling fluids, HDD rig operators must clearly understand the basic physics behind the recycling processes that are employed.

The following guide provides for a high-level practical understanding of the key principles behind HDD solids control and drilling fluid management that concludes in several key considerations that must be kept in mind when evaluating and finally selecting a package mud reclamation system. With that said, the following discussion should not be considered exhaustive and will not cover all circumstances. Ultimately, the supplier of the drilling fluid and the original equipment manufacturer of the solid control and waste management equipment should be consulted with, prior to making any key business decisions.

Section 1 - Particle Size & Effects

Despite the fact that the oil and gas industry utilizes both oil-based and water-based drilling fluids, HDD drilling fluids will remain water-based for the foreseeable future. Local laws and regulations make the use of oil-based drilling fluids impractical, especially when drilling at and near the surface.

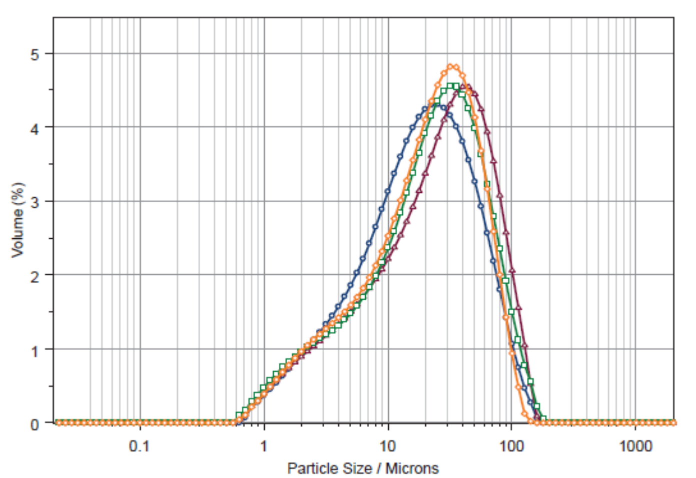
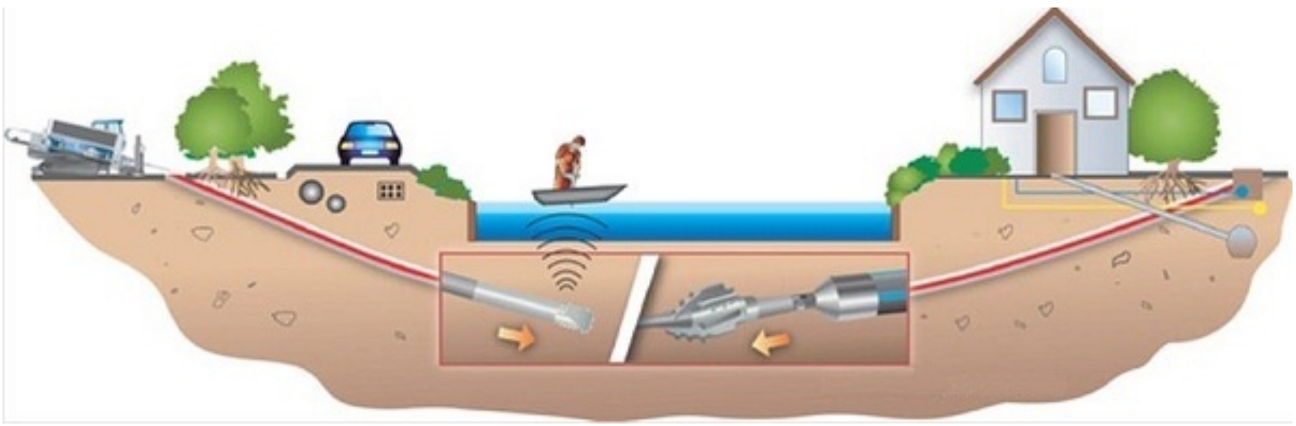


Figure 1: 4 Barite samples obtained from different producers.

As is derived from its moniker, water-based drilling fluids utilize water as the liquid solute (i.e. the media in which the additives are mixed into). The solid phase of any drilling fluid is either commercial solids or drilled solids. Most commercial solids, such as bentonite (which is used as a thickening agent to provide "body" or viscosity to the drilling fluid), have a relative particle size that can start less than one micron (0.000039 inches) and range up to 10 microns (0.00039 inches). Barite, a common weighting agent, has a particle size distribution that ranges from 1 micron to 100 microns. Figure 1 highlights the typical particle size distribution from four different barite suppliers. It is important to keep in mind that a micron is 1/1000 of a millimeter and that there are 24 millimeters in an inch.

Drilled solids are those particles that enter the mud system in the form of cuttings from the drilling bit, back reamer or from borehole debris. These solids vary in size from less than one micron & larger depending on the carrying capabilities of the drilling fluid. Note that spindle speed and the amount of push or pull force require to drill play an important factor on the particle size of the cuttings. Smaller holes or slower drilling/reaming rates tend to produce smaller drilled solids.



One of the most important objectives in solids control is to remove as many of the large drilled solid particles (i.e. contaminants"), as is practical, the first time that these solids are pumped out of the borehole. This must be done without significantly impacting the commercial drilling fluid solids. This requires properly designed and installed solids removal treating equipment, sized to process a minimum of 100% up to 125% of the mud circulation rate. Solids that are not removed during the first circulation through the surface equipment are subjected to mechanical degradation by the drill bit, reamers and mud pumps during each circulation cycle until they are too fine for removal by traditional mechanical (i.e. Primary cleaning systems utilizing shaker and hydrocyclone technology) means.

In order to evaluate the removal capabilities of the various pieces of mechanical treating equipment, it is necessary to consider the source of the solids and classify them according to the following sizes. Figure 2 highlights the general classification of solids per the American Petroleum Institute. Table 1 provides a cross reference to commonly used terminology used within the HDD industry:

Note – The nature of the drilled solids that a rig is anticipated to experience is an important factor when considering a mud reclamation system.

Table 1 – HDD Solids Classification	API Classification	Micron Range	Inches*
Large Drilled Solids	Intermediate and Coarse	>440	>0.018"
Sand	Medium	74 to 440	0.0031" to 0.018"
Silt	Ultra-Fine and Fine	2 to 74	0.000083" to 0.0031"
Clay	Colloidal	0.5 to 2	0.000021" to 0.000083"
Colloids	Colloidal	<0.5	<0.000021"

