CHAPTER

8

# Solids Control

## Introduction

***The types and quantities of solids present in drilling mud systems determine the fluid’s density…***

The types and quantities of solids present in drilling mud systems determine the fluid’s density, viscosity, gel strengths, filter-cake quality and filtration control, and other chemical and mechanical properties. Solids and their volumes also influence mud and well costs, including factors such as Rate of Penetration (ROP), hydraulics, dilution rates, torque and drag, surge and swab pressures, differential sticking, lost circulation, hole stability, and balling of the bit and the bottom-hole assembly. These, in turn, influence the service life of bits, pumps and other mechanical equipment.

Chemicals, clays and weight materials are added to drilling mud to achieve various desirable properties. Drill solids, consisting of rock and low-yielding clays, are incorporated into the mud. These solids affect many mud properties adversely. Nevertheless, since it is not possible to remove all drill solids — either mechanically or by other means — they must be considered a continual contaminant of a mud system.

Solids removal is one of the most important aspects of mud system control, since it has a direct bearing on drilling efficiency. Money spent for solids control and for solving problems related to drill solids represents a significant portion of overall drilling costs. Solids control is a constant problem — every day, on every well.

## Fundamentals

Drilling mud solids may be separated into two categories: *Low-Gravity Solids (LGS)*, with Specific Gravity (SG) in the 2.3 to 2.8 range, and *High-Gravity Solids (HGS)*, with SG of 4.2 or higher. Weight materials such as barite or hematite comprise the HGS category and are used to achieve densities greater than 10.0 lb/gal (SG>1.2). Drill solids, clays and most other mud additives fall into the LGS category and often are the only solids used to obtain densities up to 10.0 lb/gal (SG <1.2). Figure 1 shows the recommended range of total solids content for water-base muds.

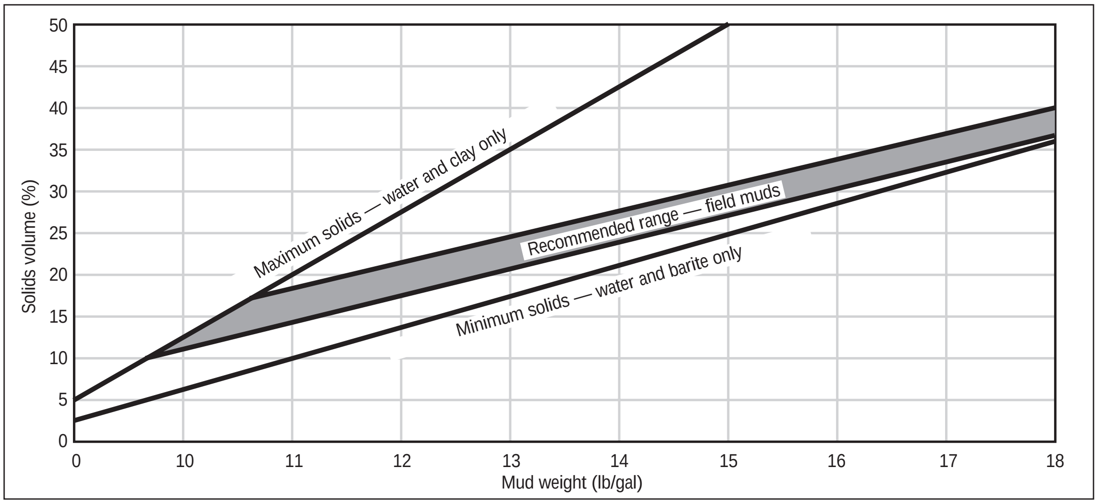


*Figure 1: Recommended range of solids in water-base muds.*

Solids control is accomplished by using one or more of the basic methods of solids separation:

- Settling.
- Screening.
- Hydrocyclones.
- Rotating centrifuges.

Hydroclones and centrifuges use centrifugal force to obtain higher rates of separation than can be achieved by gravitational settling. These methods are similar to settling and are governed by well-known laws of physics. If the mud is kept moving so that the gel strengths are broken, then the settling of particles is governed by Stokes' law, which is:

$$V_S = \frac{g_C\ D_S^2\ (\rho_S - \rho_L)}{46.3\ \mu}$$

*Where:* $V_S$ = Slip or settling velocity (ft/sec)
$g_C$ = Gravity constant (ft/sec$^2$)
$D_S$ = Diameter of the solid (ft)
$\rho_S$ = Density of solid (lb/ft$^3$)
$\rho_L$ = Density of liquid (lb/ft$^3$)
$\mu$ = Viscosity of liquid (cP)

This equation is a mathematical expression of events commonly observed; i.e., the larger the difference between the density of the solid and the density of the liquid ($\rho_S - \rho_L$), the faster the solid will settle; the larger a particle ($D_S$), the faster it settles; and the lower the liquid's viscosity ($\mu$), the faster the settling rate. Also, if force acting on the particles ($g_C$) can be increased mechanically, the settling rate is increased proportionally. For centrifugal motion like that found in hydroclones and centrifuges, the separating force is proportional to the diameter of circular motion times the square of the rotating speed (RPM) times the mass of the particle.

Field observations verify that low mud viscosity, combined with a low mud flow rate, promote the settling of larger and heavier solids. Therefore, the removal of sand and drill cuttings by settling or centrifugal force is practical and beneficial. If the mud contains barite, however, then it may settle, too. The only way that **all** drill solids could be separated from **all** barite would be for **all** drill solids to be of one size and for **all** barite to be of a completely different size and mass. Stokes' law shows that particles of different densities and size, with the same mass (density times volume), have exactly the same settling rate. For example, a sand or shale particle (SG 2.6) which is about 1½ times larger than a given particle of barite (SG 4.2), will settle at about the same rate (1½ x 2.6 = 3.9), regardless of where it is — settling pit, hydroclone or centrifuge. From a solids-separation point of view, it would be impossible to separate a 60-micron shale particle from a 40-micron barite particle, using settling techniques.

Hydroclones and/or centrifuges are not perfect in separating unwanted solids from the mud. However, the advantages presented by such equipment far outweigh the limitations. Each piece of solids-control equipment is designed to remove a sufficient quantity of target solids to keep drill solids at a manageable level. All mechanical solids-control equipment is designed to separate a certain range of particle sizes. It is important to use the right combination of equipment for a particular situation and to have it operating and arranged in the correct manner.

## Classification of Particle Sizes

***It is important to understand how particle sizes...are classified...***

It is important to understand how particle sizes in drilling mud are classified and the types of solids that fall into each category. Particles in drilling mud can range from very small clays, (less than 1/25,400th of an inch), to very large drill cuttings (larger than an inch). Due to the extremely small particles, sizes are expressed in micron units. A micron is one-millionth of a meter (1/1,000,000 or $1 \times 10^{-6}$ m). So, 1 in. equals 25,400 microns.

Drilling fluid solids are classified according to size in the following categories:

Table 1 and Figures 2 and 3 relate particle sizes to familiar terms, typical examples, screen mesh equivalents and to the solids-control equipment that will remove a given particle size.

Screen mesh is important because it determines the separation size for shale shakers. Figure 3 is a magnified drawing to show screen sizes increasing from 20 to 325 mesh and the equivalent particle size (in microns) that will pass through each screen. A 200-mesh screen is used for the API Sand Test, in which all particles that do not pass through the screen (>74 microns) are classified as sand. Ninety-seven percent of good-quality barite (<74 microns) will pass through 200-mesh screens and 95% will pass through 325-mesh (<44 microns) screens. Thus, most barite is in the same size category as silt. Premium clays, such as M-I GEL®, fall in the colloidal range, i.e., 2 microns or less.

The grouping of solids according to size does not take into account the

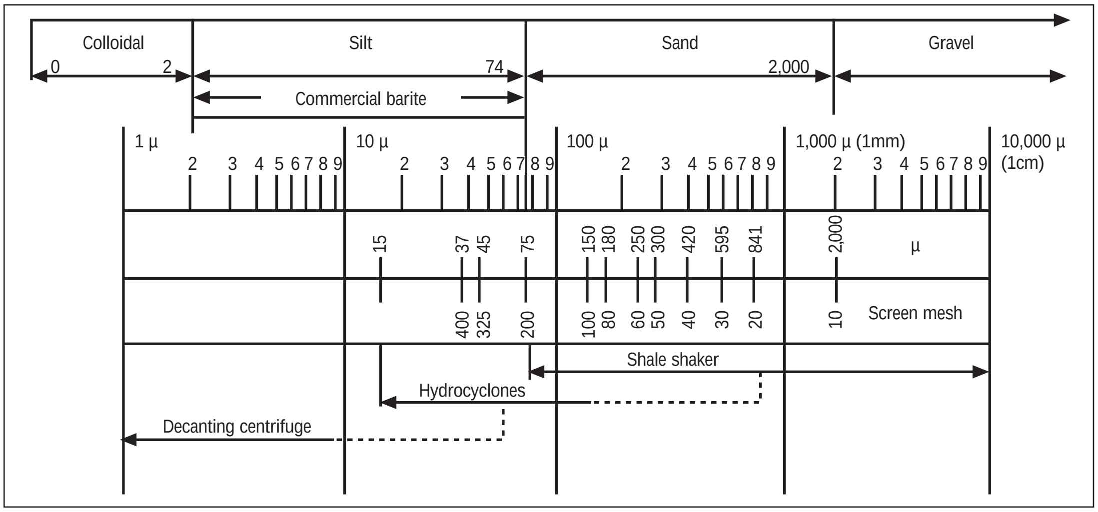


*Figure 2: Classification of particle sizes.*

| Category | Size | Example |
|---|---|---|
| Colloidal | 2 µ or less | Bentonite, clays and ultra-fine drill solids |
| Silt | 2 – 74 µ<br>(< 200 mesh) | Barite, silt and fine drill solids |
| Sand | 74 – 2,000 µ<br>(200 – 10 mesh) | Sand and drill solids |
| Gravel | Larger than 2,000 µ<br>(>10 mesh) | Drill solids, gravel and cobble |

