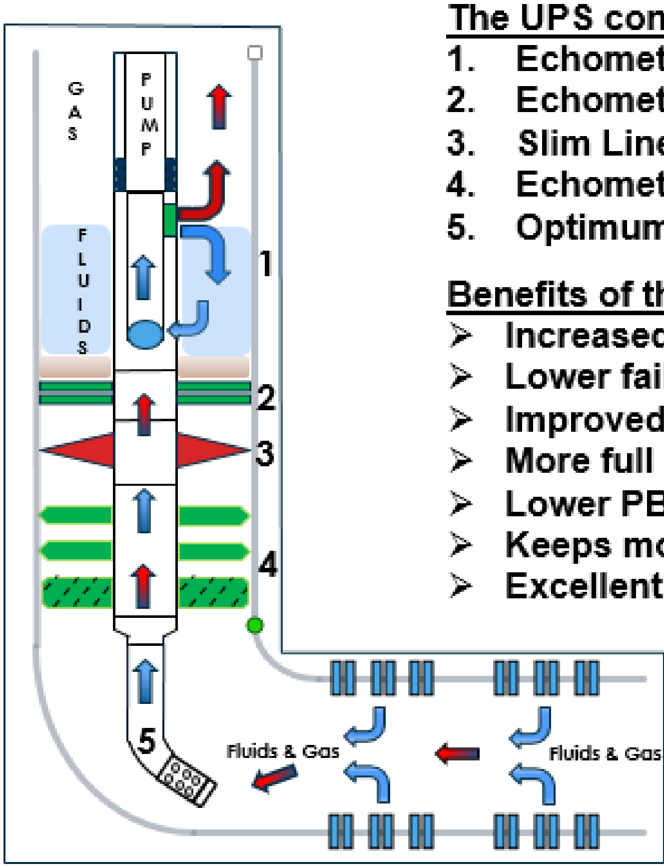
The ECHOMETER Ultimate Production System (UPS)

The production rate can be increased in horizontal wells that have the pump set near the bottom of the vertical section of the well. As the reservoir pressure declines and the production rate drops, the available producing bottomhole pressure is insufficient to push the liquid and gas from the formation up the casing or liner to the pump at the optimum rate. Substantially less pressure drop will occur if an optimum size tail pipe is placed below the pump down to near the formation.

The equipment required is tail pipe, an efficient diverter gas separator, a casing annulus isolator, a Tool Saver and a Centralizer. Producing the formation fluids up a proper sized tail pipe reduces the gradient of the fluid and lowers the required bottomhole pressure to push fluids up to the pump. Since the gradient of the gaseous column below the pump is reduced, the well will continue to produce at a higher rate for a longer period of time. Numerous tail pipe installations have resulted in substantial production increases. "Ultimate Production System" refers to a production procedure in a horizontal well when the pump is placed at the lower portion of the vertical section with a tail pipe below the pump and separator and a pack-off assembly placed around the tail pipe to force formation fluid up the tail pipe to lower the producing bottomhole pressure and increase production.



The UPS consists of the following:

1. Echometer Diverter Separator
2. Echometer Tool Saver
3. Slim Line TAC
4. Echometer Isolator w/ Centralizer
5. Optimum Sized Macaroni Tailpipe

Benefits of the Ultimate Production System:

- Increased production
- Lower failure frequency
- Improved flow dynamics from lateral
- More full pump cards
- Lower PBHP
- Keeps moving equipment out of curve
- Excellent cost-benefit

US Patent # 9,022,106
And Patents Pending

Contact us for more info at:
Brian.Ellithorp@echometer.com
Ph. (405) 837-0173
Jim@echometer.com

- Increasing Production Rate in low-Volume Pumped Horizontal Wells

Horizontal wells initially are generally high producers, but as the reservoir pressure declines, the production rate drops. Often sucker rod artificial lift pumps are set at the bottom of the vertical section after the initial high production rate has declined. Some operators have placed pumps in the curved lower section of the wellbore and have experienced a threefold increase in operating and maintenance cost. A need exists to decrease the producing bottomhole pressure without lowering the pump into the lower curved portion of the wellbore near the reservoir.