**Note: (0.001 inches = 25.4 microns so 1" = 25,400 microns).*

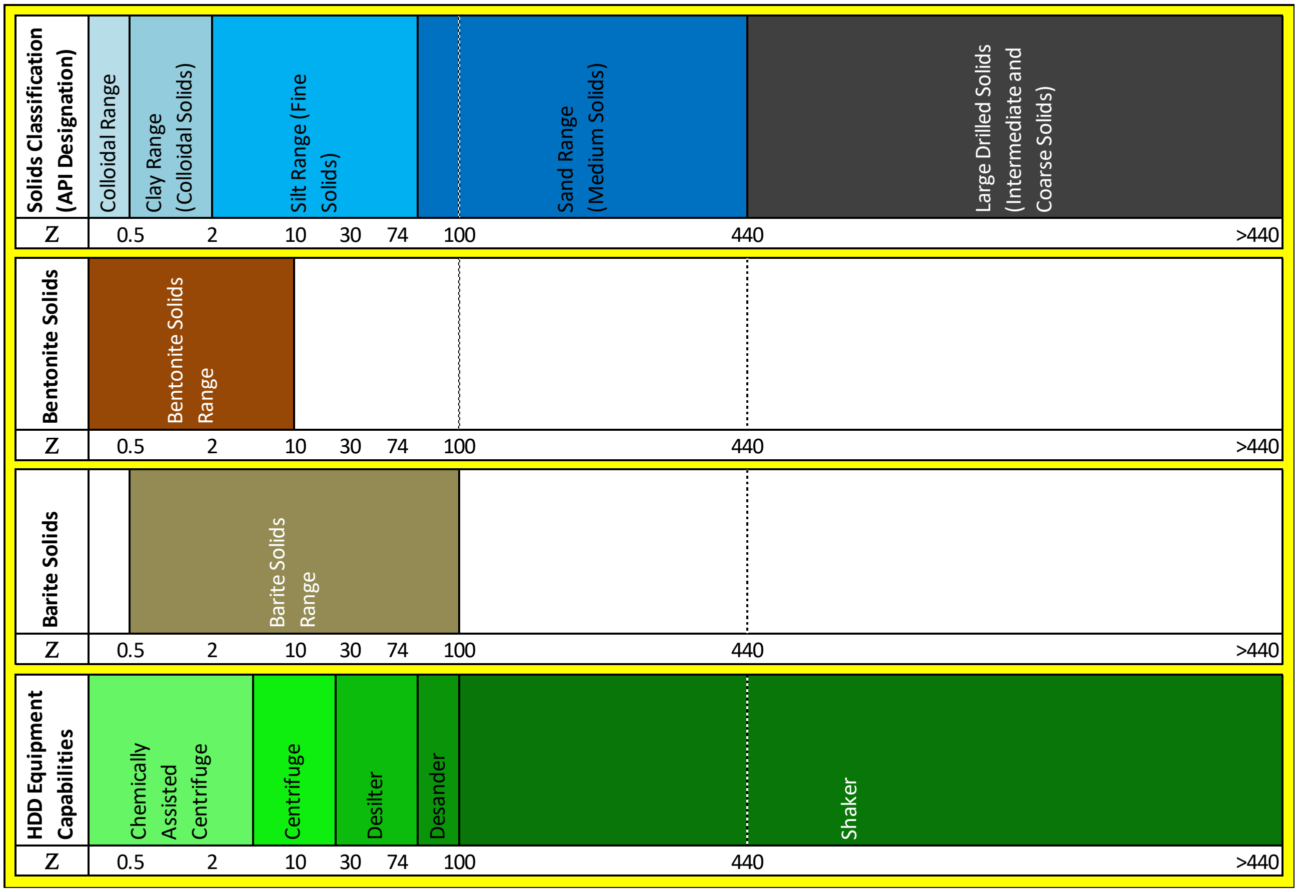


Figure 2 – HDD Solids Classification and Equipment Capabilities

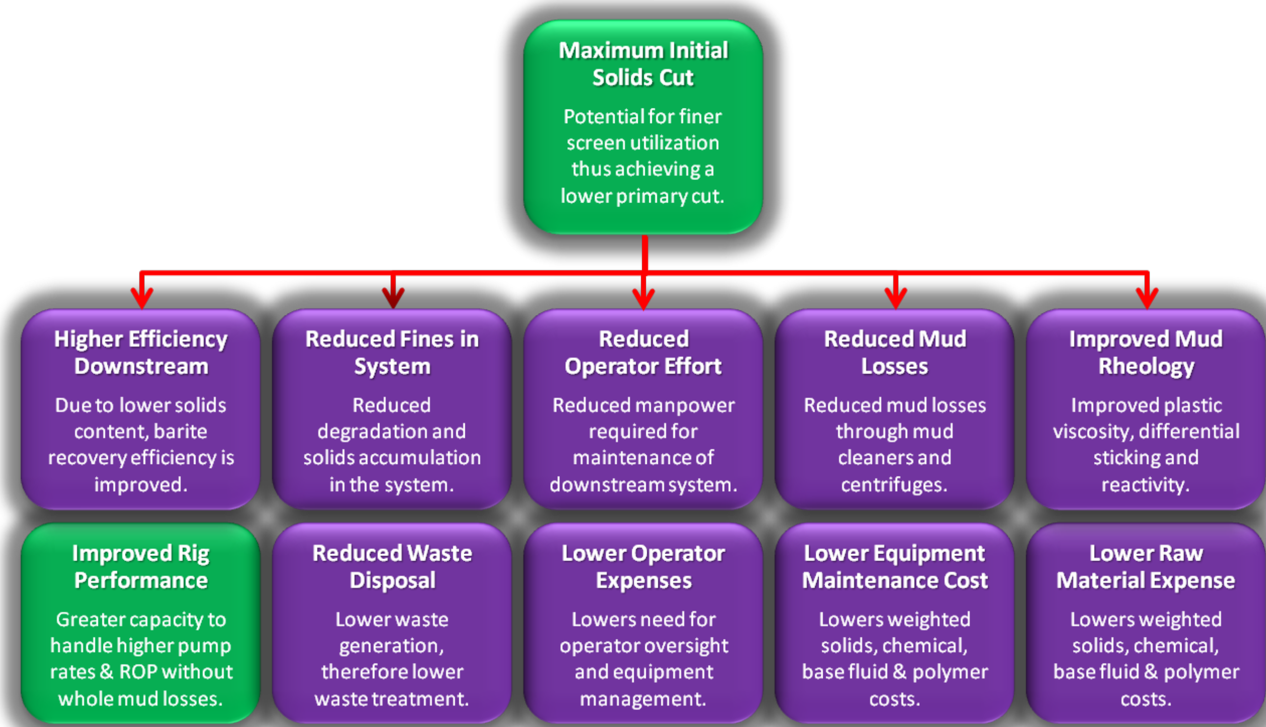
Section 2 - Benefits of Low Solids in Drilling Mud

The usage of engineered drilling fluids provides for a number of benefits, including, but not limited to:

1. Increased drilling penetration.
2. Increase bit or back reamer life.
3. Reduce mud cost.
4. Reduce triplex mud pump, mud motor & surface equipment maintenance cost.
5. Reduced clean-up & haul-off or disposal cost

However, the use of drilling fluids, without an effective solids control system can lead to a wide variety of problems, including:

1. Lowered rate of penetration.
2. Reduced bit and reamer life.
3. Increased mud cost.
4. Increased wear on triplex mud pump, mud motor and surface equipment.
5. Increased clean-up and haul-off costs.



To achieve the benefits associated with engineered drilling fluids, effective solids control planning is required. These benefits are the result of planning prior to boring and are accomplished through the use of properly designed, sized and operated solids removal equipment. It is the responsibility of the boring crew to become knowledgeable in the proper use of the equipment; otherwise the potential benefits may be reduced or nullified. Figure 3 highlights the advantages achieved of maximizing solids control system effectiveness and defines the benefits of selecting the proper mud system.

Section 3 – Solids Control System Methodologies

At present, there are a variety of methods that may be employed to control formation solids build up. Dilution of the drilling fluid with water or simply discarding of the used drilling fluid are antiquated practices that have been used for years. However, these methods have proven to become cost prohibitive as the market expectations and disposal costs have evolved. Today, the most effective method available for solids control is mechanical treatment. However, the market is evolving quickly and there are a number of conditions in which chemically-enhanced mechanical separation have become not only necessary, but financially advantageous.

3.1 – Primary Solids Control System Elements

Primary mechanical treatment systems remove formation solids using linear motion shakers or hydrocyclone devices, such as desanders and desilters. Each piece of equipment is generally limited to the range of particle removal described in Table 3. This same detail was illustrated in Figure 2 above.

Table 3 – Primary Solid Control Devices	Solids Classification	Micron Range	Inches
Standard Scalping Shaker	Large Drilled Solids (“Cuttings”)	>440	>0.018”
Fine Screen Shaker	Sand	>74	>0.0031”
Desander	Sand	>74	>0.0031”
Desilter	Silt	>25	>0.001”
Centrifuge	Clay	>5	>0.0002”
Chemically-Enhanced Centrifuge	Colloids	>0	>0”

Figure 3 – Benefits of Achieving Effective Primary Solids Control

Correctly implemented, each piece of mechanical equipment is effective within a certain particle size range. Utilizing any of these devices, or a combination of the above equipment, throughout your boring program will produce maximum benefits and result in a cost effective means of controlling your solids within an affordable budget. Knowing the maximum capabilities of each technology will greatly assist in selecting the correct mud system.

Mechanical separation equipment employs mass differences (i.e. variance in specific gravity), size differences (i.e. variances in particle size distribution), or a combination of both to selectively reject undesirable formation solids and retain desirable drilling fluid. The desanders and desilters utilize centrifugal force and mass differences between the solids density and liquid density for solids removal. The shale shakers employ a vibrating screen to manipulate micron-sized differences between solids and fluids.