*Table 1: Classification of solids by size.*

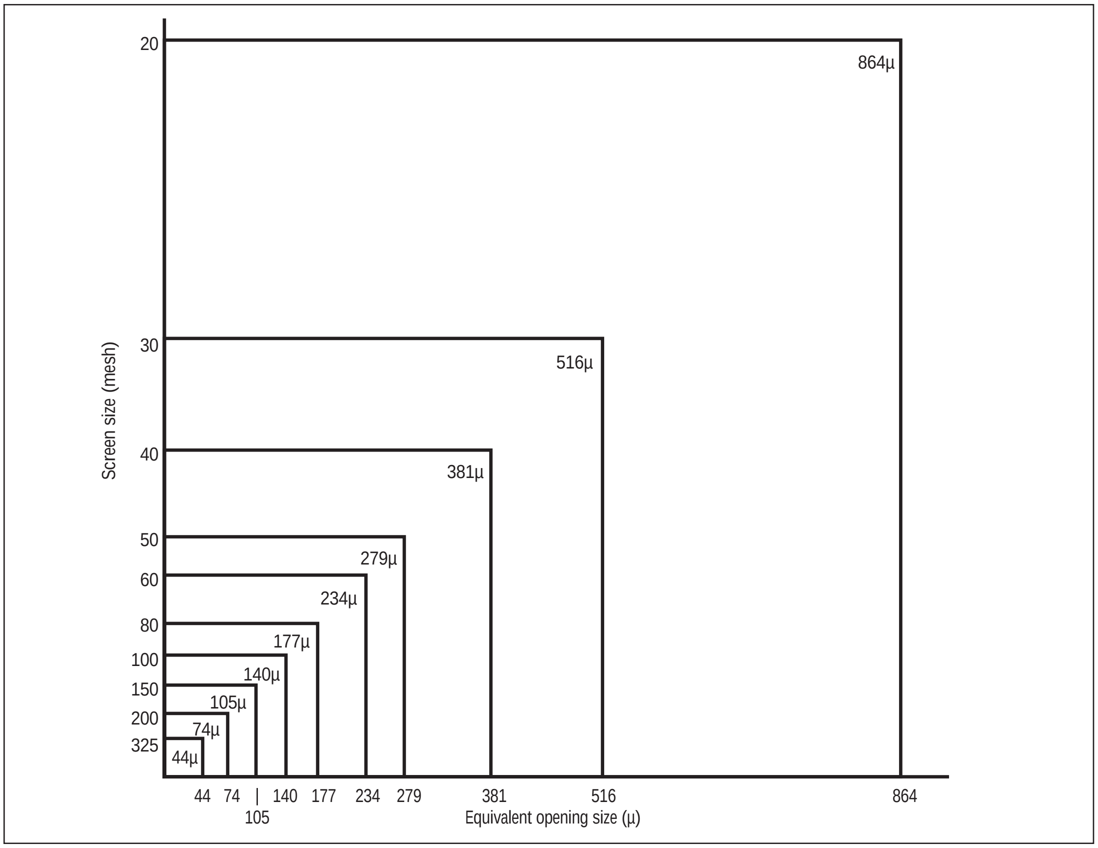


*Figure 3: Screen mesh sizes vs. opening microns.*

physical make-up of the material being measured, even though the terms "silt" and "sand" are used. For instance, silt-size particles may include shale, fine sand, fine carbonates and barite. Sand-size particles may include sand, shale, carbonates, drill cuttings plus lost-circulation material, bridging agents and coarse barite. Colloidal-size solids include bentonite and other clays; very fine drill solids (shale, sand and carbonates); and fine barite.

Generally, the term "clay", is used to describe premium ground clay minerals, such as Wyoming bentonite, which are added to increase mud viscosity and to improve the filter cake. Drill cuttings, barite and other solids, however, also will increase viscosity, especially if the particle size degrades into the colloidal range. Figure 4 illustrates how particle size affects surface area for a solid of a given volume. If an original drill solid were a 40-micron cube, it would have a surface area of 9,600 square microns. If this 40-micron cube is allowed to degrade in size to single 1-micron cubes, the number of particles will now be 64,000 and the surface area will increase to 384,000 square microns, 40 times the original. During this particle size degradation, the drill solid volume did not change. Keep in mind that a single clay platelet is only 10 angstroms thick. One angstrom is 1/10,000 microns or 1 x $10^{-10}$ m. If the 40-micron cube were allowed to break down into clay platelet thickness pieces 40 microns square, the number of particles would be only 40,000; however, the surface area would increase to 128,006,400 square microns, or 13,334 times the original surface area.

***...the term "clay", is used to describe premium ground clay minerals...***

In a drilling mud, viscosity increases proportionally with the surface area of solids. The surface area of all solids must be wetted. As the amount of liquid is reduced due to increased surface area, fluid viscosity increases and performance declines. Colloidal solids produce most of the viscosity in drilling muds due to this surface area increase. For that reason, the volume of colloidal-size solids contained in drilling mud must be controlled for the sake of economy and efficiency.

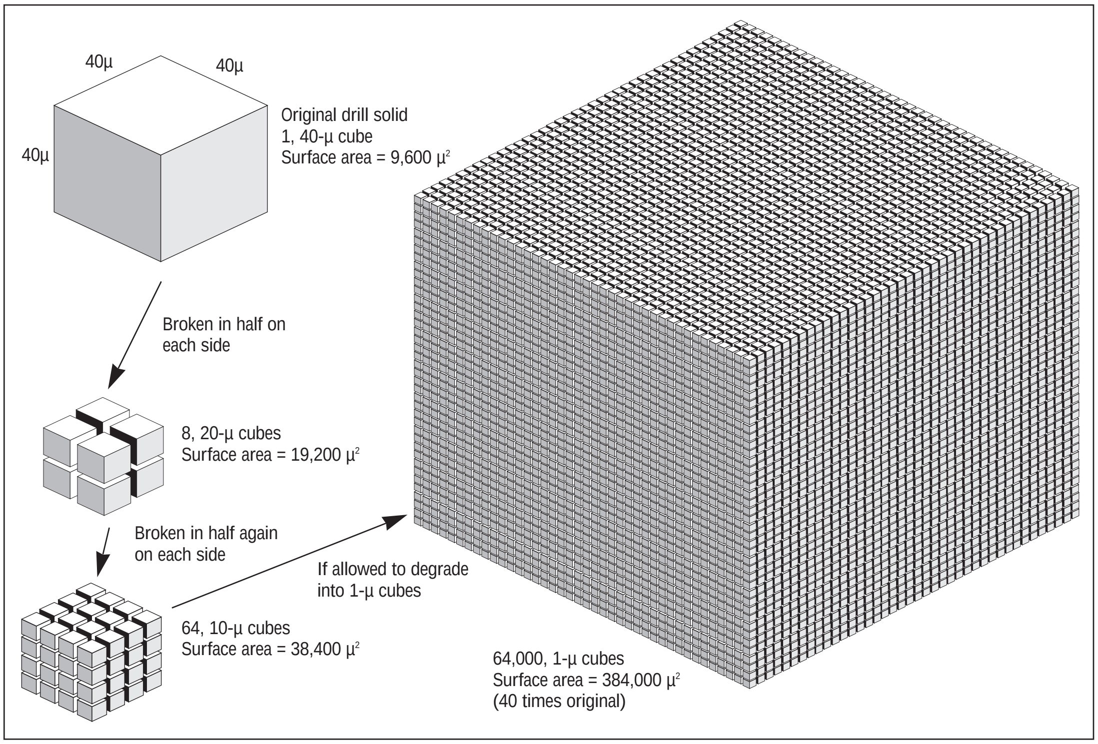


*Figure 4: Effect of particle size on surface area.*

## Methods of Solids Separation

### SETTLING PIT OR SAND TRAP

Settling pits are seldom used in modern drilling operations; however, they can be found from time to time. The rate of solids settling in settling pits or sand traps depends on (1) the size, shape and specific gravity of the particles; (2) the density of the drilling fluid; (3) the viscosity of the drilling fluid; (4) the type of fluid-flow regime; and (5) the residence time in the pit.

According to Stokes' law, effective solids settling can be achieved only when the fluid is in laminar flow. Settling rates can be increased by using low viscosities and low gel strengths. Under plug flow or turbulent flow conditions, minimal solids settling occurs, with only the very large particles tending to settle. On a drilling rig with inferior shale shakers, a sand trap or settling pit will remove some of these large drill solids. Most modern shale shakers will remove sand-size and larger solids without the need for sand traps and/or settling pits.

Solids-control equipment is rated by the volume of mud it will process and the amount and size of solids it will remove. None of the solids-control equipment used in drilling will remove 100% of the solids generated. To compare the efficiency of solids-control equipment, a *cut point* particle-size rating is used. The cut point refers

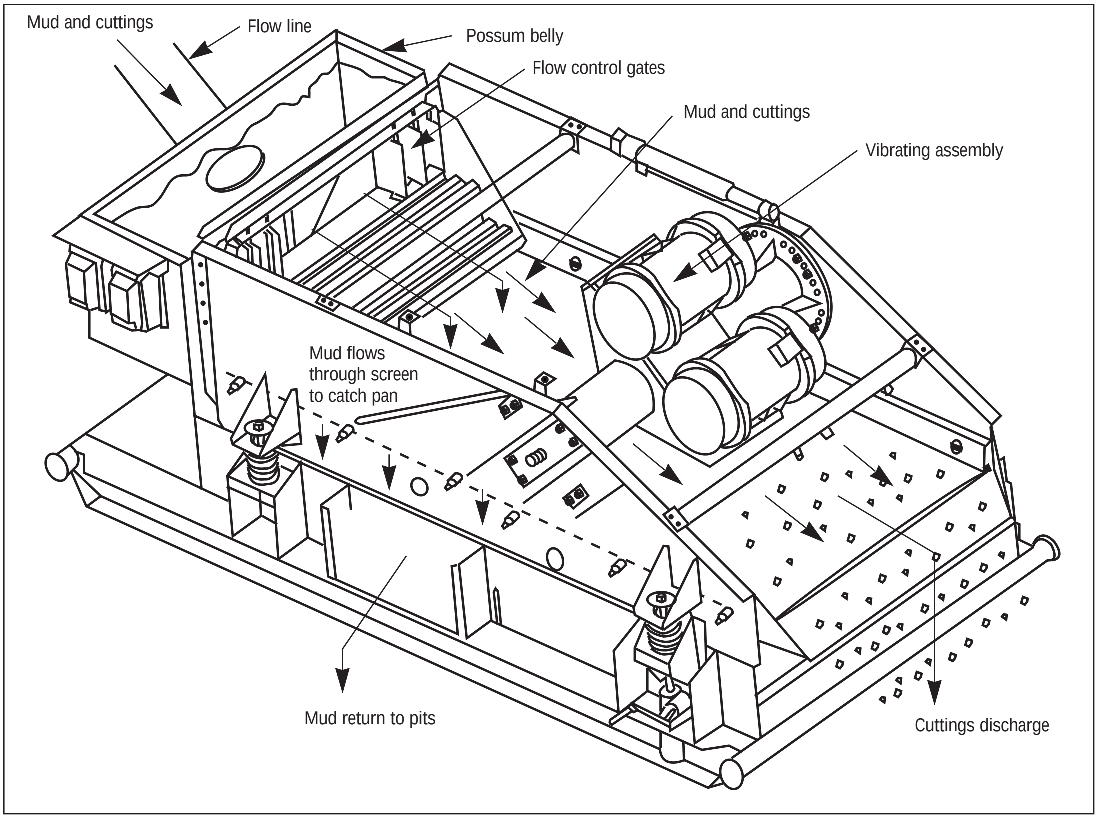


*Figure 5: Adjustable linear shaker.*

to the combination of a micron size and the percentage of that particle size removed. Cut point designations should include the percentage of the stated size removed. Cut points should always be denoted with the letter "D" with a subscript indicating the percentage removed. Without this percentage, no two cut point sizes can be compared. A $D_{50}$ cut point of 40 microns means that 50% of the 40-micron size particles have been removed and 50% have been retained in the mud system.