A paper titled "Optimizing Downhole Packer Type Gas Separators" was presented at the 2013 SWPSC on a new method of reducing the producing bottomhole pressure (PBHP) and increasing the production rate without lowering the pump from the bottom of the vertical section into the lower curved portion of the well bore. Tail pipe smaller than the tubing size is normally required and added to the bottom of the tubing /pump string to reduce the gradient of the fluids that are moving from the formation to the pump. An optimum size tail pipe is desired for maximum production rate. Figure 1 is presented in the SWPSC paper, and it shows the producing BHP for different sizes of pipe below the pump that is located in the vertical section of the well and how the PBHP is affected as a function of depth and tubular size. Smaller tail pipe than the casing shown in Figure 1 is generally required to obtain maximum production rates in partially depleted wells. The effect of using typical pipe sizes is shown in Figures 4 and 5 for common flow rates and pressures encountered in these wells.

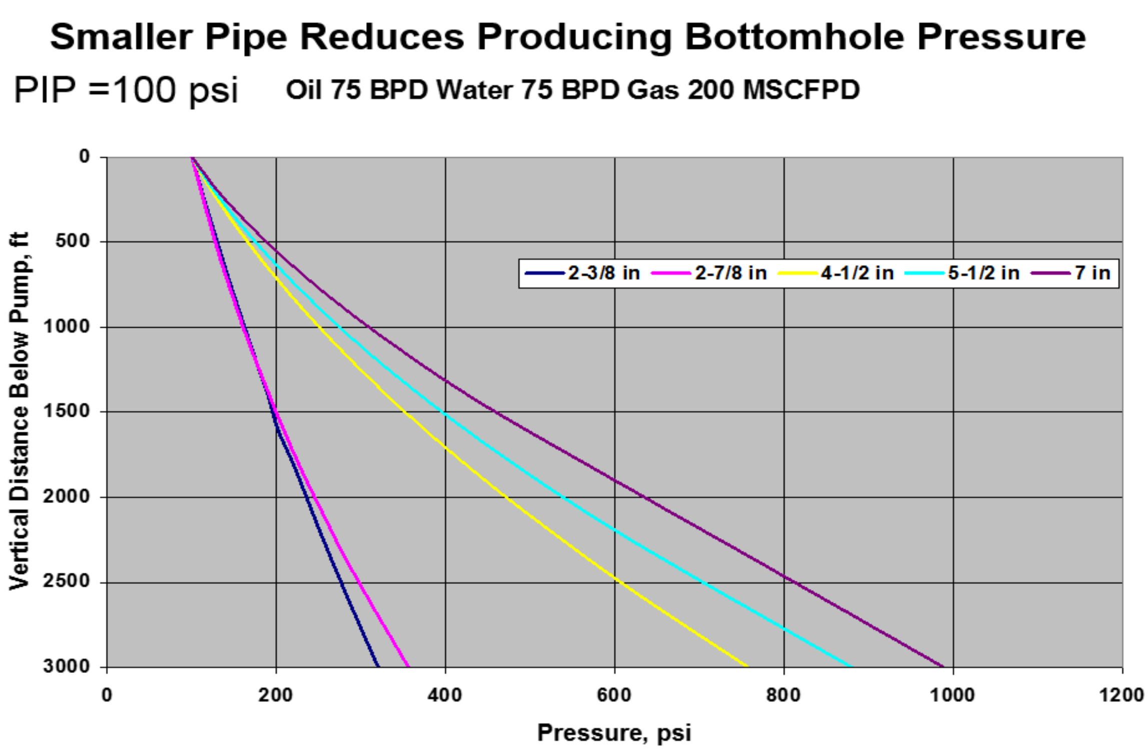


Figure 1 Producing Bottom Hole Pressures as a function of Pipe Size

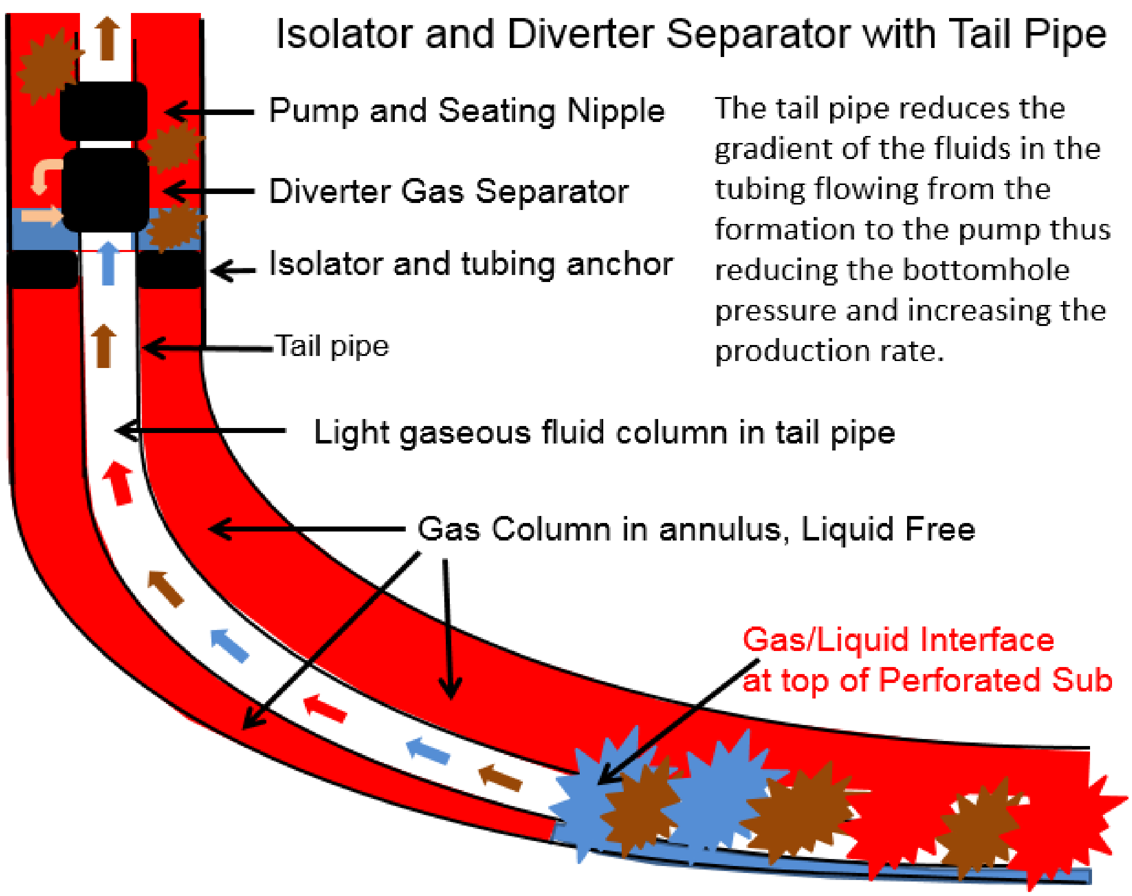


Figure 2 Components of the Echometer UPS System for Pumping Horizontal Wells with Uniform Casing Diameter.