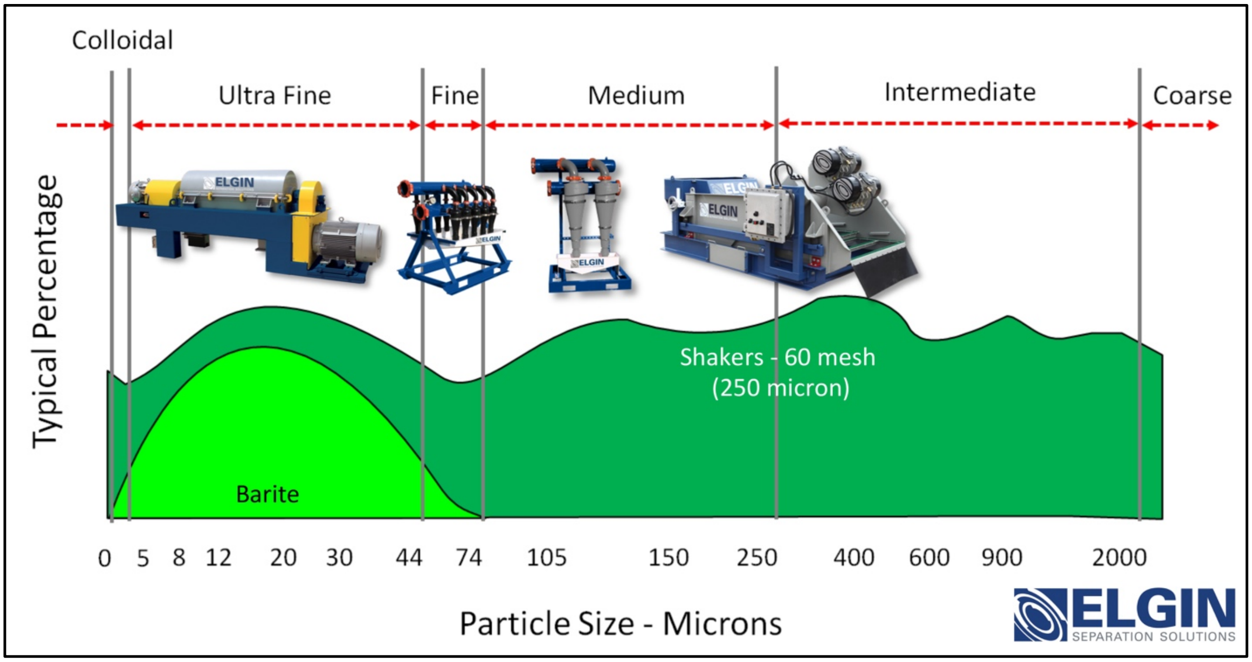


Figure 4 – Relative Solids Control Device Effectiveness Relative to Particle Size Distribution

3.2 – Solids Control System Application

A standard shaker or fine screen shaker is vital to the solids control and should process 100% of the mud returning from the starting pit before allowing this mud to be processed by any of the downstream equipment you may utilize in your solids control system. Located directly downstream from the shale shaker will be one or more hydrocyclone devices that will employee desilters, desanders or both. There are a number of industrial claims that indicate that hydrocyclones can achieve solid cuts lower than 25 microns, however when it comes to the practical application and use of solids control systems, operators should conservatively assume 25 microns as the performance limit. Table 4 highlights the hydraulic design criteria and the characteristic cut point that can be achieved with each primary solids control device.

Table 4 highlights the minimum design considerations that should be kept in mind when having a mud system configured. Ensuring that the individual components meet the standards highlighted below will greatly improve the chances for operational success.

Table 4 - Solid Control Device	Target Design Consideration	Cut Point Consideration
Shaker System	125% of the Rig Circulation Rate	Target a 74 Micron Cut
Hydrocyclone System	125% of the Rig Circulation Rate	Target a 25 Micron Cut
Centrifuge System	20% of the Rig Circulation Rate	Target a 5 Micron Cut
Tank Capacity	6 Times the Rig Circulation Rate (Should be no less than 5 times)	Requires A Separate Tank for Each Cut Achieved

When deploying a "solids control system", there are several key hydraulic design factors that must be considered. These factors simply provide a "hydraulically balanced" solids control system, however, buyers of solids control systems should not overlook the durability, dependability, and return on investment that the features and benefits of a system bring an operator.

Figure 5 – "Hydraulically Balanced" KEMTRON 600HD2.

3.3 - Summary of Effective Solids Control System:

To achieve effective solids control, the following should be deployed:

1. Obtain an effective, dependable, and durable solids control system.
2. Ensure that the solids control system acquired is:
    a. Hydraulically balanced
    b. Is capable of making both a scalp cut and a fine cut.
    c. Has sufficient drilling fluid mixing and re-circulating capacity.
3. Do not by pass the shale shaker or other solid control equipment while drilling.
4. Use the smallest mesh screen possible on the shale shaker. This will change from formation to formation and will require operators to maintain a variety of screens on hand.
5. Maintain an adequate inventory of recommended spare parts and screens.
6. Certify and assign rig personnel to be responsible for equipment operation & maintenance.
    a. Request equipment commissioning and training for your OEM.
    b. Discuss possible written training programs that may be available from your OEM.

Section 4 - Solids Control Equipment

4.1 - Shale Shakers

The first line of defense for a properly designed solids control system has been and will continue to be for years to come, the shale shaker. Shale shakers remove solids from drilling fluid as the mud passes over the surface of a vibrating screen. Particles, smaller than the openings in the screen, pass through the holes of the screen along with the liquid phase of the mud. Particles too large to pass through the screen are thereby separated from the mud for disposal. Without proper screening of the drilling fluid during this initial removal step, reduced efficiency and effectiveness of all downstream solids control equipment in the system is assured. The downstream hydrocyclones will simply be overloaded beyond their design capacity. The most effective shakers utilized within the HDD industry can be categorized as either balanced elliptical motion or linear motion shakers. Table 5 compares the advantages and disadvantages of the typical shakers available within the HDD industry:

Table 5 – Advantages and Disadvantages of Common HDD Shakers

Shaker Type:	Balanced Circular Motion	Linear Motion	Balanced Elliptical Motion	Elgin's Dual-G Variable Linear Motion
Approximate G-Force:	2 to 3	4 to 7+	4 to 5	4 to 8
Number of Motors:	1 or 2	2	2 or 3	2
Performance Advantages:	Lower cost to manufacture.	Improved solids conveyance, improved residence time, dryer cuttings when solids loading is high via the ability to use screen inclination & finer screens.	Higher 'G' forces can be safely applied, even in sticky formations as the peak forces are smoothed out.	Allows the operator to adjust the G-force. Allows the shaker to perform under high solids loading conditions and when managing reactive, sticky, or fine solids.
Performance Disadvantages:	Inefficient conveyance of solids without significant downward angle of shaker. Creates wet cuttings and undesirable discharge end thrust.	High velocity and G-force is inefficient when dealing with finer solids and reactive or sticky clay formations.	Not as efficient in handling high solids loading due to lowered G-force (i.e. as experienced when drilling "top hole" sections of a well).	Requires additional installation of a variable frequency drive to the electrical control panel and customized vibrating motors.

4.2 - Shale Shaker Screens

Basically, a screen acts as a "go-no-go" gauge: Either a particle is small enough to pass through the screen or it is not. Screening surfaces used in solids control equipment are generally made of multi-layered woven wire screen cloth and are the "heart and soul" of the shale shaker. More often than not, the quality of a shale shaker is defined by the quality of screens it utilizes. The most effective screens maintain the following characteristics:

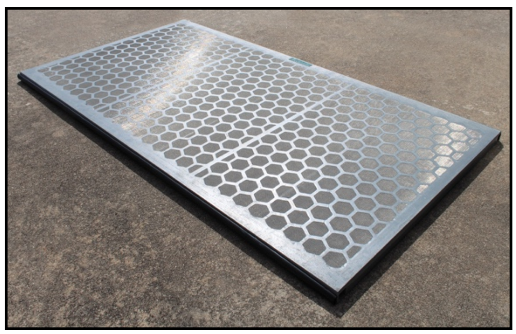


Figure 5 – Multi-Layered Shaker Screen

1. **Multi-Layered Mesh Screens** - Layered screens have two or more screen cloths, usually of different mesh, mounted in a single screen panel (See Figure 5). These screens will have openings that vary greatly in size and shape. Mesh is defined as the number of openings per linear inch. Mesh, can be measured by starting at the center of one wire and counting the number of openings to a point one inch away.