### SHALE SHAKERS

**The most important solids-control devices are shale shakers...**

The most important solids-control devices are *shale shakers*, which are vibrating screen separators used to remove drill cuttings from the mud (see Figure 5). As the first step in the mud-cleaning/solids-removal chain, they represent the first line of defense against solids accumulation. Shale shakers differ from other solids-removal equipment in that they produce nearly a 100% cut ($D_{100}$) at the screen opening size. As illustrated in Figure 3, a 200-square-mesh shale shaker screen will remove 100% of the solids greater than 74 microns, thereby eliminating the need for a desander. On the other hand, today's layered shaker screens, hydroclones and centrifuges have variable removal efficiencies for various particle sizes and usually are given a D rating (discussed later) for the target particle size.

Many potential problems can be avoided by observing and adjusting the shale shakers to achieve maximum removal efficiency for the handling capacity. Using screens of the finest mesh to remove as many drill solids as possible on the first circulation from the well is the most efficient method of solids control. It prevents solids from being re-circulated and degraded in size until they cannot be removed. As much as 90% of the generated solids can be removed by the shale

*Three basic types of shale shakers are in use today.*

shakers. Unless the shale shakers are operating properly, and have screens of the finest mesh possible, all other equipment is subject to overloading and inefficient operation (see Guidelines for Proper Operation of Shale Shakers page 8.23). Shale shakers cannot remove silt and colloidal-size solids, so dilution and other equipment is required to control ultra-fine drill solids.

Three basic types of shale shakers are in use today. They are:

- **The circular-motion shaker,** which is an older design on the market and generally produces the lowest centrifugal force, or G-force.
- **The elliptical-motion shaker,** which is a modification of the circular-motion type in which the center of gravity is raised above the deck and counter-weights are used to produce an egg-shaped motion that varies in both intensity and throw as solids move down the deck.
- **The linear-motion shaker,** which uses two circular-motion motors mounted on the same deck. The motors are set for opposite rotation to produce a downward G-force and an upward G-force when the rotations are complementary, but no G-force when the rotations are opposed. The G-force on most linear-motion shakers is variable from about 3 to 6.

Each shaker has some design advantages:

The circular-motion shaker has a low G-force and produces a fast transport (conveyance). This design works well with sticky, clay-type solids by reducing their impact into the screen surface. This shaker has a low capacity for drying cuttings, so wet cuttings are commonly discharged.

The elliptical-motion shaker has moderately high G-force and a slow transport in comparison to the circular or linear types. It produces the greatest drying and, therefore, has application in weighted mud or as a mud cleaner to dry the underflow from a desilter.

The linear-motion shaker is the most versatile, producing fairly high G-force and a potentially fast transport, depending on the rotational speed, deck angle and vibrator position.

Several different shaker types can be combined in a “cascading arrangement” to produce the greatest solids-removal efficiency. Circular-motion shakers are sometimes used as “scalping” shakers to remove large, sticky solids. The fluid then passes to an elliptical or linear shaker with higher G-force to remove the finer solids. This combination maximizes removal by allowing finer-than-normal mesh screens to be used on the secondary shakers.

The mud flow should be spread over as much of the screen surface as possible by using feed-control gates located between the *possum belly* (flow line-to-shaker transitional reservoir — see Figure 5) and the screen surface. Ideally, the mud should come to within 1 ft of the end of the screens. Above all, torn or damaged screens should be replaced *immediately.* For shale shakers designed with a negative slope, which forms a mud pool in front of the possum belly, beware of the potential for backflow of mud behind the mud pool, as well as the possibility that holes or tears might exist in the screens covered by the mud pool.

Occasionally, drill cuttings may be of the same size as the screen openings and will lodge in them. This is known as blinding of the screen. It will result in reduced screen capacity and loss of whole mud. To correct this problem, replace with a screen of finer mesh. The finer screen should keep the drill cuttings from plugging the opening so that they will be transported to the end of the shaker and removed from the mud system.

***A shale shaker is only as good as the mesh size and quality of its screen.***

### SHAKER SCREENS

A shale shaker is only as good as the mesh size and quality of its screen. A number of screen types are available today and performance varies. For example, a 100-mesh "square" screen removes 100% of the particles greater than 140 microns, while a high-flow-rate, 100-mesh "layered" screen removes 95% of the particles greater than 208 microns. This layered-screen performance is equal roughly to only a 70-mesh "square" screen. Often, screen selection is based on past experience, which should be combined with knowledge of the various screens and their differences in design and capabilities.

Some general terms used when describing shale shaker screens include:

**Screen mesh:** The number of openings per linear inch. For example, a 30 x 30-mesh "square" screen has 30 openings along a 1-in. line in both directions. A 70 x 30-mesh "oblong" (rectangular opening) screen will have 70 openings along a 1-in. line one way and 30 openings on a 1-in. line perpendicular. Depending on the manufacturer, wire size and weave, this 70 x 30-mesh screen may be described as: (1) an "oblong" or "rectangular" 70-mesh screen, (2) an "oblong 80" in an attempt to rate the effective rectangular opening in terms of a square equivalent or possibly (3) a 100-mesh screen. **Avoid using mesh designations when comparing screen types.** In addition to mesh count, various wire sizes and weave patterns are used that affect the opening size and flow-rate for a particular mesh size. The 100-mesh square, layered, oblong and bolted screens each removes different particle sizes.

***...D sizes are determined from a particle size distribution of the feed liquid and solids discharge.***

**Separation efficiency or 'cut point':** It is no longer sufficient to know a screen's $D_{50}$ cut point, because many modern screen types do not make a 100% cut. A $D_{50}$ cut point represents the particle size, where 50% of the particles of that size are removed by the solids-control device. The D subscript refers to the percent removed, so that in a $D_{16}$ cut, 16% of the stated micron size particles are removed and $D_{84}$ is the micron size where 84% of the solids are removed. These D sizes are determined from a particle size distribution of the feed liquid and solids discharge. The combination of the screen $D_{50}$ and the ratio of the $D_{84}$ divided by the $D_{16}$, gives a more complete picture regarding separation efficiency. The $D_{84}/D_{16}$ ratio indicates how exact or "sharp" the cut point is — where all of the solids down to a certain size are removed but none of the smaller particles are removed. A square mesh market-grade screen makes a sharp almost 100% cut point at the opening size of the screen and the $D_{50}$, $D_{84}$ and $D_{16}$ values are all the same micron size as the screen opening. Therefore, the $D_{84}/D_{16}$ ratio is 1.0 for square market-grade screens. It is most desirable to have screens with a $D_{84}/D_{16}$ ratio near 1.0; values above 1.5 are undesirable. The same D-type ratio applies to hydroclones and centrifuges where the ratio can be quite high, indicating an inexact cut point (see Figure 8).

**Open area:** The area not taken up by the wires themselves. An 80-mesh screen with an open area of 46% will handle a higher mud volume than an 80-mesh screen with an open area of 33%. The issue of open area must include whether a screen is flat or three-dimensional (such as a corrugated screen) and how much of that area actually is processing fluid. Corrugated or three-dimensional screens, on which a significant portion of the screen area always is exposed above the fluid, do not actually help process fluid.

**Conductance:** The relative flow-rate capacity or permeability per unit thickness of a screen (as per API RP13E). This is modeled on Darcy's law. Various manufacturers use different conductance units, such as kilodarcy/cm (kD/cm) or kD/mm, but it is helpful to think of these values relative to gallons per minute (gpm) per square foot of screen. This number is particularly useful in determining which screen to use based on flow coverage of the available screen area. For example, if a particular mud system has 33% flow coverage for a 6.1 conductance-rated, 50-mesh layered screen and a 66% coverage is desired, then a finer, 110-mesh, layered screen with a conductance rating of 2.94 should be used (66% ≅ 33% x (6.1/2.94)).

Although a screen of a certain mesh may be preferred or specified by an operator, keep in mind that the different screen types and the difference in manufacturers will cause different levels of performance in screens designated with the same mesh size. Screen size selection depends on conditions observed on location. If the volume of fluid being circulated exceeds the capacity of the screens (i.e., mud loss over the screens), or if the flow coverage of the screens is less than is desired, then another mesh size should be used.

Tables 2 to 13 list shaker screen values for U.S. standard sieve equivalents, square mesh market screen and the three most common screen series from several different shale shaker manufacturers.

| U.S. Sieve (mesh) | Cut Point (μ) $D_{100}$ | U.S. Sieve (mesh) | Cut Point (μ) $D_{100}$ |
|---|---|---|---|
| 3.5 | 5,660 | 40 | 420 |
| 4 | 4,760 | 45 | 350 |
| 5 | 4,000 | 50 | 297 |
| 6 | 3,360 | 60 | 250 |
| 7 | 2,830 | 70 | 210 |
| 8 | 2,380 | 80 | 177 |
| 10 | 2,000 | 100 | 149 |
| 12 | 1,680 | 120 | 125 |
| 14 | 1,410 | 140 | 105 |
| 16 | 1,190 | 170 | 88 |
| 18 | 1,000 | 200 | 74 |
| 20 | 840 | 230 | 62 |
| 25 | 710 | 270 | 53 |
| 30 | 590 | 325 | 44 |
| 35 | 500 | 400 | 37 |

*Table 2: U.S. standard sieves.*

| Screen Designation | Equivalent U.S. Sieve (mesh) | Cut Point (μ) $D_{100}$ | Open Area (%) |
|---|---|---|---|
| 16 X 16 | 27 | 1,130 | 50.7 |
| 20 X 20 | 28 | 864 | 46.2 |
| 30 X 30 | 41 | 516 | 37.1 |
| 40 X 40 | 43 | 381 | 36.0 |
| 50 X 50 | 54 | 279 | 30.3 |
| 60 X 60 | 64 | 234 | 30.5 |
| 80 X 80 | 80 | 177 | 31.4 |
| 100 X 100 | 108 | 140 | 30.3 |
| 120 X 120 | 128 | 117 | 30.5 |
| 150 X 150 | 140 | 105 | 37.9 |
| 200 X 200 | 200 | 74 | 33.6 |
| 250 X 250 | 234 | 61 | 36.0 |
| 325 X 325 | 325 | 44 | 30.5 |
| 400 X 400 | 400 | 37 | 36.0 |

*Table 3: Square mesh market grade cloth.*

| Screen Designation | Equivalent U.S. Sieve (mesh) | Cut Point (µ) | | | Conductance (kD/mm) |
|---|---|---|---|---|---|
| | | $D_{50}$ | $D_{16}$ | $D_{84}$ | |
| ALS 50 | 48 | 320 | 234 | 380 | 6.17 |
| ALS 70 | 73 | 200 | 150 | 241 | 3.76 |
| ALS 84 | 86 | 169 | 119 | 200 | 3.44 |
| ALS 110 | 97 | 153 | 107 | 182 | 2.75 |
| ALS 140 | 118 | 127 | 91 | 153 | 2.14 |
| ALS 175 | 152 | 98 | 70 | 117 | 1.78 |
| ALS 210 | 174 | 86 | 60 | 106 | 1.63 |
| ALS 250 | 215 | 68 | 48 | 82 | 1.21 |