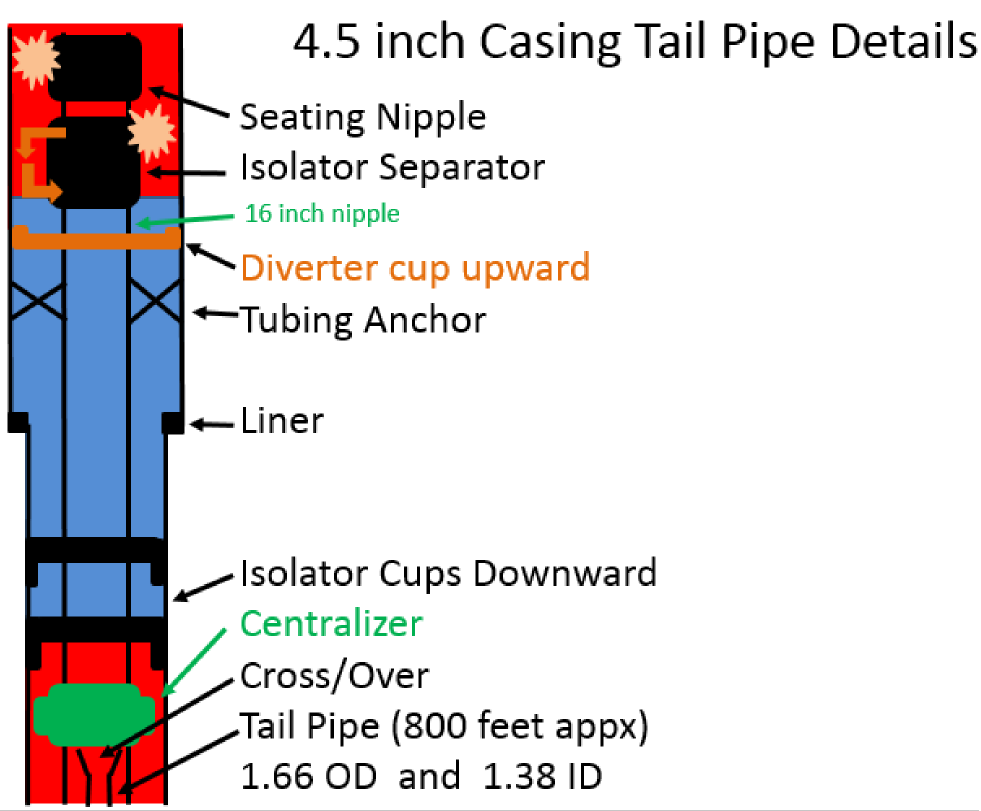


Figure 3 – Liner Completion with UPS and Tail Pipe Assembly

- Dewater Gas Wells using Smaller Production Pipe

In gas production wells, the water in the bottom of the wellbore can be lifted with the gas flowing up the production tubing if the velocity of the gas rising in the flow string is sufficiently fast to carry the water droplets and particles to the surface. As gas well production declines and water begins to accumulate in the bottom of the wellbore, the size of the gas flow string is often reduced to increase the gas velocity that will result in the higher gas velocity dragging the water droplets to the surface and out of the well. This is a very popular technique to de-water gas wells and increase gas production.

- Large Casing below pump Causes more Back Pressure

In sucker rod pumped horizontal wells with the pump landed at the bottom of the vertical portion of the wellbore, the flow string (generally casing or a liner) in the lower, curved portion of the well down to the formation is larger than the optimum size for maximum production rate. The large casing results in a heavier fluid gradient and higher back pressure than when a smaller sized tail pipe is used inside the casing. See Figures 1, 4 and 5.

- Properly Smaller Sized Tail Pipe Increases Production

If an optimum sized flow string is used in the curved portion of the casing, between the lower horizontal portion of the well up to the pump located in the lower vertical portion of the wellbore, the pressure drop will be less and the PBHP will decrease and the production from the well will increase. IF the flow string is too small, excessive flow resistance is generated, and the friction causes a high gas/liquid pressure gradient. Thus, for any gas/ water/oil flow rate, an optimum size tail pipe should be used below the pump.

A set of curves in figures 4 and 5 show the pressure drop below the pump for a typical partially depleted horizontal well using different sizes of tail pipe. The curves show the PBHP at different production rates. The production rates assume certain WOR and GOR. The graphs also assume that the pump intake pressure is 100 psi. This assumes the surface pressure is about 50-80 psi and the fluid level is within 100 feet of the pump. Thus, the graphs help to select the proper tail pipe size for operations now at present day rates and also allow estimation of proper size tail pipe until depletion.

Figures 4 and 5 show the information necessary to select the proper size tail pipe to increase production. The well conditions are taken from typical partially depleted formation conditions. The tail pipe size should be selected for present conditions and also for formation conditions that are expected in the future.