2. **Tensioned Stainless Steel Wire Mesh** – Wire mesh should be corrosion resistant and provide for a tight stretched upper surface. Screens that do not maintain a taunt upper surface will damage easily and provide a poor solids cut.

3. **API Qualification** – Screen characteristics and performance vary greatly from one supplier to another. To properly characterize the cut point of a screen and to ensure that the screens being supplied meet internationally acceptable standards, only API 13C qualified screens should be utilized.

When selecting the appropriate screens for usage, the solids control system configuration must be considered. If the system is appropriately set up with a scalping system and a fine screen system, the scalping screens must be sized just coarse enough to ensure that drilling fluid does not sheet off the shaker (i.e. whole mud losses). This happens when the scalping screen is too fine to allow the drilling fluid to pass into the solids control system's dirty tank. Typical scalping screen configurations for HDD applications range from 50 mesh to 120 mesh (80 mesh screens are a good starting point for most HDD applications). Typical fine screen configurations range from 160 to 180 mesh. It is for these reasons that operators must be fully prepared to change the screens relative to the subsurface conditions. Depending on the changes in drilling depth and length, multiple screen combinations may be required.

Relative to the use of shaker screens, it is important to remember that the size of the openings in the screen, is the distance between wires in the screen cloth and is usually measured in fractions of an inch or microns. Screens of the same mesh may have different sized openings depending on the diameter of the wire used to weave the screen cloth. The smaller the diameter of the wire results in larger screen openings allowing larger particles to pass through the screen. The larger the diameter of the wire, the smaller the particles that will pass through the screen. It is the size of the opening in a screen not the mesh count that determines the size of the particles separated by the screen. It is because of these facts that HDD system users must compare and specify screens based on their API 13C designation. This will ensure performance continuity when comparing one operation to the next, as well as allowing for proper selection when preparing for a job.

Note – Wire mesh screen performance is significantly hampered when managing sticky clay formations. Close attention should be provided to maintain the screens in good working order and to ensure that the surface of the screens is cleaned on a frequent basis. Once clays start building up on the screen surface, screen life will be significantly shortened.

4.3 - Shale Shaker Maintenance

Because of their greater efficiency, the use of fine mesh screen shakers is essential. Fine screen shaker use requires the following care:

1. **Wash down screens with power washer regularly.** This is especially important when drilling through highly reactive or "sticky" solids (i.e. clays) or when drilling with drilling fluids that incorporate polymers.
2. **Check screens for tear or rips.** Any holes must be plugged (Elgin screens are supplied with screen plugs for this purpose). Holes will create major mud weight problems and as such the screens should be checked as often as possible.
3. **Make sure screens are properly mounted.** Most shakers utilize simple wedge-block installation systems. Wedges should be tightly installed and the screen should not be loose in any manner. It is important to check the final "seating" of the screens to ensure that all seals are fully engaged with the shaker to ensure that solids bypass is mitigated.
4. **Make sure shaker is at proper angle.** Depending on the volume of solids being handled the shaker inclination must be carefully considered. It is also important to check that the shaker is operating perfectly level, regardless of the rig position.

5. **Check electrical wiring or a regular basis.** High G shakers tend to wear through wiring insulation. In addition, as most primary mud systems are continuously exposed to wet conditions, it is important that no electrical safety issues are present.
6. **Ensure proper lubrication of vibrator motors, pump motors, and leveling jacks.** All of these systems are precision devices and require preventative maintenance. The O&M manual will provide clear instructions on the minimum preventative maintenance required. These minimum requirements must be maintained in order to ensure maximum equipment life.

In addition, frequent checks must be made for plugging or blinding of the fluid on the screens. The shaker angle can be increased or decreased to help eliminate this problem. If your fluid is blinding on the screen a more coarse or finer screen may be installed to help solve the problem. Remember your shale shaker is your first line of defense in your solids control system and should be carefully maintained to ensure proper performance. It is critical that all rig personnel know the proper operation and maintenance of the shale shaker utilized.

4.4 - Hydrocyclones

Hydrocyclones are simple mechanical devices, without moving parts, designed to speed up the settling process. Feed pressure is transformed into centrifugal force inside the cyclone or cone to accelerate particle settling in accordance with Stoke's Law. In essence, a cyclone is a miniature settling pit which alloys very rapid settling of solids under controlled conditions. Hydrocyclones have become important in solid control systems because of their ability to efficiently remove particles smaller than the finest mesh screens (i.e. down to 25 microns). They are also uncomplicated devices, which make them easy to use and maintain. A hydrocyclone consist of a conical shell with a small opening at the bottom for the underflow discharge, a larger opening at the top for liquid discharge through an internal "vortex finder" and a feed nozzle on the side of the body near the wide (top) end of the cone. Drilling mud enters the cyclone under pressure from a centrifugal feed pump. The velocity of the mud causes the particles to rotate rapidly within the main chamber of the cyclone (i.e. like a tornado in a bottle). Light, fine solids and the liquid phase of the mud spiral inward and upward for discharge through the liquid outlet. Heavy, coarse solids and the liquid film around them tend to spiral outward and downward for discharge through the solid outlet or under flow.

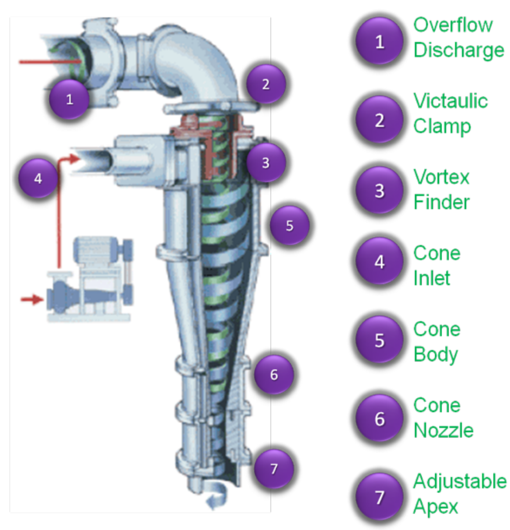


Figure 6 – Typical Hydrocyclone Configuration

Design features of cyclones units vary widely according to the size. Typical HDD industry cyclones are made of composite materials (i.e. polyurethane) and hold up to wear quite well. However, there are some drilling conditions in which ceramic cone inserts should be recommended to slow the erosive effectives of abrasive solids.

The size of cyclones in use varies from 12" down to 2", with the most common being the 4”, 5”, 10” and 12”. The measurement refers to the inside diameter of the largest, cylinder section of the cyclone. In general, but not always, the larger the cone, the larger the cut point and the greater the throughput. Table 7 provides for a relative performance comparison between hydrocyclones. However, actual cone performance will vary slightly between manufacturers.

Cone Size (Inches)	Maximum Flow Rate (GPM at 60' Head)	Maximum Cut (Microns)	Description
<2	<20	<20	Microcone
2	20	25	Desilter
3	50	30	Desilter
4	65	35	Desilter
5	80	40	Desilter
6	100	55	Desander
8	125	70	Desander
10	500	80	Desander
12	500	85	Desander

Table 7 – Typical Hydrocyclone Performance

Manifolding multiple hydrocyclones in parallel can provide sufficient capacity to handle the required circulating volume plus some reserve as necessary. Manifolding may orient the cyclones in a vertical position or nearly horizontal the choice is one of convenience & system design parameters. The position does not affect cyclone performance. The internal geometry of a cyclone also has a great deal to do with its operating efficiency. The length & angle of the conical section, the size and adjustment means of the underflow opening all play important roles in a cyclones effective separation of solids particles.

Note – To maximize operational and maintenance flexibility, hydrocyclone manifolds should include individual valve isolation for each hydrocyclone and a calibrated pressure gauge should be installed on the hydrocyclone manifold.

Operating efficiencies of cyclones may be measured in several ways, but since the purpose of a cyclone is to discard maximum abrasive solids with minimum fluid loss, both aspects must be considered. Hydrocyclones are another important line of defense in the battle against the removal of solids from your drilling fluid.