Table 4: Swaco screens for ALS shakers.

| Screen Designation | Equivalent U.S. Sieve (mesh) | Cut Point (µ) | | | Conductance (kD/mm) |
|---|---|---|---|---|---|
| | | $D_{50}$ | $D_{16}$ | $D_{84}$ | |
| XL 50 | 48 | 320 | 234 | 380 | 6.17 |
| XL 70 | 73 | 200 | 150 | 241 | 3.76 |
| XL 84 | 86 | 169 | 119 | 200 | 3.44 |
| XL 110 | 97 | 153 | 107 | 182 | 2.75 |
| XL 140 | 118 | 127 | 91 | 153 | 2.14 |
| XL 175 | 152 | 98 | 70 | 117 | 1.78 |
| XL 210 | 174 | 86 | 60 | 106 | 1.63 |
| XL 250 | 215 | 68 | 48 | 82 | 1.21 |

Table 5: XL (Southwestern) screens for Swaco ALS shakers.

| Screen Designation | Equivalent U.S. Sieve (mesh) | Cut Point (µ) | | | Conductance (kD/mm) |
|---|---|---|---|---|---|
| | | $D_{50}$ | $D_{16}$ | $D_{84}$ | |
| DX 50 | 47 | 324 | 234 | 390 | 6.77 |
| DX 70 | 64 | 234 | 171 | 274 | 4.73 |
| DX 84 | 79 | 181 | 131 | 223 | 3.65 |
| DX 110 | 99 | 151 | 107 | 185 | 3.00 |
| DX 140 | 127 | 118 | 86 | 143 | 2.33 |
| DX 175 | 158 | 95 | 66 | 113 | 1.87 |
| DX 210 | 185 | 81 | 57 | 100 | 1.67 |
| DX 250 | 205 | 72 | 51 | 85 | 1.49 |

Table 6: Advanced DX screens for Swaco ALS shakers.

| Screen Designation | Equivalent U.S. Sieve (mesh) | Cut Point (µ) | | | Conductance (kD/mm) |
|---|---|---|---|---|---|
| | | $D_{50}$ | $D_{16}$ | $D_{84}$ | |
| PWP DX 50 | 48 | 318 | 231 | 389 | 6.10 |
| PWP DX 70 | 58 | 220 | 158 | 269 | 4.18 |
| PWP DX 84 | 78 | 181 | 127 | 218 | 3.53 |
| PWP DX 110 | 100 | 149 | 105 | 184 | 2.93 |
| PWP DX 140 | 125 | 120 | 86 | 143 | 2.29 |
| PWP DX 175 | 156 | 96 | 70 | 118 | 1.77 |
| PWP DX 210 | 174 | 86 | 60 | 104 | 1.59 |
| PWP DX 250 | 213 | 69 | 49 | 84 | 1.39 |

Table 7: Derrick PWP DX screens.

| Screen Designation | Equivalent U.S. Sieve (mesh) | Cut Point (μ) | | | Conductance (kD/mm) |
|---|---|---|---|---|---|
| | | $D_{50}$ | $D_{16}$ | $D_{84}$ | |
| PWP HP 45 | 44 | 362 | 283 | 388 | 9.51 |
| PWP HP 50 | 50 | 299 | 234 | 313 | 8.20 |
| PWP HP 60 | 57 | 263 | 207 | 278 | 6.78 |
| PWP HP 70 | 71 | 208 | 158 | 221 | 4.81 |
| PWP HP 80 | 77 | 186 | 145 | 192 | 3.93 |
| PWP HP 100 | 105 | 143 | 113 | 154 | 3.20 |
| PWP HP 125 | 121 | 124 | 100 | 133 | 2.59 |
| PWP HP 140 | 147 | 101 | 79 | 113 | 2.24 |
| PWP HP 180 | 168 | 89 | 57 | 94 | 1.82 |
| PWP HP 200 | 203 | 76 | 60 | 82 | 1.59 |
| PWP HP 230 | 230 | 62 | 52 | 72 | 1.31 |
| PWP HP 265 | 261 | 55 | 44 | 59 | 0.97 |
| PWP HP 310 | 300 | 48 | 38 | 53 | 0.85 |
| PWP HP 460 | 357 | 41 | 31 | 47 | 0.60 |

Table 8: Derrick PWP HP screens.

| Screen Designation | Equivalent U.S. Sieve (mesh) | Cut Point (μ) | | | Conductance (kD/mm) |
|---|---|---|---|---|---|
| | | $D_{50}$ | $D_{16}$ | $D_{84}$ | |
| PMD DX 50 | 48 | 318 | 231 | 389 | 6.10 |
| PMD DX 70 | 58 | 220 | 158 | 269 | 4.18 |
| PMD DX 84 | 78 | 181 | 127 | 218 | 3.53 |
| PMD DX 110 | 100 | 149 | 105 | 184 | 2.93 |
| PMD DX 140 | 125 | 120 | 86 | 143 | 2.29 |
| PMD DX 175 | 156 | 96 | 70 | 118 | 1.77 |
| PMD DX 210 | 174 | 86 | 60 | 104 | 1.59 |
| PMD DX 250 | 213 | 69 | 49 | 84 | 1.39 |

Table 9: Derrick PMD DX screens.

| Screen Designation | Equivalent U.S. Sieve (mesh) | Cut Point (μ) | | | Conductance (kD/mm) |
|---|---|---|---|---|---|
| | | $D_{50}$ | $D_{16}$ | $D_{84}$ | |
| PWP HP 45 | 44 | 362 | 283 | 388 | 9.51 |
| PWP HP 50 | 50 | 299 | 234 | 313 | 8.20 |
| PWP HP 60 | 57 | 263 | 207 | 278 | 6.78 |
| PWP HP 70 | 71 | 208 | 158 | 221 | 4.81 |
| PWP HP 80 | 77 | 186 | 145 | 192 | 3.93 |
| PWP HP 100 | 105 | 143 | 113 | 154 | 3.20 |
| PWP HP 125 | 121 | 124 | 100 | 133 | 2.59 |
| PWP HP 140 | 147 | 101 | 79 | 113 | 2.24 |
| PWP HP 180 | 168 | 89 | 57 | 94 | 1.82 |
| PWP HP 200 | 203 | 76 | 60 | 82 | 1.59 |
| PWP HP 230 | 230 | 62 | 52 | 72 | 1.31 |
| PWP HP 265 | 261 | 55 | 44 | 59 | 0.97 |
| PWP HP 310 | 300 | 48 | 38 | 53 | 0.85 |
| PWP HP 460 | 357 | 41 | 31 | 47 | 0.60 |

Table 10: Derrick PMD HP screens.

| Screen Designation | Equivalent U.S. Sieve (mesh) | Cut Point (µ) | | | Conductance (kD/mm) |
|---|---|---|---|---|---|
| | | $D_{50}$ | $D_{16}$ | $D_{84}$ | |
| TBC 52 | 49 | 311 | 222 | 344 | 3.99 |
| TBC 84 | 70 | 212 | N/A | N/A | 3.08 |
| TBC 105 | 95 | 156 | 130 | 161 | 2.38 |
| TBC 120 | 106 | 142 | 118 | 146 | 2.18 |
| TBC 140 | 122 | 123 | 118 | 126 | 1.81 |
| TBC 165 | 133 | 112 | 108 | 115 | 1.67 |
| TBC 200 | 168 | 89 | 86 | 92 | 1.37 |
| TBC 230 | 193 | 75 | 73 | 77 | 1.20 |

*Table 11: Thule TBC screens for VSM 100 shakers.*

| Screen Designation | Equivalent U.S. Sieve (mesh) | Cut Point (µ) | | | Conductance (kD/mm) |
|---|---|---|---|---|---|
| | | $D_{50}$ | $D_{16}$ | $D_{84}$ | |
| 52 | 49 | 311 | 222 | 344 | 4.65 |
| 84 | 70 | 212 | N/A | N/A | 3.25 |
| 105 | 95 | 156 | 130 | 161 | 2.48 |
| 120 | 106 | 142 | 118 | 146 | 2.26 |
| 140 | 122 | 123 | 118 | 126 | 1.87 |
| 165 | 133 | 112 | 108 | 115 | 1.72 |
| 200 | 168 | 89 | 86 | 92 | 1.41 |
| 230 | 193 | 75 | 73 | 77 | 1.23 |

*Table 12: Southwestern (TBC replacement) screens for Thule VSM 100.*

| Screen Designation | Equivalent U.S. Sieve (mesh) | Cut Point (µ) | | | Conductance (kD/mm) |
|---|---|---|---|---|---|
| | | $D_{50}$ | $D_{16}$ | $D_{84}$ | |
| BHX 24 | 20 | 884 | 872 | 898 | 15.40 |
| BHX 38 | 31 | 579 | 567 | 588 | 14.70 |
| BHX 50 | 44 | 360 | 255 | 410 | 12.20 |
| BHX 70 | 69 | 215 | 141 | 280 | 5.30 |
| BHX 84 | 81 | 176 | 123 | 230 | 4.50 |
| BHX 110 | 100 | 149 | 103 | 190 | 3.40 |
| BHX 140 | 104 | 144 | 102 | 170 | 3.80 |
| BHX 175 | 144 | 103 | 71 | 133 | 1.90 |
| BHX 210 | 170 | 88 | 63 | 106 | 1.70 |
| BHX 250 | 228 | 63 | 43 | 80 | 1.40 |
| BHX 275 | 252 | 57 | 42 | 68 | 1.20 |
| BHX 325 | 319 | 45 | 35 | 51 | 0.98 |
| BHX 370 | 336 | 43 | 32 | 49 | 0.50 |
| BHX 425 | 368 | 40 | 33 | 42 | 0.61 |
| BHX 4750 | N/A | 28 | 21 | 32 | 0.15 |

*Table 13: BHX (blue hex) screens for Brandt ATL linear shakers.*

*Wet classification is the separation of solids from a slurry…*

## WET CLASSIFICATION

Wet classification is the separation of solids from a slurry according to particle mass (size and density) by means other than screening. All wet classifiers separate solids based on the variables described in Stokes' law. Several factors govern wet classification:

1. Coarser particles have a faster settling rate than fine particles of the same specific gravity.
2. High-gravity solids have a faster settling rate than low-gravity solids of the same size.
3. Settling rate becomes progressively slower as the viscosity and/or density of the mud increases.

**Note:** Frequently, centrifuges use liquid dilution to reduce viscosity so that smaller-size particles can be removed. However, two points should be considered:

a) There is a "critical dilution" point where lowering the viscosity or density with dilution no longer benefits efficient separation.
b) Conversely, if insufficient dilution is used, then the desired cut point and efficient separation cannot be achieved.

*…wet-solids classifiers… perform according to Stokes' law with regard to density, viscosity and G-force.*

The wet-solids classifiers most commonly used for solids removal from drilling muds are hydroclones and centrifuges. As mentioned earlier, these devices perform according to Stokes' law with regard to density, viscosity and G-force. They increase the settling and processing rates by increasing the G-force acting on the solid particles. The G-force acting on a solid is proportional to the (diameter of circular motion) x (the square of the rotating speed [RPM]) x (the mass of the particle).

