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Hydraulically Actuated Metering Pumps Perform Under Pressure

By Kenny Louque, Published April 2017

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The decline in oil prices has forced operators to produce oil more efficiently and cost-effectively—particularly offshore, where costs and breakeven points remain high. Over the last few years, a number of innovations have helped to improve efficiency. Sensors and communications technologies simplify maintenance. Smart assets such as drones lower labor costs and make it easier to inspect flaring towers and areas below deck. These innovations save money by helping operators detect anomalies and make repairs before the issues become costly.

But other technologies in offshore environments remain unchanged and serve as a standard component, mainly because they are trusted and proven to perform critical tasks. One such technology is the metering pump, which delivers a wide range of chemicals to provide flow assurance and equipment integrity, as well as protection, for highly reliable oil and gas production.

Hydraulically actuated diaphragm (HAD) metering pumps are widely embraced in the industry, being deployed on almost every major offshore platform in the Gulf of Mexico over the last 15-plus years including Atlantis, Thunder Horse, Shenandoah, Mad Dog and Olympus—and eventually Appomattox.

Selection Criteria

Each deepwater offshore operating environment has distinct requirements for selecting a metering pump.

Flow rate: A common thread in these offshore environments is the depths at which each platform operates. Massive amounts of power are needed to deliver flow-assurance chemicals to the wellhead, which sits in depths often exceeding 6,000 feet, plus the additional 20,000 to 25,000 feet beyond the wellhead to where the oil and gas reserves remain below the seabed.

Turndown: Metering pump turndown capabilities ensure the accurate dosing of chemicals without waste across a range of flows.

At any point during concurrent or multistage operations, pressure and temperature can vary widely. These variations call for different quantities of chemicals at different times over the well's life. The metering pumps used in these operations must make stroke and drive adjustments to deliver virtually any flow rate required by the process.

High-pressure rating: Another feature of these deep offshore plays is that they typically consist of a half-dozen (or more) subsea wells that feed a single topside platform. The Christmas tree structure at each wellhead sitting on the seabed acts as a choking mechanism. It takes the pressure from the well's subsea side, often greater than 15,000 pounds per square inch (psi), and reduces it down to standard pipeline pressures, typically 1,400 psi.

Once oil and gas moves through the Christmas tree, it can be transported up to the platform, where it is then separated and sent through the Gulf's pipeline system for further processing.

The choke point on the seabed is the highest risk area for ice-type hydrate formations, when light hydrocarbons and water mix under high pressures and low temperatures. Hydrates restrict flow and, if left untreated, could form solid plugs that block production entirely.

For equipment operating in 6,000-plus feet of water, it is difficult, expensive and in some cases impossible to unplug frozen wellheads. But hydrate formation can be mitigated with the help of chemical inhibitors such as methanol. Inhibitors work by lowering hydrate equilibrium temperatures to a point where hydrates cannot form. Chemical inhibitors are delivered continuously (or intermittently) by metering pumps at high injection rates and high pressures up to 20,000 psi that are needed to overcome friction losses and to move the chemicals through long subsea tiebacks that can stretch for miles.

Design flexibility: Because conditions can change quickly in offshore environments, a third common element for equipment is the need for flexibility. Every inch of space matters on an offshore platform. Metering pumps must be engineered to fit into vertical or horizontal motor configurations to accommodate different platform requirements. In addition, offshore environments require metering pumps to deliver a wide range of flow-assurance chemicals and to pump different chemicals that guard against scale deposits and corrosion. To do this, different liquid end options (metallic or polytetrafluoroethylene [PTFE]) must be available to provide a customized solution for various applications.

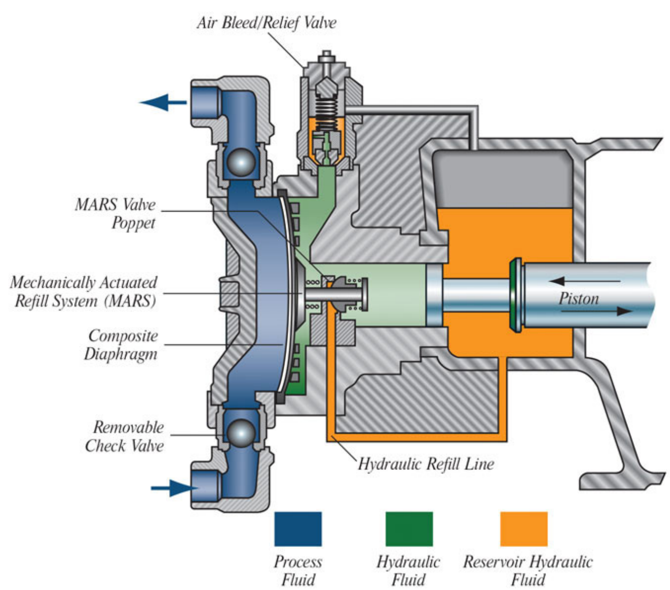

Figure 1. A cross-section of a metering pump fitted with a hydraulically actuated disc diaphragm liquid end (Graphics courtesy of Milton Roy)

