

## Choosing The Correct Flow Meters For Hydraulic Fracturing

### INTRODUCTION

Hydraulic Fracturing requires accurate and durable flow meters to monitor several processes during a fracking treatment. Ranging from the measurement of source and flowback water to the injection of chemicals, flow meters must supply correct information to move the correct amount of media to the right process on time. Plus, flow meters play an important role in taking calculations for EPA reporting. With so many available technologies on the market today, selecting the correct meter requires knowledge of fracking and the role of flow meters in each process. This white paper will explain the challenges faced in fracking, strengths and weaknesses of several flow meter technologies, and provide guidance in meter selection for fracking treatments.

### BACKGROUND

Hydraulic Fracturing is the process of creating fractures in a rock layer to release trapped natural gas. Hydraulic fracturing is done by drilling horizontally through a rock layer and injecting a pressurized solution comprised of water, a proppant, and a chemical solution. This solution is sometimes referred to as frac fluid. The proppant used most commonly is sand and holds the fractures open allowing gas to flow into the well. The fracking treatment lasts two to three months and creates a well that will provide natural gas for twenty to thirty years.

Fracking requires the measurement of liquids at several points during the treatment. Prior to the injection of frac fluid into the well, flow meters are employed to monitor supply water by measuring the flow rate into pressurized tanks. Then, flow meters are used to measure the chemical solution that is combined with water and the proppant to form the frac fluid. After injecting frac fluid into the well, flowback, or frac water, returns from the well over a period of several weeks. Flowback

is the combination of frac fluid and produced water. As flowback is collected, it must be measured using a flow meter. The amount of flowback collected must be measured for two purposes: EPA reporting and to know the amount of water that must be treated if it will not be reused in another fracking treatment. The final stage during which flow meters are used is to measure the amount of chemicals needed to treat the collected flowback water.

## CHALLENGE

While the need for flow meters in fracking is clear, the demands of the process require careful consideration when selecting the right technology for the job. The challenge that presents itself is different depending on the media the meters are measuring and the location of the meters. Later in this paper, we will apply specific challenges to specific meters. For now, here are some common challenges faced:

### CORROSIVE CHEMICALS

Measurement of chemicals injected into the water and proppant mix to form frac fluid and measurement of chemicals used to treat flowback require flow meters that withstand the corrosive characteristics of the media being measured.



Figure 1. MEMFlo™ Volumetric Flow Meters in use during a fracking treatment in the Marcellus Shale.

### FLOOD PLAIN

Depending on the location of the fracking site, flooding may be a factor. FLO-CORP has supplied meters to fracking operations where flooding is a problem. Flow meters installed in areas susceptible to flooding must be submersible to eliminate the concern for equipment damage.

### FREEZING

All meters are susceptible to freezing. For the same reason water must be cleared from pipes in structures that dip below the freezing point, flow meters and piping must be protected from damage caused by freezing temperatures. During fracking treatments, freezing is prevented on meters and piping through the installation of heat trace. Some meters are damaged by heat trace and must be avoided for this application.

## HARSH ENVIRONMENT

Hydraulic fracturing operations are generally setup in fields or cleared wooded areas. Many meters are installed in locations with ongoing exposure to the elements. Flow meters used in fracking must be able to stand the test of nature.

## HIGH PRESSURE

Flow meters involved in the high pressure aspects of fracking must be rated appropriately for high pressure conditions.

## LOW FLOW ACCURACY

Chemical mixture represents approximately 0.05% of frac fluid. Flow meters that control the introduction of chemicals with water and proppant must be able to remain highly accurate in very low flow processes. More specifically, certain velocity meters require one foot per second (FPS) to measure correctly. Large pipe diameters in fracking become a major consideration for such meters because flow is less than one FPS. (Velocity meters are flow meters that use the speed of the media to determine flow rate, such as ultrasonic and turbine flow meters.)