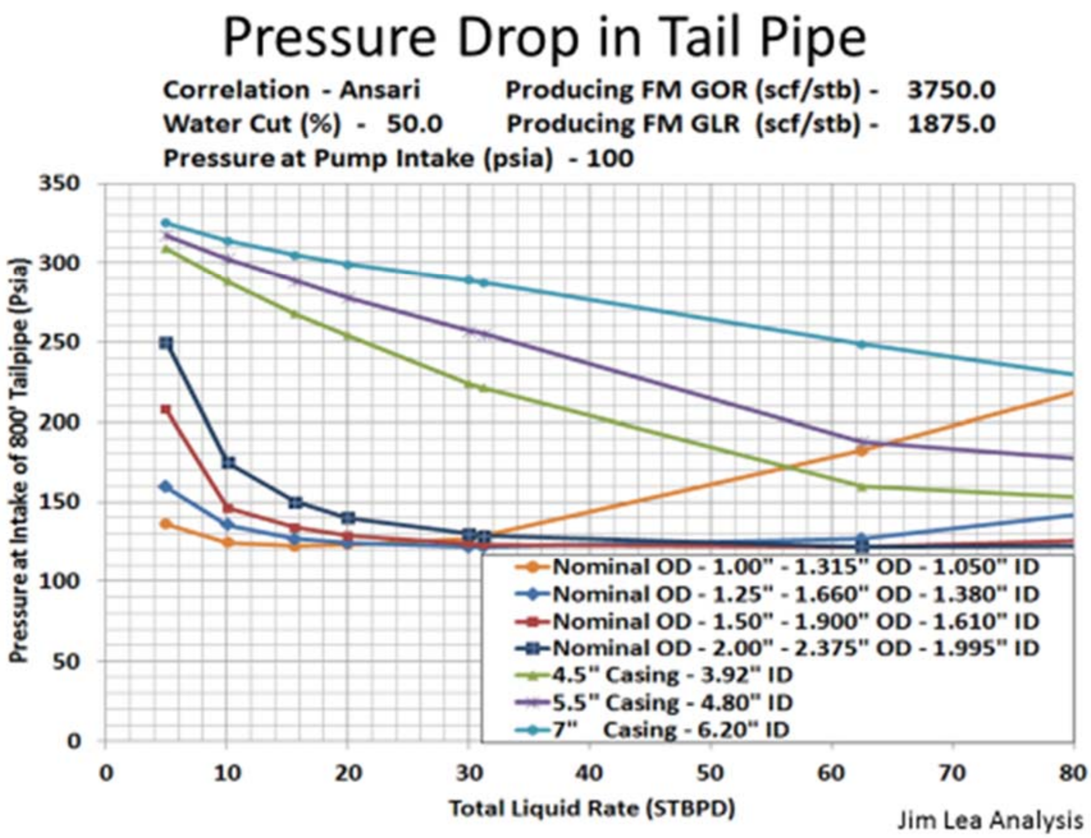


Figure 4 – Pressure at Tailpipe Intake for Low Liquid Rate Wells

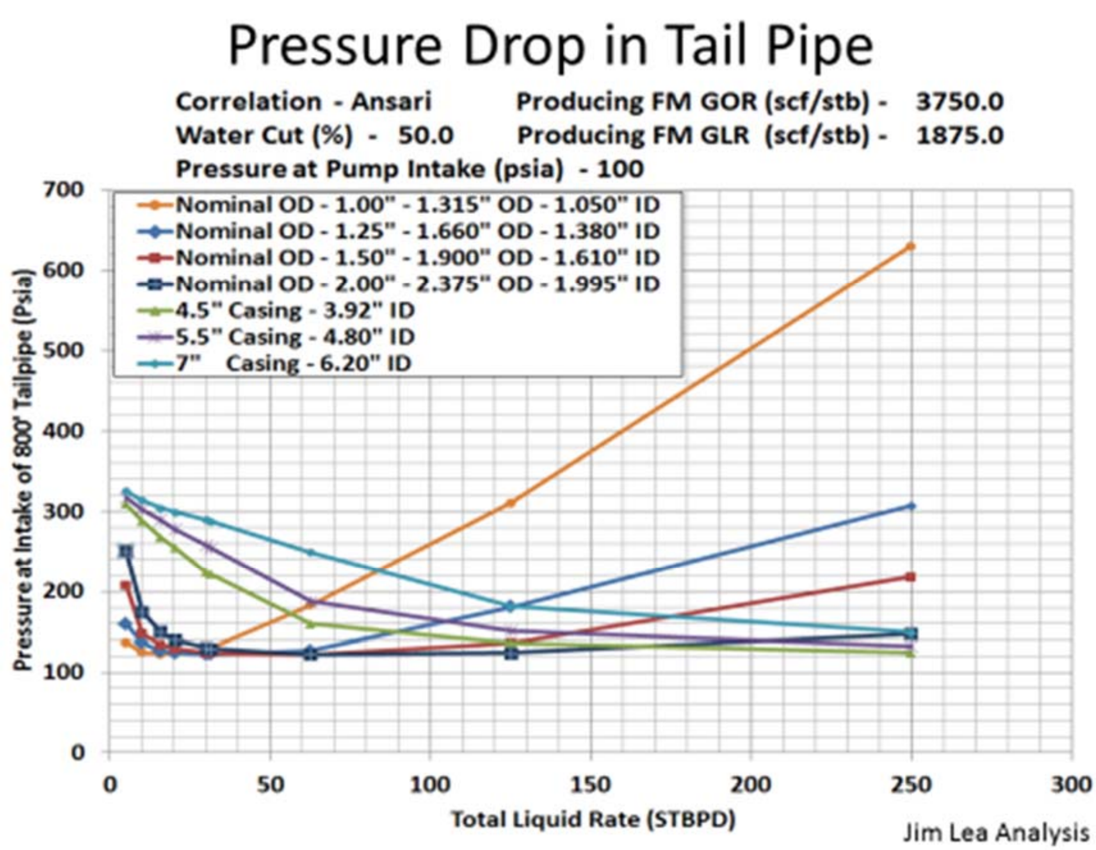


Figure 5 – Pressure at Tailpipe Intake for Medium Liquid Rate Wells

- Properly Sized Tail Pipe Increased Production in Horizontal wells.

More than a hundred wells with tail pipe installed below the pump have exhibited a significant increase in production. When horizontal wells are being produced at rates less than 100 BPD, tail pipe smaller than 2 3/8 inch is usually required to optimize production. For liquid rates over 200 BPD, tail pipe sizes of 2 inch or larger may be required for the maximum reduction in the producing BHP.

- Equipment required by UPS in addition to pumping equipment.

The required equipment for installing the Ultimate Production System "UPS" includes: an Echometer Diverter Gas Separator, a Tool Saver, an Isolator with two downward diverter cups, a Centralizer and an Adaptor from the above equipment to tail pipe. At the intake of the tail pipe a perforated sub that is 6 feet long and bull plugged on the end of the tail pipe is recommended. The gas/liquid interface in the casing annulus near the tail pipe inlet is located near the top perforations of the perforated sub located at the bottom of the tail.

- The recommended UPS assembly is represented schematically in Figure 6

In order to design and properly build this equipment, a model of the system was made. Many pressure studies were made showing what pressures would exist throughout the wellbore during normal production operations and normal shut-in conditions. The first important flow pattern that was noted is that a pack-off point where the flow of fluids should be controlled should be at the location immediately below the pump/separator/TAC assembly. Formation fluids should not be allowed to flow upward in the annulus through the Isolator, but fluids should be allowed to flow downward past the isolator and wash any sand or debris away that may have accumulated above the Isolator cups.

The equipment and pressures that are expected during normal operation are shown in Figure 6 below. Note that the pressure above the Isolator cups is less than the pressure that will exist below the Isolator. If the pump is unseated or sufficient liquid is poured down the casing, the pressure above the Isolator cups will be greater than the gas pressure below the cups and the liquid will flow downward past the Isolator cups. Sand will be washed away by the liquid. It is important that the cups prevent flow in the upward direction past the Isolator cups. Downward liquid flow is desired to wash the sand and debris away. Note the design of the Isolator cups below in Figure 7.