Pumps deliver mud to wet classifiers, but centrifugal pumps are particularly bad about causing solids to degrade in size, thus aggravating the problem of controlling colloidal solids. For this reason, centrifugal pumps operating for mixing hoppers and hydroclones should be shut down when they are not needed. Because centrifuges process a smaller volume, it is possible to use positive-displacement pumps, which do not cause as much particle-size degradation as centrifugal pumps.

A hydroclone is illustrated in Figure 6. This device has no moving parts. As liquid from a centrifugal pump enters on the outside tangent of the funnel-shaped cone, the shape imparts a circular, whirling motion to the fluid, thereby increasing centrifugal force to separate higher-mass particles at a high processing rate. The hydroclone design forces high-mass solids to be discharged from the open bottom, while the majority of the processed liquid flows back up through the vortex finder at the top to be retained. While it is difficult to achieve a sharp cut point with hydroclones, they are simple, rugged and inexpensive to operate and have a high-volume processing rate.

Centrifuges used in oilfield service are usually decanting-type centrifuges, as illustrated in Figure 11. These are high-speed, rotating centrifuges that can develop 600 to 800 or more "Gs" of separation force. Their mechanical design and ability to achieve centrifugal forces well above 500 Gs enables them to give a relatively sharp particle size cut. One drawback of most decanting centrifuges is their relatively low volumetric processing rates (<40 gpm), since only a small portion of the circulating volume can be processed by a single unit.

By examining Figure 2, it is easy to understand why it becomes impractical to desand or desilt weighted muds containing barite. Barite is a silt-size material so that desilters or desanders will discharge large volumes of this valuable material. For desanders, the median cut (depending on hydroclone size) should be in the 45- to 74-micron range, while desilters may have a 15- to 35-micron cut. Since the median particle size for barite often is in the 15- to 30-micron range, much of the barite would be discarded along with the silt or sand.

Note that barite recovery centrifuges and microclones (small-diameter, high-pressure hydroclones) — cut at 7 to 9 microns $D_{50}$ — will deliver efficient barite recovery. However, unless they are used in combination with other properly selected and sized solids-removal equipment, undesirable amounts of silt or sand may be returned to the active system.

### HYDROCLONES

Figure 6 is a cross-sectional diagram of a hydroclone or "cyclone"-type centrifugal separator. A centrifugal pump feeds a high-volume mud through a tangential opening into the large end of the funnel-shaped hydroclone. When the proper amount of head (pressure) is used, this results in a whirling of the fluid much like the motion of a water spout, tornado or cyclone, expelling wet, higher mass solids out the open bottom while returning the liquid through the top of the hydroclone. Thus, all hydroclones operate in a similar manner, whether they are used as desanders, desilters or clay ejectors.

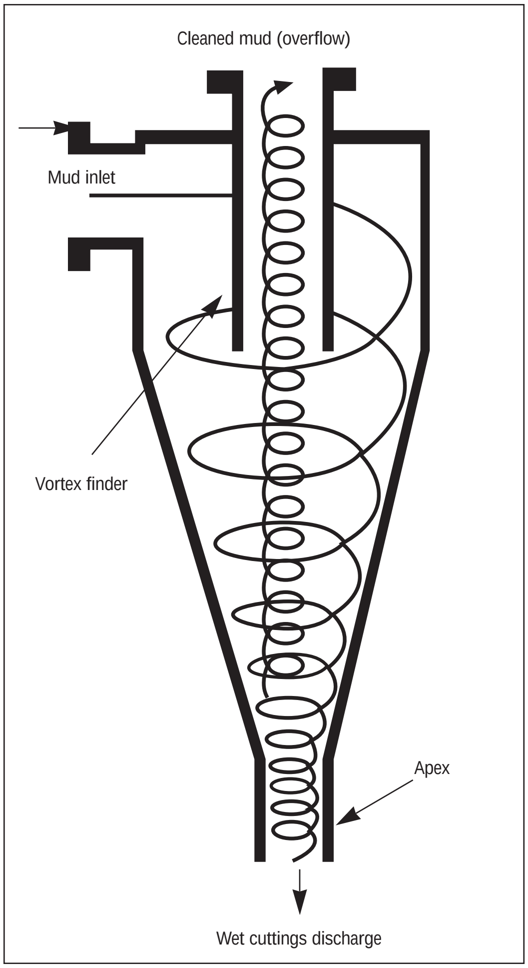


*Figure 6: Hydroclone schematic.*

Head is related to pressure as follows:

**Head (ft) = Pressure (psi)/[.052 x mud weight (lb/gal)]**

Many hydroclone devices (check with the manufacturer) are designed for about 75 ft of head at the inlet manifold. Since mud weight is a factor in the above equation, the pressure required to produce the proper amount of head will vary with mud weight. Head should be measured at the manifold inlet, since it will decrease between the pump and the hydroclone manifold. Inadequate head will result in smaller volumes of mud being processed and a larger-than-desired cut point. For example, when the head is 45 ft instead of 75 ft, a 4-in. hydroclone will process only 40 gpm instead of 50 gpm, and the cut point will be 55 microns instead of 15 microns. Excessive head also is detrimental, with most solids carried back into the mud system.

***..."vortex finder" extends into the hydroclone body from the top.***

A short pipe called a "vortex finder" extends into the hydroclone body from the top. This forces the whirling stream to start downward toward the small end of the hydroclone body ("apex" or "underflow"). Larger and/or heavier particles are thrown outward toward the wall of the hydroclone, while the fluid with the finer, lighter particles (which move outward more slowly) all move toward the center within the moving liquid. Since it is preferable to retain most of the liquid and discharge

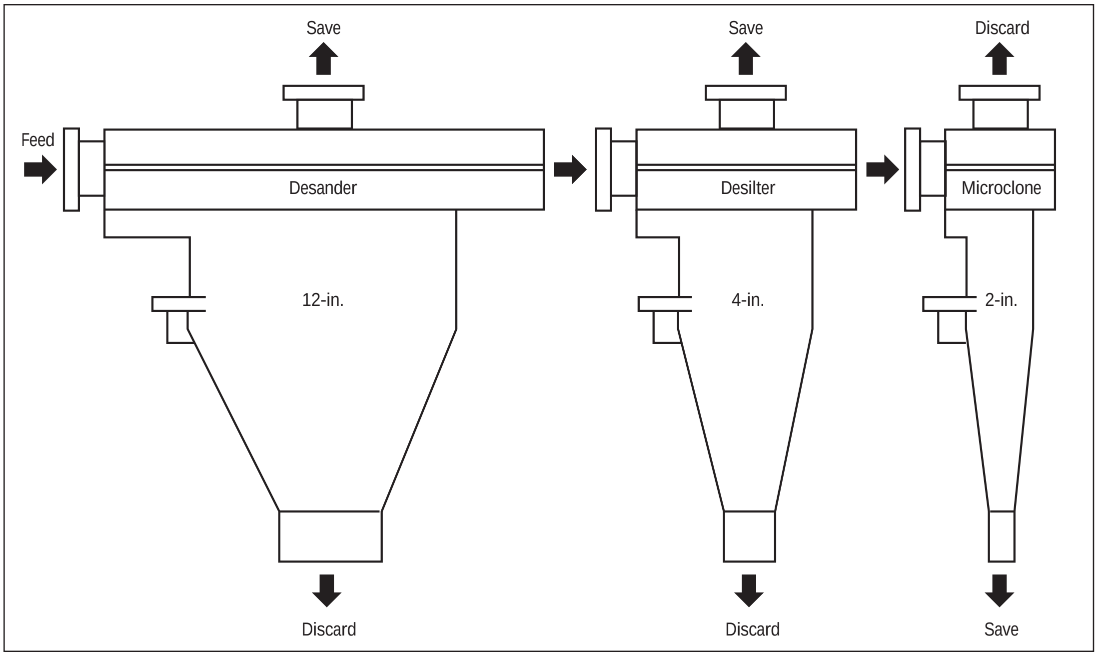


*Figure 7: Hydroclone applications.*

only solids, the apex opening (bottom) must be smaller than the vortex opening. The larger particles and a small amount of fluid will pass out of the apex. The remainder of the fluid and smaller particles will reverse direction and pass upward inside the hydroclone of fluid, leaving by way of the vortex finder (overflow).

Figure 7 illustrates hydroclone applications. When using hydroclones as desanders or desilters, the underflow from the apex containing coarse solids is discarded and the overflow (effluent) is returned to the active mud stream. When used for barite recovery or to eject clay, the hydroclones return the underflow containing barite to the active mud system and discard the effluent containing clays and other fine particles.

The size and number of hydroclones required will vary, depending on the application. Desanders usually are 6-in. hydroclones or larger, with two 12-in. hydroclones being common. Generally, desilters use 4- to 6-in. hydroclones, with 12 or more 4-in. hydroclones being common. Clay ejectors or microclones use 2-in. hydroclones, with 20, 2-in. hydroclones being common. Capacity is related to hydroclone size, so more smaller hydroclones are required for a given volume than larger ones. An example of hydroclone removal efficiency, showing the cut and $D_{10}$ - $D_{50}$ - $D_{90}$ values for typical 3-, 4- and 6-in. hydroclones, is depicted in Figure 8.

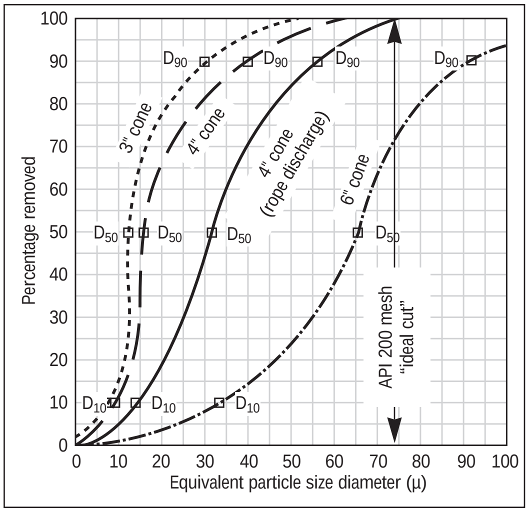


*Figure 8: Typical hydroclone performance.*

***The size and number of hydroclones required will vary…***

The hydroclone discharge, or underflow, must be evaluated to ensure that the hydroclone is operating efficiently. The discharge should be in the form of a fine spray, with a slight suction felt at its center. Conversely, a “rope-type” discharge with no air suction is not desirable, since the cut point and slope will be increased (see Figures 8 and 9). However, when drilling a large-diameter hole at high ROP, the feed may become overloaded with solids and result in a rope-type discharge. At times, this may have to be tolerated, since shutting the unit down would be worse. If a hydroclone begins to exhibit a rope-type discharge and the feed is not overloaded, the feed pressure may be improper or the hydroclone may be worn out or plugged. With some hydroclone types, it may be possible to adjust apex size to produce a spray discharge. If the feed pressure is in the correct range and a rope-type discharge cannot be corrected, the capacity of the unit usually is too low for the drilling conditions. A general guide to the maintenance and trouble shooting of desanders and desilters is included on page 8.24.

