“Managed Pressure Drilling, MPD, is an adaptive process used to precisely control the annular profile throughout the well bore. The objectives are to ascertain the down-hole pressure environment limits and to manage the annular hydraulic pressure profile accordingly. This may include the control of back pressure by using a closed and pressurized mud return system, an annular back pressure pump or other such mechanical devices. MPD is intended to avoid continuous influx of formation to surface.”

MPD involves drilling utilizing a controlled environment that proactively manipulates the annular pressure profile by increasing or decreasing back pressure at the surface.

The surface pressure can be managed by the incorporation of specialized MPD equipment, such as Rotating Control Flow Diverter (RFCD), MPD choke manifold, and Annular Back Pressure (ABP) pumps.

MPD techniques allow control the annular pressures dynamically, enabling drilling in areas where otherwise it would not be economically or technically attainable with conventional drilling techniques.
The main reasons for considering MPD techniques are shown below:

- To enable drilling
- Maximize production through minimizing reservoir impairment
- Reservoir characterization
- Minimizing NPT
- Reduce drilling cost

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

- Elimination of a casing string
- Decrease probability of differential sticking
- Instantaneous reduction/increase in bottom hole pressure (Well control)
- Reduce probability of lost returns
- Improve ROP
- Decrease formation damage
- Lower probability of formation stability problems
- Mitigate the problems associated with ballooning
- Improve hole cleaning
- Increase the length of the hole that can be drilled
- Kick detection and control
- 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.

MPD semi-automatic manifold with Integrated Control System: Our MPD manifolds have been designed to automatically maintain the annulus surface back pressure during drilling operations within a predetermined pressure operating window by using a set of two tight shut off capable actuated full bore drilling chokes. These are controlled by a PLC based control system to maintain the selected set point pressure using an HMI interface panel for operator input of required settings and for displaying control system output parameters.

Higher pressure separators: Most MPD separators have a working pressure of less than 250 psi. Reform Energy Service’s MPD 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 MPD 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.

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 RFCDs have several unique patent pending design components intended to make this RFCD one of the safest and most efficient available.

MPD PACKAGES

FULL BASIC

Rotating Flow Control Diverter

Been considered the main enabling piece of equipment for MPD, our RCDs will provide the necessary seal between the wellbore and the atmosphere, allowing drilling when gas and fluid influxes are encountered.

MPD Choke Manifold

As part of the primary barrier for well control during MPD operations, our Semi-Automated control choke system will provide a reliable way to maintain the bottom hole pressure required for drilling.

Mud/Gas Separator

It allows to capture and separate large volume of free gas within the drilling fluid. If there is a "KICK" situation, this vessel separates the mud and the gas, diverting the fluid back to the pits/tanks and the gas is vented to a flare.
High Pressure Four Phase Separator

In a kick situation, our high pressure four-phase separator will allow to circulate the influxes in a safe and controlled manner, avoiding the need of shutting the well. Complete with dual geological sample catchers, fluid handling equipment for fluid and solids transfer, and automatic dump valves.

Closed Top Cascading 400 bbl 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.

Nitrogen Generation and Compression Equipment

Some operations may require lighten the drilling fluid. Nitrogen generation and the air compression packages will be provided by a third party.

Ammonia Scrubber

The ammonia scrubber will remove or neutralize the substances considered harmful to the environment.

Flare Stacks

Our flare stacks offer zero ground disturbance and eliminates the need for anchors, and use a Tornado pilot system, which substantially reduces the consumption of propane. This saves substantial time and cost.
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.

Visit us at www.reformenergy.com
The DM-4500 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 design components intended to make this RFCD one of the safest and most efficient available.

The DM-4500 system is completely serviceable and maintainable in the field. All of the following equipment is housed within the provided tool house, which is also an ISO Certified shipping container.

Each DM–4500 13 5/8” RFCD includes:

- 3,000 psi static working pressure (non-rotating, limited by the API side outlet flanges)
- 3,000 psi continuous rotating working pressure
- RPM up to 200
  - Max. temperature rating of 250°F / 121°C when using high temp oil and short time full load on bearings
  - Optimal operating temperature of 194°F / 90°C with high temp oil and continuous full load on bearings
  - Optimal operating temperature of 140°F / 60°C with standard temp oil and continuous full load on bearings
- Hydraulically rotated clamp (eliminates the need for an operator to ascend the stack)
- 13 5/8” thru-bore of main body (bearing assembly out)
- 7 1/16” thru-bore of bearing assembly’s hollow shaft
- 17” OD for bearing assembly when removed from body
- Bottom connection: 13 5/8” 5M RTJ API flange
- 1 – Side outlet connection: 7 1/16” 3M RTJ API studded outlet
- 1 – Side outlet connection: 4 1/16” 3M RTJ API studded outlet
- 1 – Side outlet connection: 2 1/16” 3M RTJ API studded outlet
- Weight: Est. 2,900 lb.
- Overall height: Est. 40”
“The DM–4500 RFCD comes in a portable building for easy transport and storage.”