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## SUSPENDED PARTICLES IN SUPPLY WATER & FLOWBACK

Supply water - When possible, water for the fracking treatment will be collected from surface body water, such as rivers and lakes to reduce truck traffic. When pumping and measuring water from such supply waters, flow meters must allow for particulate matter (suspended solids) in the water if a thorough filtering process is not in place.

Flowback - Since flowback is initiated by pumping frac fluid into the well, it already contains proppant, which by definition is a suspended solid in the fluid. Furthermore, after injecting frac fluid into the rock layer through the well, the fluid is combined with produced water often containing clay, dirt, metals, and chemicals. The measurement of flowback is important, but can be challenging to ill-equipped flow meters.

## VISUAL INDICATION

The nature of fracking is the setup of temporary drilling bases. While some automatic processes are put in place, a large portion of the operation relies on visual checks by workers. Flow meters that excel in meeting the needs of a fracking treatment allow workers to make frequent visual checks quickly. Visual checks can be divided into two categories: mechanical indication and digital readout. Mechanical indication is the display of flow without the use of electronics. Digital readout uses electronics to convert flow into a digital signal that is visible on an LED display or other monitor. Depending on the technology and design, meters can be equipped with one or both of these options. Often in fracking, workers simply need to confirm flow rate, but do not need the added features of an electronic transmitter. Mechanical indication is a great way to keep electronics out of the field when they are not needed, while still having an accurate measurement of flow rate.

## TECHNOLOGY

In FLO-CORP's experience, five flow meter technologies have been tested or are commonly in use in hydraulic fracturing including Coriolis Mass Flow, Positive Displacement, Turbine, Ultrasonic, and Volumetric. As it pertains to hydraulic fracturing, here is a summary of these technologies:

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### CORIOLIS MASS FLOW METERS

**Description** - Coriolis mass flow meters measure flow through the use of tubes vibrating at their resonant frequency. These tubes rotate around fixed end points creating the Coriolis effect and measuring the mass flow of liquid at a fixed point per unit of time.

**Pros** - Mass flow meters are capable of handling corrosive chemicals and can be supplied with digital readout for visual indication.

**Cons** - These meters are sensitive to vibration and cannot operate in an environment with a lot of physical abuse. Mass flow meters are unstable in low flow applications and some mass flow meters are damaged by heat trace. Furthermore, these meters cannot handle particulate matter.

**Result** - Coriolis mass flow meters are not durable, cannot handle suspended solids, and do not handle low flow applications well. For these reasons, they are not suitable for hydraulic fracturing.

## POSITIVE DISPLACEMENT FLOW METERS

**Description** - Positive displacement flow meters divide flow into metered volumes by displacing components (typically gears) inside the meters. Positive displacement meters measure the volumetric flow rate of the media.

**Pros** - Positive displacement flow meters are accurate low flow meters. These meters can be supplied in 316 stainless steel for use in corrosive and high pressure applications and can be used with heat trace. Additionally, positive displacement meters can be fitted with digital readout for visual indication.

**Cons** - These meters do not allow for particulate matter. Suspended solids can impede flow and/or damage the meters. Many positive displacement meters are not built in 316 stainless steel or appropriate material to handle corrosive media. In the event of using such meters, corrosive chemicals can pit the gears, meter bodies, and shafts.

**Result** - Positive displacement meters are well suited for the chemical injection needs of fracking. For supply water and flowback, volumetric flow meters are a better solution (see full explanation below).



Figure 2. PDFlo™ Positive Displacement Flow Meter

## TURBINE FLOW METERS

**Description** - Turbine flow meters are velocity meters that convert the rotation of a turbine into flow rate. The turbine's speed of rotation combined with surface area is used to determine fluid velocity.

**Pros** - Turbine flow meters are well suited to deal with chemicals and corrosive fluids, high pressure and particulate matter. In addition, they can be supplied with digital readout and used with heat trace.

**Cons** - These meters have limited low flow rangeability typically requiring at least one FPS. Additionally, they are affected by pulsating flow which is a common variable in fracking.