4.4.1 - Desanders

As noted in Table 7, Desanders are hydrocyclones larger in diameter than 5". Desanders are installed downstream from the shale shaker and ahead of the desilters (if desilters are utilized). The desander removes sand size particles and larger drilled solids, which have passed through the shale shaker screens. These solids are discarded along with some liquid into the waste tank. The clean mud is then discharged into the next tank ready to be run through the desilters. Though desanders are not necessary for all application, when installing a desander, follow these general recommendations:

1. **Sizing** - Size the desander to process 100-125% of the total mud circulation rate to accommodate for the “bulked-up” volume associated with cuttings. Especially deploying very coarse scalp cut screens.

2. **Minimize Frictional Losses** - Keep all lines as short & straight as possible with a minimum number of pipe fittings. This will reduce loss of pressure head on the feed line and minimize any backpressure on the overflow discharge line. Do not reduce the diameter of the overflow line from that of the overflow discharge manifold.
3. **Overflow Discharge Line** - Direct the overflow line downward into the next downstream compartment at an angle of approximately 45%. Installation of the overflow discharge line in a vertical position may cause vacuum on the discharge header and pull solids through the cyclone overflow, reducing the cyclones efficiency. Keep the end of the discharge line above the surface of the mud to avoid creating a vacuum in the line.
4. **Equalization Line** - Install a low equalizer line to permit backflow in to the desander section.

Operating desanders at peak efficiency is a simple matter, since most desanders are relatively uncomplicated devices. Here are a few fundamental principles to keep in mind:

1. **Operating Pressure** - Operate the desander unit at the recommended feed manifold pressure, usually around 30 PSI. A feed pressure too low decreases efficiency and a pressure too high puts un-due wear & tear on the cyclone.
2. **Cone Inspection** - Check cones regularly to ensure the discharge orifice is not plugged. Maintenance of desanders normally entails no more than checking all cone parts for excessive wear and flushing out the feed manifold between bores. Large trash may collect in feed manifold, which could cause cone plugging during operation. Preventive maintenance minimizes downtime & repairs are simpler between bores, rather than during drilling operations.
3. **Recirculation** - Run the desander continuously, letting fluid overflow back and process over & over. Many systems in the market allow for only one pass through the desanders. Yet, due to their inefficient nature, this is insufficient to achieve a proper cut. Only the overflow from the desanders should be allowed to move to the next cleaner tank.
4. **Spray vs. Rope Discharge** - Operate the desander with a light spray rather than a rope discharge to maintain peak efficiency.

4.4.2 - Desilters

As noted in Table 7, a desilter uses smaller hydrocyclones, usually 5" or smaller. The smaller cones enable desilters to make the finest particle size separation of any full flow solids control equipment. Removing particles of 25 microns and larger. Multiple cones are normally used in this application to obtain the required capacity needed for a solids control system. When installing a desilter, follow these general recommendations:

1. **Sizing** - Size the desilter to process 100-125% of the total mud circulation rate.

2. **Flow Arrangement** - Take the desilter suction from the compartment receiving fluid processed by the desander.
3. **Minimize Frictional Losses** - Keep all lines as short & straight as possible with a minimum number of pipe fittings. This will reduce loss of pressure head on the feed line and minimize any backpressure on the overflow discharge line. Do not reduce the diameter of the overflow line from that of the overflow discharge manifold.
4. **Feed Pump** - Do not use the same centrifugal pump to feed both the desander & desilter. If both pieces of equipment are to be operated at the same time, they should be installed in series and each should have its own pump.
5. **Overflow Discharge Line** - Direct the overflow line downward into the next downstream compartment at an angle of approximately 45%. Installation of the overflow discharge line in a vertical position may cause vacuum on the discharge header and pull solids through the cyclone overflow, reducing the cyclones efficiency. Keep the end of the discharge line above the surface of the mud to avoid creating a vacuum in the line.
6. **Equalization Line** - Install a low equalizer line to permit backflow in to the desander section.
7. **Inlet Pretreatment** - If a shaker scalping cut is not taken prior to the hydrocyclones, install a guard screen over the suction with 1/4" slots to prevent large trash from entering the unit and plugging the cones. Typically, desilters should not be run directly from the mud pit without some form of scalp cut to remove out large coarse solids.

Operating a desander ahead of the desilter takes a big load off the desilter and improves its efficiency. Operating desilters at peak efficiency is much the same as operating a desander. Here are a few fundamental principles to keep in mind:

1. **Operating Pressure** - Operate the desilter at the recommend pressure 32 - 40 PSI.
2. **Apex Adjustment** - As solids increase, the cone apex can be opened slightly to help increase solids removal.
3. **Cone Inspection** - Check cones regularly for bottom plugging or flooding, since a plugged cone allows solids to return to the active mud system. If a cone bottom becomes plugged, unplug it with a skinny long rod. If a cone is flooding it may need to be adjusted or the feed may be partially blocked off. It should also be inspected to make sure the cone is not worn out. A desilter's smaller cyclones are more likely than a desander's cones to become plugged with oversized solids, so it is important to inspect them often for wear and plugging. This may generally be done between bores, unless a failure occurs. The feed manifold needs to be flushed and checked for debris between bores.
4. **Recirculation** - Run the desilter continuously, letting fluid overflow back and process over & over.

4.4.3 - Centrifugal Pumps

Another important aspect of a well engineered solids control system is the use of centrifugal pumps. Centrifugal pump not only mix the mud to be pumped down the bore hole, but also provide the feed pressure and volume required to operate the hydrocyclones. Maintenance of these pumps is essential to the operation of your solids control equipment. The following is a list of proper maintenance procedures.

1. **Alignment** - Check alignment between motor & pump. This alignment must be correct.
2. **Bearings** - Check the bearing oil or grease on the mechanical end of the pump.
3. **Packing** - Check that gland packing is adjusted correctly not too tight. Grease gland packing per manufacturer's recommendations.

It is also important to remember that pumps will present approximately 50% of the maintenance required when operating a mud system. The nature of the abrasive formation solids constantly wears at the impellers and the seals, therefore requiring constant maintenance. As such, all efforts should be taken to ensure that the pumps utilized are conservatively operating within their performance range. Pumps operating at their operational limits (i.e. as defined by their respective pump curves) will result in a much higher level of maintenance than those pumps operating well within their performance window. Talk with the original equipment manufacturing to review the pump curves and ensure that the pumps being specified for your application (as it relates to mud weight, solids content, and viscosity) are properly sized for your application.

4.4.4 – Centrifuge Technology

Centrifuges are new to the HDD industry. Though they are relatively expensive, when compared to shakers and hydrocyclones, they resulting impact is impressive. As highlighted in Figures 2 and 4, unlike shakers and hydrocyclones, centrifuges target colloidal and ultra fine suspended solids. Depending on the operating speed of the centrifuge, operators can target specific sized solids. However, it is important to note that many clays,

Figure 7 – Elgin's KEMTRON 600XPT with On-Board Centrifuge Technology.

including bentonite, are based on solids that have a particle size distribution outside the capabilities of a centrifuge (i.e. less than 5 microns). Even then to achieve solids separation at 2 to 5 microns, the centrifuge would need to operate at its maximum speeds.

To ensure the best operation of a centrifuge, a primary treatment system must be utilized. Primary treatment systems refer to the deployment of shakers and/or hydrocyclone technology as a pretreatment system prior to feeding the centrifuge. Despite the level of sensitivity and pretreatment required, by adding a centrifuge to a traditional HDD mud recycling system, operators can quadruple drilling fluid life and therefore significantly reduce waste disposal costs.

A closed-loop solids control system can be provided by adding polymer chemistry. Chemically-enhanced solids control systems can remove 100% of all suspended solids from your drilling fluid. It is the only method within the HDD industry that allows 100% recycling of an operators drilling fluid. As environmental regulations and disposal costs escalate, centrifuge technology will become a standard HDD technology.

5.0 Selecting the Proper Mud System

With large rigs it is very easy to see why mud recycling is necessary. It is practically impossible to fathom how anybody could organize logistics on and supply 600 GPM (36,000 gallons per hour) of water, 8 metric tons of bentonite and additives and disposal of similar quantities of fluid every hour. Besides the obvious logistical problem with large volumes of fluid there is the shear cost and environmental issues involved.

Due to increasing environmental concerns and the more competitive market, it has become economical to use recycling with small rigs that have only 38 GPM of flow. In places like California and Florida where jobs are stopped for toads and turtles not a single gallon of fluid can be allowed to flow into the environment. When you start to consider factors such as downtime and auxiliary equipment wear and maintenance, using recycling systems begins to make more and more sense for even the smallest jobs.