Included RFCD accessories (in base package):

- 1 – Spare complete bearing assembly
- 1 – Snubbing adaptor, 7 1/16” 5000 psi API top flange, complete with tapped blind
- 1 – Bearing assembly oil cooling power pack and hoses (220/3/60)
- 1 – Clamp actuator air/hydraulic power pack and hoses
- 1 – Bell nipple/seal face protector (for use when the bearing assembly is out of the body)
- 1 – DM-Series tool package (all tools required to service and maintain RFCD)

Transport Building / Tool house (20’ ISO Shipping Container)

The tool house building is designed to be used as a work room and storage area for the RFCD and spare parts. This building is rated for Class 1 Div. 2 and will remain a certified ISO shipping container.

Tool house

Permanently mounted within the container will be the following components:

- 1 – 6’ work bench complete with lower and overhead cupboards
- 1 – Lockable element storage rack
- 1 – Bearing assembly stand complete with bearing assembly pressure test chamber and 220/3/60 rotating gear box for breaking in new bearings and seals
- 1 – Roof-mounted beam c/w 1-ton, trolley and block and tackle
- 1 – Multi-drilled studded plate for head storage (tapped for all lower spool flange sizes)
- 2 – Explosion proof light fixtures (roof mounted internally)
- 1 – 220 / 60Hz AC unit
- 2 – 150’ electrical cables for power requirements
- Length: 20’ / Width: 8’ / Height: 8’
- Weight: Est.10,500 lb. (container with internals only, no head)

Visit us at www.reformenergy.com
Stripping Elements

Reform provides stripping elements to match any size drill pipe and offers two compounds depending on the application:

- Urethane, which has the best wear properties in all applications up to 194°F / 90°C but has a limited life in oil-based drilling systems
- HSN for oil-based drilling systems or high temperature applications up to 284°F / 140°C (note: wear characteristics are not as good as urethane)
Reform Energy Service's MPD manifold has been designed to automatically maintain the annulus surface back pressure during drilling operations to maintain the downhole drilling window. It uses two drilling chokes which are controlled by a PLC control system to maintain the selected set point pressure using an HMI interface panel for operator input of required settings and for displaying control system output parameters. If required the manifold can also be used in a manual mode.

MPD Manifold with Integrated Control System

- Double block and bleed 4” x 6” ANSI 900 lbs 2000 psi working pressure ball valve manifold assembly
- Independent flow paths to dual pneumatically actuated 4” ANSI 900 lbs 2000 psi 3” full bore tight shut off capable drilling chokes
- Each 4” flow path has a set of upstream and downstream double block and bleed WOM Dual seal 4” ANSI 900Lbs flanged full bore ball valves with gear operator
- 6” bypass or gut line capability
- Bypass line has a set of double block and bleed WOM Dual seal 6” ANSI 900Lbs flanged full bore ball valves with gear operator.
- Flow path and bypass of gut line ball valve sets have bleed off option between to provide the double block and bleed capability required to allow for maintenance or repairs to be carried out during operations if required.
- Housed in an offshore skid and crash frame with lifting sling set and fork lift pockets
Choke Control System Hardware

- Explosion proof Eexd PLC enclosure which houses:
  - PLC system components
  - Data storage
  - Power supplies
  - Intrinsically safe barriers and input-output connectors
- Intrinsically safe operator control panel:
  - Touch screen HMI panel
- Intrinsically safe pressure and temperature transmitters
- Intrinsically safe integrated alarm beacon and sounder system

Choke Control System Software

- Designed to automatically control the pneumatically actuated drilling chokes either independently or in parallel
- The choke control system can be operated either:
  - LOCAL: via the operator control panel
  - REMOTE: via LAN cable to laptop
- WITS interface for transmission of data to 3rd parties
**Additional Safety Features**

- 100% operational redundancy of the drilling chokes
- Digital and backup mechanical choke position readouts on drilling chokes
- Fail in last position logic in case of power failure on drilling chokes
- Choke failure and choke plugging logic activates audible and visual alarms
- Double block and bleed ANSI / ASME ball valve on all flow paths.