**Result** - Turbine flow meters are not the best choice when supplying flow meters for fracking. Despite their ability to successfully measure corrosive media, the low flow demands of chemical injection in fracking are better met with positive displacement meters. When considering the measurement of supply water or flowback, volumetric meters are better suited to handle pulsating flow (see full description below).

## ULTRASONIC FLOW METERS

**Description** - Ultrasonic flow meters measure the velocity of media by using ultrasonic transducers. The transducers emit a beam of sound energy through a pipe with one transducer sending the signal and the other transducer receiving the signal. The measurement is taken on the average flow of media through the path of the ultrasonic beam by calculating the difference in transit time between the two transducers. The difference in transit time is equal to the velocity of the liquid in the pipe.

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**Pros** - Ultrasonic flow meters are more easily installed than other flow meter technologies because they are installed on the exterior of the pipe and do not require an interruption of service during install. These meters are also compatible with heat trace and can be supplied with digital readout.

**Cons** - The transducers on these meters go bad quickly in the elements and the harsh environment of fracking. When used, the transducers or meters must be replaced frequently. Ultrasonic flow meters do not accurately measure flow when the media has high PPM (parts per million) of particulate matter. These meters also come up short in low flow applications, especially under one FPS. Aeration and turbulence can destroy the signal. Turbulence can be caused by flanges or connections, which are common in the fracking setup.

**Result** - Ultrasonic flow meters were tested on fracking sites, but are not suitable for use. FLO-CORP discovered the leading reason is a lack of durability resulting in the replacement of ultrasonic meters on site.

## VOLUMETRIC FLOW METERS

**Description** - Volumetric flow meters, also termed variable area flow meters, represent a range of meters designed around the principle of displacing a float with flow to get a measurement. The measurement taken is based on the volume of flow per unit of time.

**Considerations for this comparison** - Because of the broad range of volumetric flow meters, this white paper will focus on the pros, cons, and results of FLO-CORP's MEMFlo™ flow meters. These meters are designed using the volumetric principle of flow measurement. However, FLO-CORP's meters have specific strengths, differing from other volumetric flow meters, that uniquely equip them for harsh industrial applications.

**Pros** - FLO-CORP's MEMFlo volumetric flow meters have an excellent tolerance to suspended solids. These meters are built without springs, cams, or seals to wear out, harnessing gravity as resistance on the float. Furthermore, MEMFlo meters have mechanical indication with 360° rotation of scale so easy visual indication can be setup on any side of the meter regardless of mounting. Special scales are available for varying flow ranges and chemicals. These meters have a 30 to 1 turn down ratio for wide rangeability and are submersible. The all metal version of these meters allows for high pressure, harsh environments, and corrosive fluids. The heavy bodied PVC or CPVC version of these meters is well-suited for corrosive media and brine solutions. Both models can be used with heat trace. When needed, these meters can be supplied with non-contacting sensor electronics which provide digital flow rate and total indication through proportional two wire analog output.

**Cons** - These flow meters must be mounted vertically. (If the meter is off by 10°, the predictable reading error is usually less than 1%. Essentially, if the meter appears plumb, it is close enough.) In some low flow processes, these meters will lack the accuracy needed and positive displacement meters are preferable.



Figure 3. MEMFlo™ MFVC PVC & CPVC Corrosive Resistant Flow Meter



Figure 4. MEMFlo™ MFAM All Metal Flow Meter

**Result** - FLO-CORP's design of the volumetric flow meter is very well-equipped for hydraulic fracturing. For chemical injection processes, the specification for the meters should be reviewed to determine if flow is too low. If chemical flow is within the acceptable range, MEMFlo flow meters are built to handle corrosive chemicals and are recommended for this use. For the measurement of supply water and flowback, these meters provide an outstanding solution. When considering their tolerance to particulate matter and high pressure, rotation of scale, heavy construction for harsh environments, ability to be submersed, and rangeability, these meters were designed for the demands of fracking. Furthermore, mechanical indication is built into MEMFlo meters for a visual display of flow rate. If needed, these meters can along be supplied with electronic digital readout.