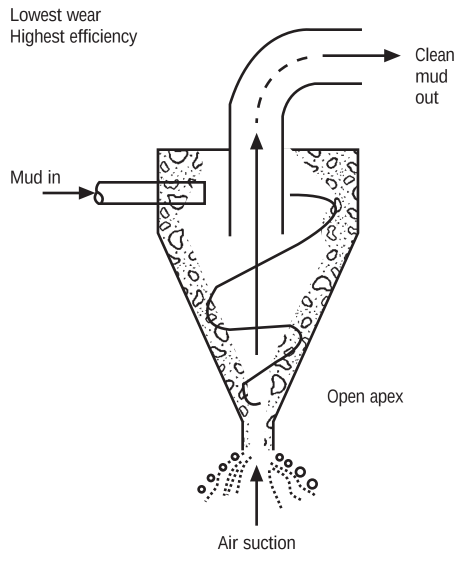


Figure 9a: Spray discharge and air suction.

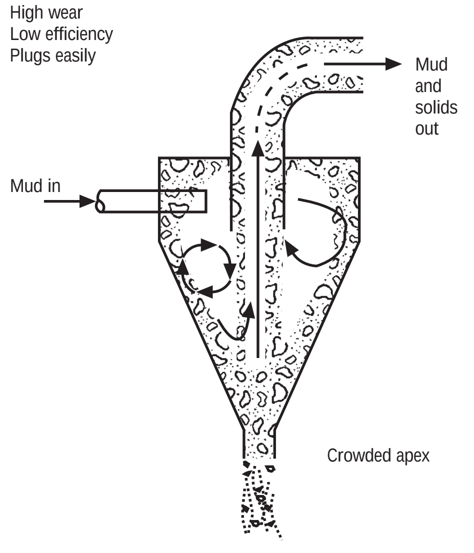


Figure 9b: Rope discharge. No air suction.

*Figure 9: Change from spray to rope underflow with solids overloading.*

***A desander is needed to prevent overload on the desilters.***

### DESANDERS

A desander is needed to prevent overload on the desilters. Generally, a 6-in. ID or larger hydroclone is used, with a unit made up of two 12-in. hydroclones, rated at 500 gpm per hydroclone, being common. Large desander hydroclones have the advantage of a large volumetric capacity (flow rate) per hydroclone, but have the disadvantage of making wide particle-size cuts in the 45- to 74-micron range. To obtain efficient results, a desander must be installed with the proper “head” pressure.

***...the entire flow should be desanded before being desilted.***

### DESILTERS

To achieve maximum efficiency and prevent overloading the desilter, the entire flow should be desanded before being desilted. Generally, a 4-in. ID hydroclone is used for desilting, with a unit containing 12 or more 4-in. hydroclones, rated at 75 gpm per hydroclone, being common. The proper volumetric capacity for desilters and desanders should be equal to 125 to 150% of the circulation rate. Large-diameter wells with high circulation rates require a greater number of hydroclones. Desilter hydroclones generally process a significant volume of fluid and have a more-desirable narrow cut-point, as depicted in Figure 8. A well-designed and properly operated 4-in. hydroclone will have a $D_{50}$ cut point of 15 to 35 microns, with a $D_{90}$ of around 40 microns. Since barite falls into the same size range as silt, it also will be separated from the mud system by a desilter. For this reason, desilters are rarely used on weighted muds above 12.5 lb/gal. Both desilters and desanders are used primarily while drilling surface hole and where unweighted, low-density muds are used.

***A mud cleaner, in effect,* desands *a weighted mud.***

## MUD CLEANERS

Basically, a mud cleaner is a desilter mounted over a vibrating-screen shaker — generally 12 or more 4-in. hydroclones above a very fine-mesh screen, high-energy shaker (see Figure 10). A mud cleaner will remove sand-size drill solids from the mud, yet retain the barite. It first processes the mud through the desilter, then screens the discharge through a fine-mesh shaker. The mud and solids that pass through the screen (cut size depending on screen mesh) are saved; the larger solids retained on the screen are discarded.

By API specifications, 97% of barite particles are less than 74 microns in size; therefore, most of the barite will be discharged by the hydroclones and will pass through the screen and be returned to the system. A mud cleaner, in effect, *desands* a weighted mud and is a backup to the shale shakers. Mud cleaner screens vary in size from 120 to 325 mesh. For a mud cleaner to be an effective solids-control device, the screen size must be finer than the screen size on the shale shakers.

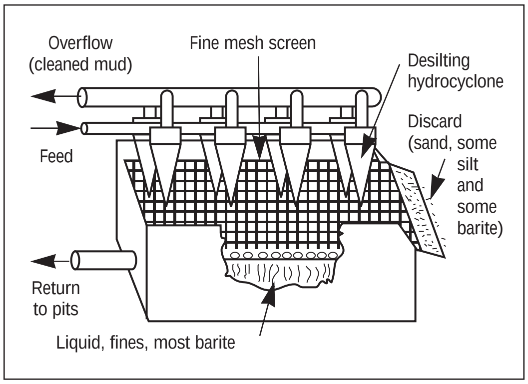


*Figure 10: Schematic of a mud cleaner.*

Although drill solids removal and barite recovery are the most common uses for the mud cleaner, the salvage of expensive liquid phases (synthetics, oils, saturated salt, KCl, etc.) together with barite, will reduce mud costs. Also, the material discarded from the vibrating screen is notably drier, so in many cases, the decreased volume and dryness of the waste material lowers disposal costs. Unless the mud cleaner is discharging a significant amount of solids, the centrifugal pump feeding the desilter will be causing detrimental particle-size degradation. If fine-mesh shale shaker screens of 200 mesh or less are operating properly and no mud is bypassing the shakers, a mud cleaner may not be of any additional value.

**…decanting-type centrifuges** ***increase the forces causing separation of the solids…***

## CENTRIFUGES

As with hydroclones, *decanting-type centrifuges* increase the forces causing separation of the solids by increasing centrifugal force. The decanting centrifuge (see Figure 11) consists of a conical, horizontal steel bowl rotating at a high speed, with a screw-shaped conveyor inside. This conveyor rotates in the same direction as the outer bowl, but at a slightly slower speed. The high rotating speed forces the solids to the inside wall of the bowl and the conveyor pushes them to the end for discharge.

Whole mud is pumped into the hollow spindle of the conveyor, where it is thrown outward into an annular ring of mud called the “pond.” The

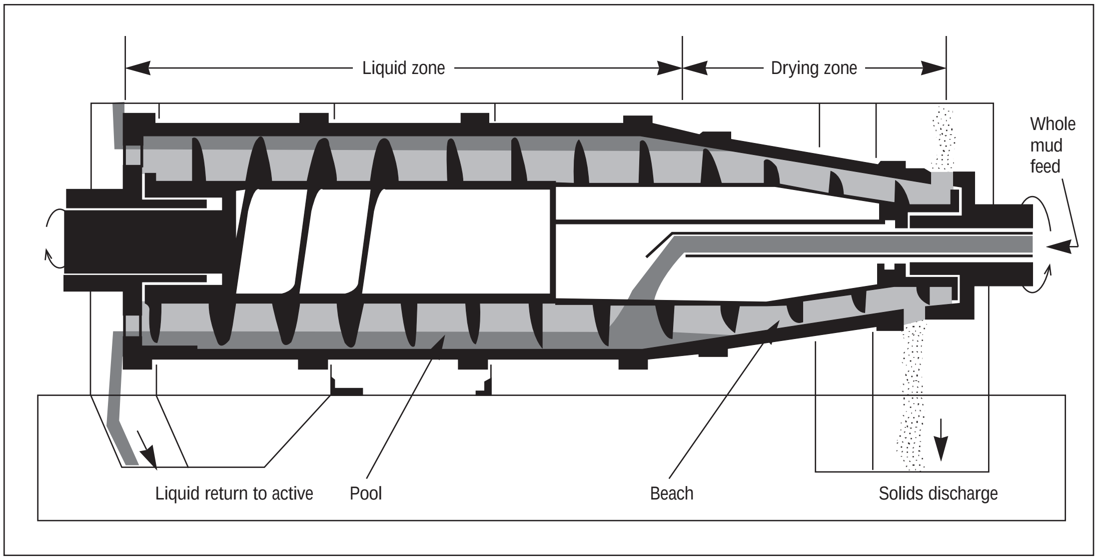


*Figure 11: Cross section of a decanting centrifuge.*

level of this pond is determined by the height of the liquid-discharge ports at the large, flanged end of the bowl. The slurry then flows toward the ports through two channels formed by the conveyor blades, since solids pack against the inner wall of the bowl. As these particles pack against the wall, the conveyor blades push them along toward the small end of the bowl. They emerge from the pond across the tapered dry area (the beach), where they are stripped of all free liquid, then conveyed out the discharge ports at the small end of the centrifuge.

Centrifuges are capable of making a sharp cut point. The ideal cut point is the particle size at which all larger particles are separated and all finer particles are retained. This is, however, not possible, so the actual stated percent of cut-point (D number) should be included when comparing centrifuge performance characteristics. A $D_{95}$ indicates that based on weight, 95% of all particles larger than the $D_{95}$ micron size are removed. Manufacturers use various D numbers, including $D_{50}$, $D_{84}$, $D_{90}$ and $D_{95}$. Also, in a weighted drilling mud with solids of mixed specific gravity, the cut point may refer only to the particles of higher specific gravity (barite, for example). Therefore, the cut point for low-SG solids (clays and shale) may be 1.5 times the rated number.

***An important aspect of centrifuge operation is the dilution of the slurry...***

An important aspect of centrifuge operation is the dilution of the slurry being fed into the unit. The purpose of this dilution is to reduce the feed viscosity to maintain the device's separation efficiency. Generally, the higher the base mud viscosity, the more dilution needed (2 to 4 gpm of water is not uncommon). For efficient centrifuge operation, the effluent viscosity should be 35 to 37 sec/qt. If the viscosity is above 37 sec/qt, the slower settling rate lowers efficiency. If the viscosity is much below 35 sec/qt, too much water is being added. This will cause turbulence inside the bowl, reducing its efficiency. Manufacturers' recommendations concerning mud feed rates and bowl speed should be followed closely.

***...using a centrifuge will discard some beneficial mud additives...***

The accumulation of fine drill solids will increase viscosity and gel strengths, indicating the need for a centrifuge. However, using a centrifuge will discard some beneficial mud additives (solids) like bentonite and lignite. If treatments are not adjusted to account for this loss, mud properties may be compromised, increasing the potential for drilling problems such as differential pipe sticking. Therefore, when a centrifuge is being used, bentonite and other treatments must be increased to maintain good filter-cake quality. Using a centrifuge does not eliminate the need for periodic dilution as 100% solids-control efficiency is impossible. Dilution and treatments should be used to maintain the desirable properties of the mud system.