**Specifications**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNV 2.7-3 Skid &amp; Frame</td>
<td>4.5 m L x 2.0 m W x 2.3 m H</td>
</tr>
<tr>
<td>Max. Gross Mass</td>
<td>8,000 kgs</td>
</tr>
<tr>
<td>Tare</td>
<td>7,200 kgs</td>
</tr>
<tr>
<td>Payload</td>
<td>1,000 kgs</td>
</tr>
<tr>
<td>Air supply</td>
<td>50 scfm @125 psi</td>
</tr>
<tr>
<td>Max. working temp.</td>
<td>121°C</td>
</tr>
<tr>
<td>Service conditions</td>
<td>H2S / CO2 NACE MR0175</td>
</tr>
<tr>
<td>Inlet/outlet flanges</td>
<td>6” Fig 206F x 6” ANSI 900RF Flange with test plug</td>
</tr>
<tr>
<td></td>
<td>6” Fig 206M x 6” ANSI 900RF Flange with test plug</td>
</tr>
<tr>
<td>Power supply requirements</td>
<td>220 VAC for Skid lighting, 24 VDC for Choke control system</td>
</tr>
<tr>
<td>50 meters of SCADA &amp; 30 of WITS cable</td>
<td>Cat 5e SWA cable with Stahl Exd quick connects</td>
</tr>
</tbody>
</table>

*Manufacturing codes are in compliance with API 6A, API 6D, ANSI B31.3, NACE MR01-75, ATEX Zone 1 & DNV 2.7-3.*
Reform Energy Service's MPD manifold has been designed to automatically maintain the annulus surface back pressure during drilling operations to maintain the downhole drilling window. It features two drilling chokes which are controlled by a PLC control system to maintain the selected set point pressure using an HMI interface panel for operator input of required settings and for displaying control system output parameters. If required the manifold can also be used in manual mode.

**MPD Manifold with Integrated Control System**

- Double block and bleed API 4 1/16” 5,000 psi gate valve integral manifold assembly
- Independent flow paths to dual pneumatically actuated API 4 1/16” 5000psi 3” full bore tight shut off capable drilling chokes
- Integrated 4” bypass
- Additional 6” bypass if required
- Manually and hydraulically operated WOM Model 200M API high performance gate valves
- Maximum Working Pressure: 5,000 psi
- Manifold Design Temperature: -20 to 250 °F
- Service conditions: H2S / CO2 NACE MR0175
- Housed in a DNV 2.71 frame with lifting sling set and fork lift pockets
Choke Control System Hardware

- Explosion proof Eexd PLC enclosure which houses:
  - PLC system components
  - Data storage
  - Power supplies
  - Intrinsically safe barriers and input-output connectors
- Intrinsically safe operator control panel:
  - Touch screen HMI panel
- Intrinsically safe pressure and temperature transmitters
- Intrinsically safe integrated alarm beacon and sounder system

Choke Control System Software

- Designed to automatically control the pneumatically actuated drilling chokes either independently or in parallel
- The choke control system can be operated either:
  - LOCAL: via the operator control panel
  - REMOTE: LAN cable to laptop
- WITS interface for transmission of date to 3rd parties
**Additional Safety Features**

- 100% operational redundancy of the drilling chokes
- Digital and backup mechanical choke position readouts on drilling chokes
- Fail in last position logic in case of power failure on drilling chokes
- Choke failure and choke plugging logic activates audible and visual alarms
- Double block and bleed API gate valve philosophy on all flow paths
- Hydraulic pump open / pump close gate valves on each flow path with hose extensions provided to allow full remote operation of manifold if required

**Specifications**

<table>
<thead>
<tr>
<th>DNV 2.7-1 Skid &amp; Frame</th>
<th>4.2 m L x 2.4 m W x 2.6 m H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Gross Mass</td>
<td>14,000 kgs</td>
</tr>
<tr>
<td>Tare</td>
<td>12,200 kgs</td>
</tr>
<tr>
<td>Payload</td>
<td>1,800 kgs</td>
</tr>
<tr>
<td>Air supply</td>
<td>125 psi</td>
</tr>
<tr>
<td>Inlet/outlet flanges</td>
<td>6&quot; GR 52</td>
</tr>
<tr>
<td>HMI control panel</td>
<td>ATEX Zone 1 Stahl Colour Touch Screen</td>
</tr>
<tr>
<td>50 meters of SCADA &amp; 30 of WITS cable</td>
<td>Cat 5e SWA cable with Stahl Exd quick connects</td>
</tr>
</tbody>
</table>

*Manufacturing codes are in compliance with API 6A, API 14C, NACE MR01-75, ATEX Zone 1 & DNV 2.7-1.*