Figure 8 – Elgin's KEMTRON 600HD2-T

Summarizing the details highlighted in Section 1 and Section 2, there are three primary functions of drilling fluid:

1. To evacuate the bore - transport cuttings/spoils to the surface.
2. To provide lubricity for reduced friction.
3. Build Wall Cake in bore for reduced fluid loss.

Maintaining good drilling fluid makes your jobs more efficient and in many cases the fluid is what makes the jobs successful. By recycling your drilling fluid with a good system you can maintain your drilling fluid throughout a project while decreasing your water, disposal and additive costs as well as reducing downtime and increasing the life of your triplex pumps, mud motors, and drill gear. The use of packaged recycling system provides for several operational advantages.

These become more clear when evaluating the nature of systems that provide only a mixing and pumping unit. A mixing and pumping system requires the following:

1. Continuous make up of drilling fluid for the length of the job.
2. Disposal of spoils (return mud).
3. Additional requirements of fresh water, bentonite, and chemicals.

A mixing and pumping system does not:

1. Clean sand in starting bentonite mud.
2. Clean sand from river water when used to make up mud.
3. Reduce downtime because of having to wait on fresh water or disposal trucks.

In contrast, a recycling/mixing system allows:

1. The clean-up of starting bentonite mud to extend life of pumps, drill gear, and mud motors.
2. For the minimization of water usage, bentonite, and additives for the make-up new mud.
3. For the minimization of disposal fees, trucking costs, and driver/operator costs.
4. For the reduction in downtime waiting on fresh water and disposal trucks.
5. Contractors to be viewed as environmentally friendly.

5.1 – Defining the Capabilities and Size of a Mud Recycling System

Though there is no industry standard, but after building hundreds of mud recycling systems for the industry over the last decade, Elgin has developed a great deal of practical experience when it comes to sizing a mud recycling system. Generally speaking, a mud system should be no smaller than 120% of the mud pump capacity, but no larger than 150% of the mud pump capacity. Installing a mud system that matches the maximum hydraulic capacity of the mud pump will not sufficiently take into account the "bulked up" volume of drilling fluid created when returns are coming back from the hole rich in drilled solids.

Conversely, systems that are too large will not sufficiently maintain the hydraulic balance, when employing technologies, such as hydrocyclones or mud guns. As an example, if a rig were drilling with 400 gpm of drilling fluid, but you were using a 1,000 gpm mud system, then the two 500 gpm desanders would be starved and would provide a very poor cut. In addition, if your mixing system deployed mud guns only, you

Figure 9 – Elgin's KEMTRON 1500HD2

would continuously be pulling from the clean tank to feed the mud guns quicker than the clean tank could be filled. These are but a few examples of why selecting the proper mud systems should be carefully considered.

The unit should be able to clean, continuously, even with a solids loading of 20-30% with a viscosity of 70 seconds (marsh funnel). In cases where higher viscosity muds are anticipated recycling unit manufactures must be appraised of the situation, as this can significantly affect pump motor and impeller sizing.

Different manufacturers emphasize different aspects of their units as being factors that affect the capacity. Some emphasize the tank volume, some emphasize the screen area and G-force of the vibrating shaker, some focus on the capacity of the hydrocyclones, and others emphasize the micron size of the particle removed by the hydrocyclones. Both the shaker and the hydrocyclones are critical components that contribute towards defining the capability of a system. Individually these are all important, but none singularly can dictate the recycling capacity or the quality of the final clean fluid. Ultimately, the recycling capacity is defined by a combination of soil conditions, operation conditions, and recycling system specifications.

Figure 10 – Elgin's KEMTRON 400HD2-T

It is also important to understand that a single mud system is not to be purchased for a single job. The goal is to deploy the mud system under a number of conditions on a number of job sites. As such, mud systems that can be easily reconfigured or inherently include operational flexibility should be of a key concern. Some systems will only work on a very narrow band of operational conditions. It is important to understand what those limitations are before securing a new system.

5.2 – Key Mud System Selection Considerations

The key is to clearly understand what you are paying for. Not all mud systems are created equal, despite industry attempts to use "hydraulic capacity" as the defining feature. This would be no different than saying that all food was defined by its calories, versus its nutritional benefits, additives, flavor, and texture. Yes, a 200-calorie soda has the same caloric content of a 200-calorie apple, but they are obviously quite different. Mud systems in the HDD industry are no different.

Note - Not all mud systems are created equal, despite industry attempts to use "hydraulic capacity" as the defining feature.

Simply defining the quality of the mud system based on how much can be pumped through it, simply does not define the overall effectiveness or durability of the unit. Operators need to consider the drilling rig that the mud system will be connected to, the expected soil conditions, anticipated mud properties, bore length, and rate of penetration. Even when keeping all of these conditions in mind, it is easy for mistakes to be made. Some common selection pitfalls are highlighted in Table 8 below:

Table 8 - Pitfalls	Cost	Quoted System Capacity	Actually Received	Lesson Learned	Punchline
1	$40,000	1,000 gpm	A 1000-gallon tank with one vibrating shaker and no screens. There was no pump to transfer fluid to the unit, no generator to power the system, no hydrocyclones to further clean the fluid and no pump to transfer the fluid back to the rig.	He got what he paid for. For $40,000, not much more could have been provided. He felt cheated, but his biggest fault was ignorance.	He had no written detailed specifications, no performance guaranty, and no warranty from the supplier. He had paid for the equipment and had no recourse.
2	$20,000	4,200 gpm	4,200 gallon tank with several partitions and a series of pumps.	There has never, yet, been a triplex rig pump that could pump 4200 GPM. His system was incomplete and relied more on allowing the spoils to settle in the tank, which at the end of the day needed to be vacuumed out of the bottom of the tank.	Tank capacity is only one key factor in system performance. More importantly, system maintenance and operational costs must be taken into account when selecting a system. The capital cost will only be 25% of the lifetime costs of maintaining and operating a mud recycling system.
3	$70,000	300 gpm	A mud system with three 5” hydrocyclones and a small shaker.	5” hydrocyclones can only manage 80 gpm per cone, equating to 240 gpm. In addition, the shaker lacked sufficient surface area to quickly remove course solids.	Cone capacity is bit one key factor in system performance and must be able to handle 125% of the mud pump capacity. In addition, there must be hydraulic balance between hydrocyclones and the shaker(s).
4	$40,000	230 gpm	A 230 gpm mud system, but the pumps were undersized and could not handle more than 150 gpm, based on the mud weight.	You get what you pay for. All pumps are not equal and it is important to understand the hydraulic capacity of the pumps based on the anticipated mud weight that they will be exposed to.	A mud system is more than just shakers and hydrocyclones. The pumps incorporated must be carefully considered as they are critical to the successful operation of a mud system and are the center for approximately 50% of all mud system down time.
5	$400,000	600 gpm	Packaged mud system with two shakers, desanders and desilters on a 55’ rock-over trailer.	During the first river crossing, the system could not handle more than 200 gpm. At higher flow rates, the sand content in the clean fluid was greater than 7%, causing major damage to the down-hole pump.	A mud system is critical to keeping your mud costs in check. However, a bad mud system can dramatically increase your maintenance and operations expenses of ancillary equipment.

What all of these contractors should have known in order to make informed decisions:

- **Do Your Homework** - The first advice to contractors would be to carefully review the available technical information. HDD mud system companies have done an excellent job over the last few years providing published data that can be found on their own websites. Brochures provide a lot of technical information, but not necessarily all or the right information. Be sure to understand clearly what the level of drilling fluid cleanliness is and where you want to spend your money. In some cases, when the job is short and there is little expected need for the mud system in the future, buying cheap may be the best option.

- **Ask for References -** Ask manufacturers to provide a reference list with names and contact information. Talk to these references to find out the pluses and minuses of the recycling/mixing system, what type of rig they utilized, and what kind of drilling conditions they encountered while using the system? There is a wealth of knowledge available free of charge that will quickly enable you to identify the type and capacity of a mud recycling system needed to suit your conditions. In some cases, getting good field feedback can lead you into having custom options integrated into your system.