### CENTRIFUGE APPLICATIONS

*Dual centrifuges are incorporated in closed-loop systems.*

In weighted drilling fluids, a centrifuge is normally used for barite recovery. The centrifuge is arranged to separate mostly barite, returning it to the system, while discarding the liquid phase containing the detrimental fine and colloidal solids. The discarded liquid volume is replaced with liquid dilution or new volume. Due to the low capacity of most centrifuges, only a small portion of the circulating volume is processed, so dilution and treatments can be adjusted to maintain chemical concentrations and satisfactory properties.

In unweighted drilling fluids, a centrifuge is normally used for liquid recovery. The centrifuge is arranged to separate and discard silt-size solids and return the liquid phase to the system. The centrifuge solids discharge is basically dry solids with little free water, unlike the wet discharge from hydrocyclones. The cleaned liquid phase still contains some ultra-fine and colloidal-size solids, but many situations benefit from the additional solids removal. The applications for unweighted muds include: fluids with an expensive liquid phase (oil-base, synthetic, saturated salt, etc.) and where drilling waste disposal is expensive, such as at zero-discharge drill sites, where wastes must be collected and disposed of elsewhere.

Another application of a centrifuge is processing underflow from hydroclone units like desilters or clay ejectors. Hydrocyclones are designed to process the full flow of a mud system, while a centrifuge can handle only partial flow. By having the centrifuge process the underflow of the hydrocyclones, it is cleaning more of the system volume than it could process directly. In this application, the centrifuge also dries out the normally wet discharge from the hydroclones, discharging basically dry solids while retaining the liquid. This is beneficial when the liquid phase of the mud is very expensive or when waste discharge needs to be kept at a minimum.

Dual centrifuges are incorporated in closed-loop systems. The first centrifuge is operated as a barite recovery unit; the second, operated at higher G-force (RPM), processes the effluent from the barite recovery centrifuge, returning the liquid to the mud system and discarding the solids. Dual centrifuges are used commonly with oil-base mud systems. When used with water-base muds, a flocculant is sometimes added to the effluent of the first centrifuge to improve solids separation in the second centrifuge.

Centrifuges also are used for mud “dewatering,” in which whole mud is treated to form dry solids for disposal and clear water for recycling. For this application, the solids content of the mud is brought to a very low level. Then, chemicals are added to encourage the particles to coagulate and flocculate. Once the fluid is properly treated, it can be processed through a centrifuge, with mostly dry solids and water being recovered. Normally, dewatering applications require special metering pumps and processing equipment, as well as experienced personnel.

Reduction of mud costs, without sacrificing control of essential mud properties, is the main purpose of, and justification for, using a decanting centrifuge. Although it helps control undesirable fine solids, the centrifuge’s principal function is to minimize dilution and maintain acceptable properties in the mud system (see Guidelines for Proper Operation of Decanting Centrifuges page 8.25).

## Rig-Ups

***Correct rig-up is essential to getting maximum separation efficiency…***

Correct rig-up is essential to getting maximum separation efficiency from solids-removal equipment. The mechanical equipment usually is set up in a descending order, based on the particle size that it will remove. Although a degasser, or mud-gas separator, is technically not a solids-removal device, it should always be located immediately after the shale shakers, because centrifugal pumps and solids-control equipment do not operate efficiently with gas-cut mud.

***…a sand trap can catch the larger particles that would plug or damage…***

A "sand trap" is a settling pit that is beneficial to a marginal mud-cleaning system. Located under or directly after the shale shaker, a sand trap can catch the larger particles that would plug or damage downstream equipment if a screen develops a hole or if the shaker is bypassed. Gravity is the force acting on the particles, so this compartment should never be stirred or used as a suction or discharge for hydroclones. This type of trap also is essential in maintaining a minimum-solids mud system.

Other guidelines also can help improve solids-control efficiency. Some of them are:

1. Never use the same feed pump for different types of solids-control equipment (desander, desilter, mud cleaner, centrifuge). Doing so will either bypass equipment with part of the fluid or place too great a load on specific parts of the equipment.
2. Never discharge into the same pit where the feed is located. This will allow a significant part of the flow to bypass the solids-control equipment without being treated.
3. Never take the feed from downstream of the discharge. This also allows a significant part of the flow to bypass the solids-control equipment.
4. Size desanders and desilters so there will be a "backflow" from the downstream pit compartment to the feed compartment. This will ensure 100% processing of the total flow.
5. Never take a solids-control equipment feed from the mixing pit. This will remove the mud chemicals being added. This happens most frequently on rigs where the centrifugal pump for the mud hopper is being used to feed the solids-control equipment.

Figures 12 through 16 show typical rig-ups of most solids-control equipment. Each pit (with the exception of the sand trap) is assumed to be thoroughly mixed by blade-type pit mixers.

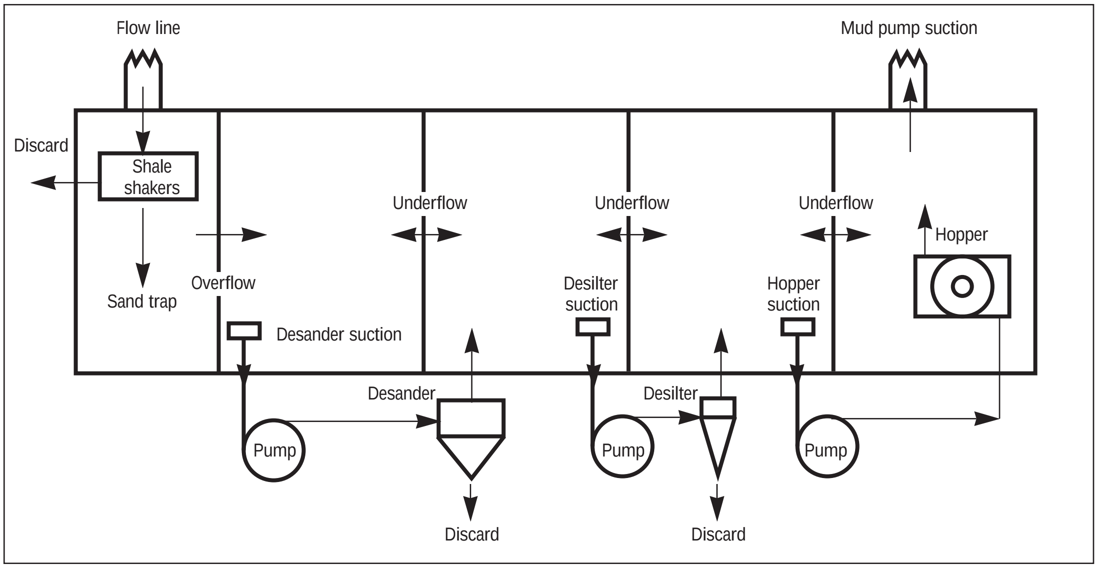


*Figure 12: Basic system unweighted mud.*

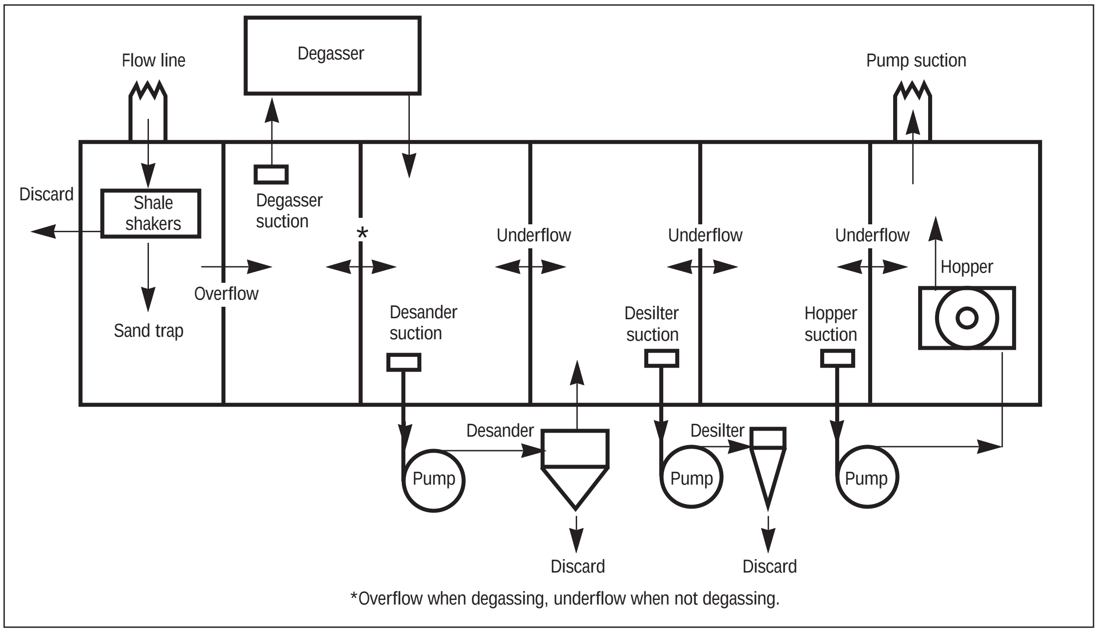
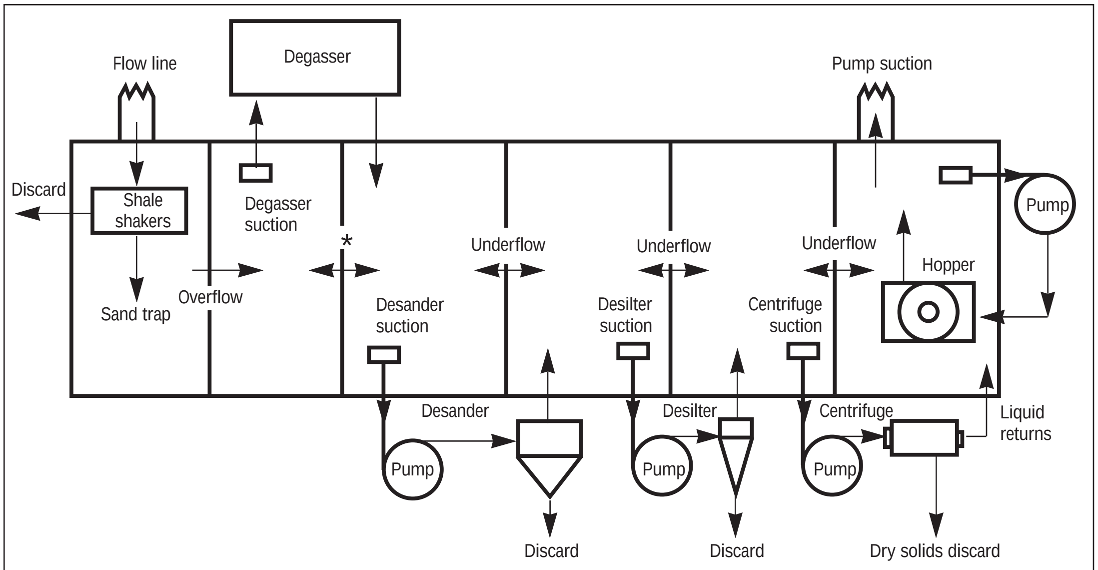
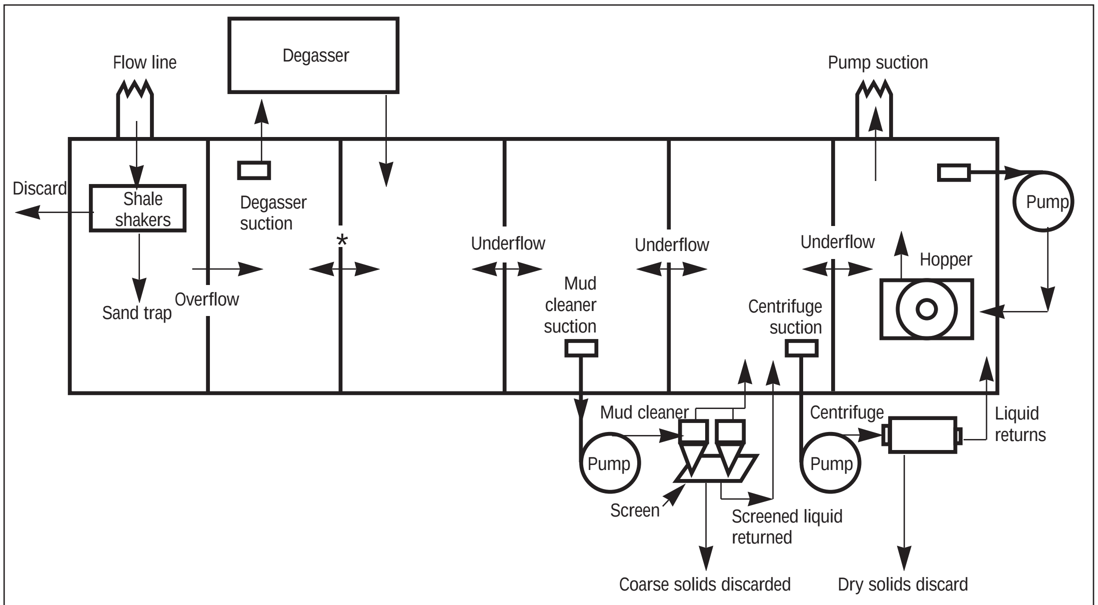


