UNDERBALANCED DRILLING

Modern Underbalanced Drilling (UBD) technology has been around for more than 10 years, but variations of the technology such as flow drilling have been around for over 30 years.

In Underbalanced Drilling operations, the pressure of the drilling fluid in the annulus (hydrostatic head of the fluid, whether being circulated or at rest) is intentionally engineered to be less than the formation pore fluid pressure in the openhole section of the well, so as not to damage the formation during drilling.

![Diagram: Underbalanced Condition vs Conventional (Overbalanced) Condition]

Conventional mud systems were unable to accomplish this since even the lightest mud available could cause damage due to fluid invasion. The damage caused during drilling operations required stimulation to eliminate the skin. Often times, this procedure was unsuccessful, resulting in an uneconomic well. Problems with drill string sticking and lost circulation were also commonplace in these formations.

This underbalanced condition can be achieved by using a gas as the drilling fluid, utilizing a lighter fluid, or a combination of both, liquid and gas fluid, in a form of foam or mist, thereby reducing the density of the entire circulating system.

As a consequence, formation fluids flow, freely, into the well when a permeable formation is penetrated during underbalanced drilling.

![Diagram: Flow from reservoir, drilling fines migration, fluid losses, Skin]

This required the development of surface control equipment to handle the flow while drilling. Through this evolution, the modern age of underbalanced drilling was born.

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The main reasons for considering UBD techniques are shown below:

- To enable drilling
- Improve ROP
- Extends the life of the drill bit
- Maximize production through minimizing reservoir impairment
- Reservoir characterization
- Minimizing NPT
- Reduce Stimulation Requirements
- Reduce overall drilling cost
- Earlier Production
- Environmental Benefits

This technique resolves many traditional drilling problems and hazards. Some of the benefits include:

- Decrease probability of differential sticking
- Reduce probability of lost returns
- Decrease formation damage
- Improve hole cleaning
- Increase the length of the hole that can be drilled
- Reservoir characterization

**TECHNOLOGICAL ADVANTAGES AND COST SAVING FEATURES OF OUR EQUIPMENT**

Reform has taken great pains in designing its own equipment with many innovative features to save time and money, and enhance safety. The following are some of the key differences versus other equipment on the market.

**Fully portable:** Typically, UBD separator are built on skids. At Reform, each UBD unit is built right into a trailer for easy towing. This offers great cost savings to the client, especially in cases where multiple locations need to be serviced.

**Trailer booster:** Our UBD equipment is capable of accepting a booster, meaning we can easily add wheels to distribute weight that normally would be problematic in the case of a road ban. This means you can conduct business as usual when others face work stoppages. We can also add a jeep under the front of the trailer.

**Higher pressure separators:** Most underbalanced separators have a working pressure of 250 psi. Reform Energy Service’s UBD units have a working pressure separator of 500 psi. This translates to less erosion on the equipment and lower costs to you for downtime.
Multiple inlets with sleeves: Most separators have only one inlet, which means when it erodes, it causes immediate downtime. Our UBD units have multiple inlets, so flow can be dispersed. We also sleeve the inlets to reduce downtime and cost (sleeves are inexpensive and relatively easy to replace). No heat treatment or radiography is required.

Multiple compartment sparge system: Most of our competitors simply sparge one compartment of the separator. We sparge several compartments, meaning the tanks stay cleaner, resulting in cleaner drilling fluid. This helps prevent damage to the separator, rig equipment and downhole tools, reducing downtime.

Variable speed auger: The variable speed auger removes solids from the separator and can adjust for the amount of solids in the fluid. This saves wear-and-tear on the pump and keeps the tanks cleaner. It also helps to reduce downtime.

Self-contained electric heating system: Our UBD systems feature their own self-contained electric heating systems. This means you’ll never need to supply a boiler for our equipment, reducing your operating costs.

High horsepower fluid transfer pumps: Most companies use 5 HP pumps. Reform Energy Service’s UBD systems use 10 HP pumps. This results in less downtime due to overtaxed motors.

Dual head electrical chemical injection pumps: Most companies use pneumatic systems (using nitrogen or propane). Ours use electricity, saving substantial operating costs.

Tornado pilot system: Our UBD units use a Tornado pilot system, which substantially reduces the consumption of propane and ultimately saves on operating costs.

Free standing flare stacks: Our flare stacks offer zero ground disturbance and eliminate the need for anchors, as well as a picker to set them up. This saves substantial time and cost.

2” 5K Kelly bleed manifold with 2 bypass choke loops: The dual choke manifold is capable of bleeding off drill string to the separator, direct to the flare or down the fluid line.

4” 5K plug valve drill manifolds with dual choke 4” bypass: Typically, when a valve leaks, the flanges must be broken to change it out. Most operators will insert a new valve without re-pressure testing the manifold. In our manifold, we use plug valves, eliminating the need to remove the complete valve when repairs are made. With our drill manifolds, the plug and seats can be removed and replaced without breaking any flanges in a very timely manner. This is safer and quicker — and means the client’s other
contractors aren’t waiting around while valve maintenance is being done (or redone because the lack of pressure testing caused a failure).

**Rotating Flow Control Diverter:** Our RFCDs are one of the industries newest passive rotating control heads, designed in accordance with API Specification RCD-16. These RFCD has several unique patent pending design components intended to make this RFCD one of the safest and most efficient available.

**Dual pressure relief valves:** If the UBD system becomes overpressured, you risk safety hazards. Most competing systems have a single pressure relief valve to combat this. Ours has two — if one fails, there is always a backup.
ROTATING FLOW CONTROL HEAD  DM-4500 RFCD

Head Data

- 3000 psi static working pressure / API-6A tested to 4500 psi.
- 3000 psi dynamic working pressure.
- Rated for 200 RPM.
- Tested to RCD-16 API specifications.