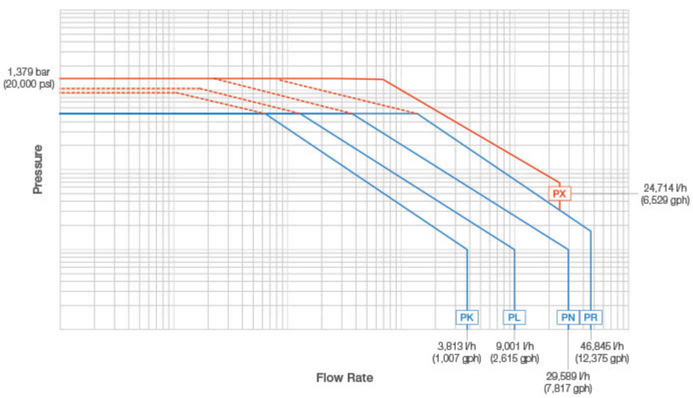

Figure 2. For high-pressure chemical injection, metering pumps performance ratings may be required to reach up to 20,000 psi (1,379 bar).

Reliability: A final common requirement for pumping equipment used in offshore environments is reliability. Because the value of a single day's production vastly exceeds the pump's cost, it is easy to see why this requirement is so important.

Maintainability: Equipment deployed on offshore platforms are difficult to reach, and maintenance is expensive. This equipment, which usually operates continuously, should be designed to last for 20 years without unplanned or emergency maintenance intervention. Routine maintenance for wear items, such as check valves, O-rings and seals, should be done on schedule. Wear items should be able to be replaced in less than an hour and without specialized tools, and all of the required replacement parts should be easily obtainable via standard maintenance kits.

Setting the Design Standard

When operators started working in ultra-deep environments in the 1990s, very few metering pump companies had any experience addressing pressures exceeding even 10,000 psi.

One of the limiting factors for pumping equipment was the diaphragm. It was understood that metal diaphragms were required to handle the required pressures, but pump manufacturers had yet to discover how to flex a metal diaphragm in a manner that could withstand the pressure without failing.

Through innovative engineering and extensive trial and error with application-specific metal alloys, the HAD was developed that continues to set the standard today. The HAD acts as a barrier between the piston and the process fluid. The piston's pumping motion is applied to hydraulic fluid, causing the diaphragm to flex back and forth with the piston's reciprocating action.

The HAD is designed to operate with equal pressure between the hydraulic and process fluids, eliminating diaphragm stress. This pressure-balanced design contributes to the unmatched longevity of HAD pumps.

With other types of diaphragm designs, the pressure must be contained by a tube or diaphragm. With no pressure on the non-process side, the pressure is unbalanced and the diaphragm (or tube) must withstand all of the process pressure.

With a HAD pump, the diaphragm remains balanced between two pressurized fluids and can operate under low stress. None of the moving parts in the pump get stretched or compressed, resulting in longevity (running for 96,000 hours) with minimal maintenance.

Not only does this particular metal diaphragm design produce higher pressures than traditional materials, but it also manages difficult chemicals such as abrasives and slurries more easily and efficiently.

Looking Ahead

Although the fundamental design elements of HAD pumps have been around for many years, today's pumps continue to evolve through advanced diaphragm materials, efficient hydraulic systems, enhanced control interfaces, various motors and variable speed drives, electronic capacity adjustments for remote control, increased turndown (up to 1,000:1) and advanced leak-detection systems that offer a unique combination of proven, yet innovative, technology.

Despite the unique challenges, offshore oil and gas production still represents one of the industry's best rewards, as hundreds of billions of barrels remain sitting in known yet untapped offshore reserves around the globe.

The Energy Information Administration (EIA) reports that global offshore oil and gas production has increased in each of the last two years. Even as oil prices remain below $60 per barrel, the EIA estimates that crude production in the Gulf of Mexico will reach record levels in 2017, with as many as six massive deepwater fields set to come online in the next 18 months.

The combination of attractive offshore prospects and newly gained production efficiencies should set offshore producers up for a sustained run. However, the continual need to increase efficiency across the entire offshore spectrum has become a permanent quest. This quest is best accomplished by combining new innovations with trusted technology, such as the metering pump, which has proven its ability to handle flow assurance and equipment integrity requirements in any environment, and at any depth.

Kenny Louque is the southern regional manager for Milton Roy. For the last 35 years, Louque has served the oil and gas industry for Milton Roy. He may be reached at 337-754-7834 or Ken.Louque@miltonroy.com. For more information, visit www.miltonroy.com.

Figure 3. A supermajor operating in the Gulf of Mexico and a metering pump company have enjoyed a relationship that dates back to the 1980s.