*Figure 13: Unweighted mud with degasser.*



*Overflow when degassing, underflow when not degassing.

*Figure 14: Unweighted mud with centrifuge.*



*Overflow when degassing, underflow when not degassing.

*Figure 15: Weighted mud with mud cleaner and centrifuge.*

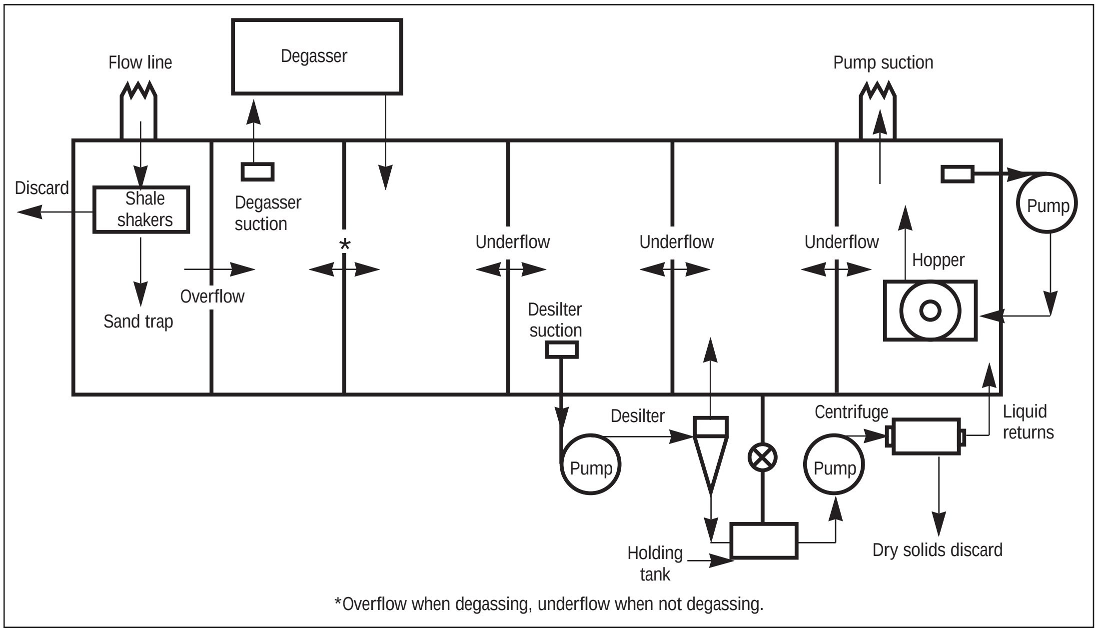


*Figure 16: Weighted mud centrifuging underflow from hydroclones.*

## Guidelines for Proper Operation of Shale Shakers

1. **Mount and operate the shaker in a level condition.** Both the solids and volume capacities will be reduced if a shaker is not level.
2. **Provide the proper voltage and frequency.** Low voltage reduces motor life. Low frequency reduces the vibrating motion and capacity.
3. **Be certain the vibrator is rotating in the proper direction, for proper solids discharge.** The top of the shaft should rotate toward the solids discharge end.
4. **Install the proper screen support cushions in accordance with the manufacturer's directions.** Screens that rub against steel rapidly wear out. The hardness of the rubber is critical for properly seated screens.
5. **Take special care to tension screens properly in accordance with the manufacturer's recommendations.** If screens are improperly tensioned, their life will be reduced.
6. **Screens should be sized such that mud will cover 75 to 80% of the area.** This permits using the capacity of the shaker with some provision for handling surges.
7. **With multiple deck shakers, the proper combination of screen sizes should be used.** On divided multiple screen deck shakers, the same screen size should be used on all panels.
8. **A water (or oil) hose should be provided to wash down the screens.** All screens blind and plug to a certain degree. Mud left on the screens during trips will temporarily plug the screen openings. When circulation is stopped prior to a trip, the screens should be washed.
9. **A water (or oil) spray is occasionally used on the shaker screens to assist the removal of wet, gummy particles (gumbo) off the screen.** It should never be used continually.

The water spray dilutes the mud and washes smaller particles through the screen that would have otherwise adhered (piggy-backed) to larger particles being removed at the shaker.

10. **Never bypass the screens, even during a trip, unless lost-circulation material is in the mud.** A bypassed shaker rapidly fills the sand trap and removes the backup capacity for large solids. Downstream solids removal equipment will not properly operate if large solids are circulated past the shaker. Bypassing a shale shaker will cause desander and desilter plugging. Mud brought from another location should only be added to the active mud system through the shale shaker.
11. **Wash and monitor shaker screens on connections.** Screens with holes or tears should be replaced immediately when detected.

## Maintenance and Trouble Shooting of Desanders and Desilters

**(IMPROPER OPERATION AND PROBABLE CAUSES)**

1. **No wet solids discharge at the apex (bottom)**
   - a) **Bottom opening (apex) plugged.** Turn unit off. Loosen bottom adjustment. Push a rod up through the bottom opening to break up dried or caked mud. If this is not successful, remove top of hydroclone and take out object plugging apex. Make sure the shale shaker is not bypassed. Re-adjust bottom and replace top of hydroclone.
   - b) **Feed pressure (head) too high.** Adjust to proper head pressure, or 75±5 ft, using accurate pressure gauge.
   - c) **Mud cleaned of all particles hydroclones can remove.** If drilling is very slow or if the unit is running during a trip, removal can approach zero at the underflow and unit should be shut down and run only periodically.
   - d) **Worn inlet nozzle, vortex finder or hydroclone ID.** Remove hydroclone and inspect for excessive wear. Replace hydroclone if there is any question as to its condition.
   - e) **Hydroclone improperly installed.** Remove and inspect hydroclone and re-install according to manufacturers' instructions.
2. **Flooding liquid out of apex (bottom)**
   - a) **Feed pressure (head) too low.** Check pump suction for restrictions, inadequate liquid level for pump suction or air entering suction. Check pump impeller blades for wear and proper size. Check pump discharge for correct manifold routing to only one hydroclone solids-control unit. Check condition of pump packing and alignment-clearance of pump impeller. Be sure the pump suction compartment is bottom-equalized to the overflow discharge compartment downstream.
   - b) **Hydroclone inlet plugged resulting in inadequate feed pressure.** Remove hydroclone and inspect, removing any objects plugging inlet. If feed plugging occurs frequently, carefully inspect shale shaker for bypassing cuttings and shaker screens for holes/tears. Install a suction screen on the

centrifugal pump. Do not bypass the shale shaker.

c) **Vortex finder plugged, resulting in back-pressure on hydroclone.** Remove hydroclone and inspect, removing any objects plugging vortex tube. If feed plugging occurs frequently, carefully inspect shale shaker for bypassing cuttings and shaker screens for holes/tears. Install a suction screen on the centrifugal pump. Do not bypass the shale shaker.

d) **Worn inlet nozzle, vortex finder or hydroclone ID.** Remove hydroclone and inspect for excessive wear. Replace hydroclone if there is any question as to hydroclone condition.

e) **Hydroclone improperly installed.** Remove and inspect hydroclone and re-install according to manufacturers' instructions.

**3. Hydroclones plugging**

a) **Feed header (feeding hydroclone inlets) plugged.** Stop feed pump, remove the blind victaulic cap from the inlet header end and remove obstruction. Replace the blind cap and restart pump after checking suction screen. Do not bypass shale shaker.

b) **Hydroclone overloaded (roping).** More solids-control capacity needed. Solids removal system cannot handle excessive drilling rates and/or solids loading.

**4. Inlet head fluctuating**

a) **Restricted pump suction.** Check for plugging, gas-cut mud or foam at the pump suction. Inspect general condition of pump and piping.

## Guidelines for Proper Operation of Decanting Centrifuges

1. Do not operate the centrifuge without the **rotating assembly shroud and belt guards** fastened in place.
2. Rotate the bowl by hand first to ensure "free" (no drag) movement.
3. Do not operate if unusual noise or vibration develops; lube bearings per supplier's recommendation (typically every 8 hours of operation).
4. Allow the unit to attain desired rotational speed **prior** to starting the feed pump.
5. Do not overfeed ("crowd") the centrifuge.
   **Symptoms:**
   - Safety torque coupling frequently disengages.
   - Unit packs off rapidly.
   - "Excessive" amount of weight material in the overflow.
   - "Wet" solids discard from unit.
6. Heavily weighted and viscous fluids require lower feed rates and higher dilution rates.
7. Ensure proper agitation is available at the centrifuge pump suction and in the barite return tank.
8. Remember to turn off the dilution liquid after the centrifuge has been shut down.
9. Review start up and shut down procedures; if inadequate, notify supplier.
10. If a problem develops that is not understood, call a centrifuge technician **before** attempting to repair.