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## PRICE POINT

The price point of specific flow meters will vary based on their exact build; however, as a general guide, here is a ranking of these technologies from most expensive to least expensive.

MOST EXPENSIVE

Coriolis Mass Flow
Positive Displacement
Ultrasonic
Turbine
Volumetric

LEAST EXPENSIVE

## FINDINGS

Weighing the challenge that hydraulic fracturing presents to flow instrumentation against the available technologies and their price points, allows specific findings to be drawn from the data. Below are these findings for each process within the fracking treatment. If you are unsure about the proper technology for your application, please contact FLO-CORP or another flow technology professional.

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## TRANSPORT OF WATER TO PRESSURIZED TANKS

Clean water - Volumetric flow meters are suitable for this application because of their accuracy and wide rangeability. Suspended solids are not a consideration in clean water so turbine flow meters can work depending on whether pumps are creating pulsating flow. However, volumetric flow meters are still preferable given their lower price point.

Surface body water - MEMFlo volumetric flow meters are the best choice given their tolerance to suspended solids with limited or no filtering and the lowest price.

## CHEMICAL INJECTION FOR CREATION OF FRAC FLUID AND TREATMENT OF FLOWBACK

Two meter technologies could meet the requirements of these applications including volumetric flow meters and positive displacement flow meters. In certain low flow applications, positive displacement meters are preferable given their high accuracy and low flow capabilities. However, if volumetric meters can handle the accuracy requirements, they remain preferable because of their price.

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## MEASUREMENT OF FLOWBACK

MEMFlo volumetric flow meters are preferred for handling flowback. These meters are built to handle what is perhaps the most challenging measurement of the treatment. MEMFlo meters are able to withstand the corrosive nature of flowback, while accurately measuring flow despite some proppant returning along with produced water containing sediment from the rock layer. Their heavy construction makes them a prime choice for the harsh environment of fracking and specifically the measurement of flowback.

## CONCLUSION

Hydraulic Fracturing creates the demand for accurate flow instrumentation. Fracking treatments require flow meters in two main areas: the movement of water and water based mixtures, and the movement of chemicals. When considering factors such as durability, rangeability, low flow, corrosive resistance, and price, two main technologies emerge as superior: positive displacement flow meters and MEMFlo volumetric flow meters.

When selecting meters for fracking (or any application), it is recommended to seek out professional help. While this white paper is a guide to meter selection, the appropriate technology choice will always depend on the specifics of an application. FLO-CORP supplies all technologies discussed in this white paper. Please feel free to use this white paper, FLO-CORP, and other resources to assist in selecting meters for fracking and other applications.

## ABOUT FLO-CORP

FLO-CORP (Flow Line Options Corp.) is committed to providing properly selected and configured flow, level, and display products with a focus on innovation and customer service. In 1988, FLO-CORP was incorporated in the State of Ohio and started as a small distribution company. In the last five years, FLO-CORP has moved past distribution and into manufacturing our own line of products. Through manufacturing, we have gained more control over origin of product, quality, and lead times. Furthermore, FLO-CORP now has creative control in the development of new products. We can focus on adding the functionality and features that will best serve our customers. FLO-CORP's management of quality, lead times, and innovation come together allowing us to provide more product value to our customers. We remain committed to personal customer interaction, where help can still be found without hearing an automated phone system. The FLO-CORP family is dedicated to working hard for our customers by using over three decades of combined experience in flow, level, and display.

For more information on FLO-CORP's  
**MEMFlo™ Volumetric Flow Meters and PDFlo™ Positive  
Displacement Flow Meters**, please contact:

**FLO-CORP**  
471 E. Bergey St.  
Wadsworth, OH 44281  
877-356-5463 (toll free)  
330-331-7172 (fax)  
[sales@flo-corp.com](mailto:sales@flo-corp.com)

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