- **Look to the Mud** - Another valuable source of information is your supplier of bentonite and drilling additives, including polymers. Discuss with them the kind of projects you plan, the highest viscosity required to perform the job, and the kind of return mud volume anticipated with percentage of solids spoils loading. A mud system must be able to manage the mud, not just the total volume of mud to be cleaned.

- **Consider ALL of Your Assets** – A mud recycling system can influence the performance of and the costs associated with running your other assets. Specifically, a poor mud system can cause your drilling fluid costs to increase and your maintenance costs of your mud pump to increase unnecessarily. These are expensive by-products of a poor performing mud system.

Figure 11 – Elgin's KEMTRON 1000HDX

The table below shows which Elgin package systems to pair with the most common HDD rigs on the market.

	American Auger ™						Ditch Witch™				Herrenknecht™						
	DD-110	DD-155T	DD-220T	DD-440T	DD-660RS	DD-1100RS	JT20	JT30	JT60	JT100	HK80CK	HK100C	HK150C	HK250C	HK400C	HK500T	HK600T
KEMTRON 200HD2							✓	✓									
KEMTRON 400HD2	✓								✓								
KEMTRON 600HD2										✓							
KEMTRON 1000HD2		✓	✓								✓	✓	✓				
KEMTRON 1500HD2			✓	✓	✓	✓								✓	✓	✓	✓

	Prime Direct ™				Universal HDD ™								
	PD 70/13 CU	PD 110/23 CU	PD 180/33 CU	PD 225/52 CU	UNI 22 x 22	UNI 30 x 40	UNI70 X 90	UNI 80 x 100	UNI 110 x 120	UNI 160 x 240	UNI 220 X 240	UNI 250 X 400	UNI 440 X 700
KEMTRON 200HD2					✓	✓							
KEMTRON 400HD2							✓	✓					
KEMTRON 600HD2									✓	✓	✓	✓	
KEMTRON 1000HD2											✓	✓	✓
KEMTRON 1500HD2	✓	✓	✓	✓									✓

	Vermeer ™									
	D20 x 22	D36 x 50	D60 x 90	D100 x 120	D100 x 140	D220 x 300	D330 x 500	D500 x 500	D1000 x 900	D1320 x 900
KEMTRON 200HD2	✓	✓								
KEMTRON 400HD2			✓							
KEMTRON 600HD2				✓	✓					
KEMTRON 1000HD2					✓	✓				
KEMTRON 1500HD2							✓	✓	✓	✓

Table 9: Elgin Package System Paired with HDD Rigs

5.3 – Key Operating Specifications for Consideration When Comparing Options

Selecting a proper mud system requires more than good references and experience. As with all technology, systems evolve with time. Consequently, there are a few considerations that should be taken into account at a minimum when selecting a new mud system:

5.3.1 - Clean Mud Quality

Since igneous rock is extremely abrasive, it is preferable to have a sand content of less than 0.5% in the recycled clean drilling fluid to minimize wear and tear on your mud motors, triplex pumps, and drill gear. Most motor and pump manufactures desire the clean fluid sand content of 0.5%, but do not tolerate anything over 2%. If you will be drilling rock, sandstone, limestone, unconsolidated sand formations or sticky fragile clays the volume of return mud, the solids loading and the quality of the clean mud become extremely critical.

Achieving good mud quality requires operational harmony between each of the systems deployed. A mud system cannot afford to have a good shaker, without good pumps or a good hydrocyclone system without good screens. All systems must design to interact with a single purpose.

5.3.2 - Vibrating Shakers

Vibrating shakers are identified by three critical factors:

1. Screen surface area
2. G-Force
3. Conveyance

However, there are several other factors that need to be kept in mind, such as the operational flexibility. Can the shaker be adjusted while drilling? Can the screens be installed efficiently? Can the shaker performance be adjusted relative to the operating conditions and subsurface lithology?

Note - Discards with a high percentage of clay will appear wet due to the water trapped within the Clay. Clays are hydrophilic and will carry a great deal of moisture with them when they leave the shaker. It is important to recognize that the performance of a mud system should not be judged on the dryness of the solids being removed from the drilling fluid, but the overall cut point being achieved. Angle of the shaker should be adjusted depending on the conditions. With a linear motion shaker the deck of the shaker can be angled up to allow for longer fluid residence time on the screen – creating dryer solids discharge.

Note - Most HDD units today are built with linear motion shakers. If using a linear motion shaker then the mud system should be rigged-up at a zero degree level (i.e. flat plane). If a flat plane cannot be achieved, then it is important that the discharge end of the shaker is pointed in the upward direction. When the angle of the shaker is pointed in the downward position or at a negative inclination, the solids will leave the shaker wetter. Positioning the system correctly will help achieve dryer solids discharge.

As highlighted by Section 4.2, it is important to keep in mind that the shaker is not the defining feature when it comes to achieving good cut point performance. Ultimately, the screens are responsible for the shakers performance. As outlined by API 13C, shaker screen performance is defined by two critical factors:

1. Conductance (kilodarcy/mm2)
2. D-100 Cut Point (microns)

It is a known fact that large screen area of the shaker and high G-Force applied to the shaker bed permits the use of finer screens with greater throughput. However, it also needs to be recognized that the higher the G-force the higher the screen consumption. Utilizing shakers that can vary their G-force will ultimately help improve operational performance. Consequently, changing the G-force will not change a screens cut point. Screen selection is a key factor to achieving dry solids discharge. Screens may need to be changed as drilling conditions vary. In addition, more modern shakers now provide the operator the ability to change the shaker excitation from linear motion to balanced elliptical motion and/or even change the G-force through a VFD. All of these factors can significantly influence the discharge dryness.

Note - If your hydrocyclones leaking between the “nut” and the “body”, check the level of tightening applied. The Apex Nut should not be tightened too tightly as to not allow solids and liquids to exit the hydrocyclones. The Apex Nut should be hand tightened only. Hydrocyclones should also be checked regularly to make sure the apex has not worn out causing a rope discharge of fluid. An umbrella spray means the cone is working correctly and efficiently

5.3.3 - Hydrocyclone Capacity

As highlighted in Section 4.4, hydrocyclones with varying cone diameters have specific throughput capacities and cut points. Larger cones can handle higher capacities; however, they have a coarser micron cut. Smaller cones, while having a reduced capacity, allow for a finer cut. With large flow rates where solids loading tends to be high it is advisable to use 10” or 12” cones, often termed desanders, to remove >80 micron plus particles. This will then be followed by pumping the overflow from the desanders through smaller cones, termed desilters, which will remove >25 micron particles. In projects involving small flow rates, because of the lower solids loading in the return mud, it is possible to combine the desanding and desilting by processing the fluid through small diameter abrasion resistant cones.

Note - Even if the system is appropriately sized to handle the drilling fluid returns from a cleaning perspective, a mud system must also have sufficient “clean tank” capacity in order to allow for practical mixing of drilling fluid batches.

5.3.4 – Mud Mixing and Capacity

A large mud hopper with a properly sized venturi is an essential part of the mud mixing and recycling system. Bentonite mud and polymers need to have shear energy imparted to allow for quick hydration and dispersion. Good quality bentonite may

Note - If your liquids tend to run along one side of your shaker adjusted the level the system. If this is not achievable, then try adjusting the jacks on your linear motion shaker. If this does not correct the problem, then you may need to adjust the vibrator motors as it is possible that one of the motors weights has slipped.

contain 2% to 8% sand while construction grade bentonite may contain 6% to 15% sand. Therefore the recycling system must be integrated into the mixing system to allow you to remove sand from the newly mixed mud.

However, simply having a mud system that mixes well is only one consideration. An operator must also carefully consider the size of each mud batch that can be made. Too small of a clean tank will not only make operational more difficult, but it can leave your down-hole mud pump to starve or run dry. This is a common oversight made by rig operators. Elgin recommends that the clean tank provide for at least two minutes or residence time as calculated by the volume of the tank divided by the down-hole pump rate. If the clean tank is 2,000 gallons and the down hole pump needs 500 gallons per minute, then 2,000 divided by 500 would provide 4 minutes of residence time.

5.3.5 - Agitation

In order to allow the solids to be removed by the vibrating shakers and hydrocyclones they should not be allowed to settle at the bottom of the tank. It should not be necessary for you to have to vacuum out the bottom of the tank once a day or even once a week to remove the settled spoils. Agitation suspends the solids in the fluid and allows the recycling equipment to do its job of removing the solids.