Physical Head Data

- 1 - 7 1/16`` 3K side outlet studded flange.
- 1 - 2 1/16`` 3K side outlet studded flange.
- 1 - 4 1/16`` 3K side outlet studded flange.
- 7 1/16`` - 9.75`` thru bore of the hollow shaft.
- 40`` overall height of head.
- 17`` max OD of bearing assembly with split clamp.
- 21`` max OD of bearing assembly with one piece clamp.
- Weight (approx.) - 2,700 lbs.

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ROTATING FLOW CONTROL HEAD  DM-2000 RFCD

Head Data
- 2000 psi static working pressure / API-6A tested to 3000 psi.
- 1000 psi dynamic working pressure.
- Rated for 200 RPM.
- Tested to RCD-16 API specifications.

Physical Head Data
- Available bottom flange sizes / Any API size & ratings.
- 1 - 7 1/16" 3K side outlet studded flange.
- 1 - 2 1/16" 3K side outlet studded flange.
- 30" overall height of head.
- 16" OD of bearing assembly.
- 13 5/8" full bore through the head with no bearing assembly.
- Weight (approx.) - 1,900 lbs.

The DM-2000 RFCD is one of the industry’s most innovative passive rotating control heads, designed in accordance with API Specification RCD-16. This RFCD has several unique patent pending components intended to make this RFCD one of the safest and most efficient available.

The DM-2000 system is completely serviceable and maintainable in the field.
Reform has taken great pains in designing a separator with many innovative features to save time and money, and enhance safety.

Rated from 275 to 1440 psi, and equipped with a trailer mounted Flomax choke manifold, liquid metering, gas turbine, flow line, production/liquid line, and gas line, Reform Energy Service’s units are one of the safest, efficient, and well-designed systems on the market.

We guarantee that all our innovative features will not only improved the safety, but also will reduce the overall cost of your operations.

P-tank 4 phase separators from 275 psi to 500 psi

- Volume 18.5 m³
- Permanently mounted on Tridem step deck trailer
- 2" 5,000 psi Flomax bleed off choke manifold
- 2" liquid metering
- 6" gas turbine
- 2" 5,000 psi flow line and fittings
- 4" 5,000 psi flow line and fittings
- 4" 2,000 psi production line and fittings
- 4" 2,000 psi liquid line and fittings
- 4" 2,000 psi flare line and fittings
- 27 Kw or 35 Kw diesel generators
- Industrial upright air compressor
- Pressure washer
- Electric or pneumatic Texteam pump
- Electric Ruffneck heaters
- Catadyne heaters

*Units vary by psi
PUMP HOUSES

Our unique design allows the Pump House and the Pressure Tank to engage together minimizing the necessary surface to "rig in".

This compact and fully equipped unit has a 4" plug valve drill manifold, geological sample catchers, a progressive cavity auger pump, a centrifugal sparge pump, centrifugal transfer pumps, electric Ruffneck heaters, and a tool room.

Also they are mounted in a Tridem stepdeck trailer which is highly mobile. This translates to less costs and operation time.

Pump house

- 4" API 5,000 psi choke manifold
- 2 – 3" 5,000 psi H2 Cameron chokes
- 3 – 4" Flomax plug valves
- 2 – 3" Flomax plug valves
- 2 – 720 psi working pressure geological sample catches
- 1 – 4"x5" 5 HP Roper progressive cavity auger pump
- 1 – high pressure 20 HP Travaini centrifugal sparge pump
- 2 – 4"x3" 10 HP Mission centrifugal transfer pumps
- Work benches
- Electric Ruffneck heaters
- All necessary electrical hook ups
- Mounted permanently on a 53’ Tridem step deck trailer
Our trailer mounted Tool House building is equipped with a 100 KW John Deere generator, allowing us to self-supply electricity and therefore save logistical and supply costs.

A workbench, storage cupboards, and all kinds of electrical requirements are also found on this skid. The pipe skid portion of this unit holds all required pipe and fittings.

The above features make this unit a perfect complement to all types of operations.

**Tool house**

- 100 Kw John Deere generator
- Electric Ruffneck heaters
- All necessary hook ups
- Work benches
- Storage cupboards
- 150' 4" 5,000 psi flow line and fittings
- 300' 4" 2,000 psi liquid line and fittings
- Mounted permanently on a 48' Tandem step deck trailer
- Emergency eye wash station
STORAGE TANKS

When drilling in a closed loop sour environment, our closed top cascading 400 bbl storage tanks will enhance the separation and subsequent removal of any poisonous gas from the system. Additionally, they will act as a retention vessel generating a cleaner and solid free drilling fluid.

OIL BURNER

Burner is designed for maximum clean burn capability with minimal fall-out. The oil path through the burner is via a 2" mixing chamber that also allows the passage of solids without causing blockages and subsequent performance problems. Flame ignition is by propane pilot flame and electronic igniter that is operated remotely from the burner.

PUMP SKID

Three 6" by 4" Mission pumps to support circulation of drillings fluids from pressure/storage tanks to shakers/rig tanks/mud pit.

Visit us at www.reformenergy.com
Reform Energy Service’s 60’ flare stacks are zero ground disturbance and eliminate the need for anchors.

The use of a Tornado pilot system will ensure that all hydrocarbons and poisonous gases are combusted, and will reduce the consumption of propane, saving operating costs.

Depending on the expected flow rates and customer needs, Reform Energy can supply 60’ to 120’ flare stacks.

**Flare Stacks 6”/60' up to 8”/120'**

- 8” x 120' free standing flare stack
- 6” x 60’ trailer mounted flare stack
- 150’ of 4” line pipe and pups
- Tornado ignition system

*Flare stack vary by length*