Figure 12 – Elgin's KEMTRON 200HD2-S

5.3.6 – Transportation and Logistics

If you are working in a city or along narrow easements you may need a trailer-based system, however, other aspects come into play. You may want to consider a recycling system that has rear solids discharge. This allows you to park your recycling unit behind the rig with a dumpster behind it, to collect the spoils discard.

If you are planning to use the unit overseas you need to consider a skid-based unit that can be loaded on a freight carrier and unloaded on location. If location is remote, far from main roads, a skid based system under 20 tons, can be picked up by a construction crane and walked to location, close to the rig. This may be especially critical in the case of river crossings with difficult access.

5.3.7 – Centrifugal Pumps and Impeller Selection

The pump flow rates, whether the mud mixing/hopper pump or the desander/desilter pump, should be able to achieve designed flow parameters at 65-75 feet of head. Trash and Transfer pumps should be adequately sized to pump the fluid at maximum flow rate from the recycling unit to the rig pump, or from the pit to the recycling unit.

The selection of the pumps may not require a great deal of evaluation, if they are properly sized by the mud system original equipment manufacturer. However, it should be noted that pump performance (including effluent pressure and volumetric flow rate) are highly influenced by the specific gravity of the drilling fluid.

Simply knowing the size of the pump inlet and outlet (i.e. 4" x 3") is not enough when specifying or replacing pumps. The pump impeller and motor size are critical features. If you are replacing a pump within an integrated system, make sure to replace the pump with an impeller and/or motor of the same specifications. As an example, replacing a 4x3 pump that included an 11" impeller with a new 4x3 pump with 13" impeller will indeed allow the pump to push more volume. However, due to the amperage draw on the motor, the motor will trip during use.

5.3.8 – Training and Commissioning

The manufacture should provide on-site start up and training for all newly purchased recycling systems. Just as with any capital equipment purchase, the buyer should expect training and assistance from the supplier and prompt service for the life of the equipment. Ultimately, mud systems do not run themselves and operator attention is required. As such, the quality of your operators and the level of training that they have will greatly influence the operational and cost effectiveness of any system, regardless of the manufacturer.

5.3.9 – Power

Different clients have different requirements. Most recycling systems in North America come complete with an integrated generator to power the unit. Generator size is critical to ensure adequate power supply for both starting peak and operating load as well as be able to power additional items such as area lighting, power tools, trash pump, etc.

It is also important to note that some urban areas now enforcing noise limitations and emissions limits for the use of generators. Selecting sound attenuated generators and/or generators that meet various EPA standards (i.e. Tier III Air Emission Standards) must be taken into account.

5.3.10 – Trailers

Trailer axles and tires should be adequate to handle varying road conditions and load requirements. Trailer jacks should have at least 25% more capacity than maximum operating live load. It is also important that the manufacturer carefully consider the loads center of gravity when operated upon a trailer and the impact a live-load has on the axels.

A trailer that cannot support the system when full of drilling fluid is worthless considering how heavy bulk drilling fluids are when maintained within a mud system.

Note – It is not recommended to pull a recycling unit while it is full or even partially full. However, as a matter of convenience, some contractors move recycling units short distances against the manufacturers recommendations. It is advisable for the operator to check with the manufacture to make sure the trailer axles are properly sized to handle this task in order to prevent damage to the trailer.

Note – The kind of hose used for transferring fluid from the pit to the unit and from the unit to the rig can affect the effectiveness of the pumps. High friction hose such as collapsible fire hose can lower the distance the pump can transfer the fluid while other thick-wall rubber hoses or PVC pipe will provide you will further transfer capabilities. Always check what feet of head at what capacity the pump should be able to handle. Make sure the pump will meet your

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5.3.11 – Special Features

Most experienced mud system manufacturers provide a variety of custom options and special features available. These may include winterization, environmental protection features (i.e. spill pans), custom paint, and multiple sampling valves. Ask your manufacturer about the special features that can be added to your unit.

5.4 – When to Dump?

No shaker / hydrocyclone combination can consistently and/or effectively remove particles less than 25 microns. The dispersion of this fine clay creates excessive build up of viscosity creating a host of problems. In these situations the old practice was to dump and dilute. This is no longer permissible due to increasing environmental restrictions.

With a good system you should not need to dump the fluid and make new fluid. By using basic mud testing equipment such as a marsh funnel, sand content kit and mud balance, fluid can be sampled and maintained. However, drilling through special formations with fragile, hydratable clays is a problem. These clays, being submicron in particle size, quickly disperse into the water phase and are not easily removed by standard recycling systems. In such cases, centrifuge technology is required (See Section 4.4.4). In the worst of case, centrifuge technology coupled with polymer enhancement will be required.

Today's methodology is to treat this situation with the use of centrifuges or dewatering units, otherwise known as chemically enhanced centrifuge separation. This allows for the separation of drilling fluid to clear water and solids. The clear water can either be added back to the fluid for dilution purposes or used for making new mud. Though there are conditions in which a simple centrifuge will be more than sufficient, when dealing with colloidal and ultra-fine solids, coagulation and/or flocculation are your only options for achieving an effective cut point.

Figure 13 – Elgin's Mobile Dewatering Technologies

Section 6 – Summary

Elgin's Package Mud Reclamation Systems are designed for durability, reliable and consistent performance. This performance comes from a combination of proprietary design considerations that Elgin religiously maintains with each unit it sells. The three driving design philosophies include "Hydraulic System Balance", "Operational Residence Time", and "Continuous Recirculation". It is the combination of these design principles that sets Elgin's products apart.

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6.1 - Hydraulic Balance

Figure 14 – Elgin's KEMTRON 1500HD2

To start, each Elgin mud system must be hydraulically balanced. This means that the shaker scalping pass, hydrocyclone pass, hydrocyclone feed pump, mud gun / hopper pump, and transfer pump must be equally rated to support the rated capacity of the system. As an example, when it comes to Elgin's KEMTRON 600T, the scalping pass is designed to handle 600 gpm, the hydrocyclones are designed to handle 600 gpm, and each of the pumps are designed to handle 600 gpm. This same design consideration is taken into account for each Elgin mud system.

6.2 - Operational Residence Time

Hydraulic balance simply ensures that all the individual components of the system work harmoniously together. However, to maximize the operational practicality of the system, Elgin requires each of its systems to have a net minimum hydraulic residence time of 5 minutes. In going back to Elgin's KEMTRON 600, as the unit is rated for 600 gpm, then the total tank capacity must be at least 5 times 600, or 3,000 gallons. At 3,100 gallons, Elgin's KEMTRON 600T maintains our minimum designed residence time targets. By achieving this target, the operators are provided enough time to respond to changing conditions, the chances of starving the down-hole pump are reduced, and lighter fluids are allowed to decant from the dirty tank to the clean tank, further enhancing the mechanical separation aspects of the shaker and hydrocyclones.

6.3 - Continuous Recirculation

Finally, Elgin's "secret sauce" for optimum system performance is a tried and true design feature called Continuous Recirculation. Elgin's systems are designed to allow the hydrocyclone overflow (clean cut) to recirculate back to the same tank that the hydrocyclones were fed from. Until this feed tank (typically the dirtier tank) fills, the clean overflow from the hydrocyclones will not overflow into the cleaner tank. Not only does this allow the drilling fluid to be recirculated through the hydrocyclones several times, but it also dilutes the feed to the hydrocyclones, therefore allowing a significantly improved cut capability. By allowing the drilling fluid to pass through the hydrocyclone system a number of times in a diluted state significantly improves the overall performance of the system.

However, there are also situations in which such a configuration may not be best suited. As such, Elgin has incorporated "Splitter Boxes" allowing operators the option of managing their mud system in Continuous Recirculation or in a Single Pass mode.

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It is Elgin's commitment to integrating each of these design features into the industry's most durable solids control platform, that has earned Elgin the reputation as the industry's most reliable "go-to" system. If your focus is quality, reliability, durability, and timely support, then look no further. Elgin provides "Durable Value. Now."

To learn more about solids control and waste management equipment visit www.ElginSeparationSolutions.com or email us at Elgin.info@Elginps.com.

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KEMTRON 400HD2

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