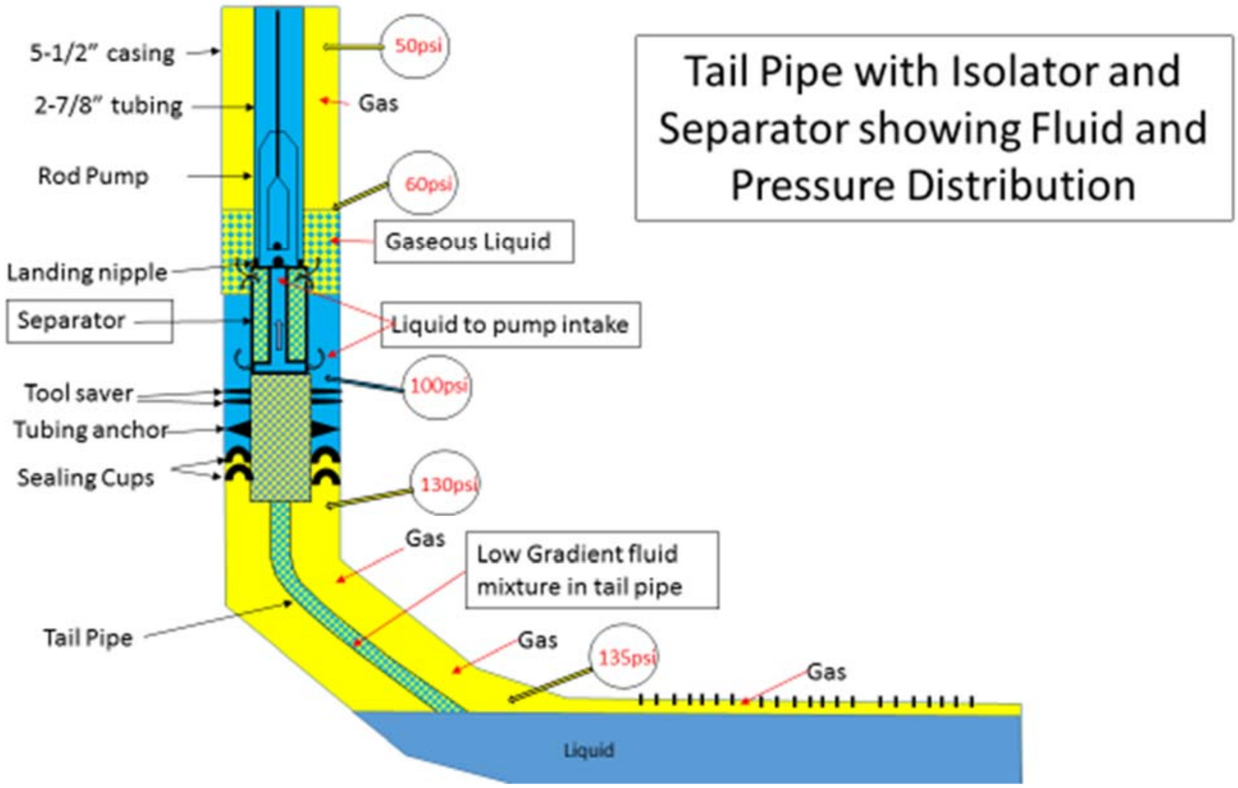


Figure 6 – Typical UPS Installation Schematic Showing Fluid and Pressure Distribution.

- Wellbore equipment and Pressures

The flow rate of formation fluids into the wellbore will be the same as the rate of formation fluids flowing up the tail pipe except for periodic times when slug flow occurs. The pack-off (Isolator) prevents upward flow and gas will collect under the Isolator in the casing annulus and force all of the formation fluids to flow up the tail pipe. A gas/liquid interface will exist at the top of the perforated sub attached to the end of the tail pipe. It is also noted during normal operation that the pressure below the pack-off (Isolator) is greater than the pressure above the Isolator. So, the pack-off device could be a simple cup seal that is elastomer coated with seal rings and is pointing downward. A complete pack-off assembly like a packer that stops flow in both up and down directions is not desired since it increases the chances of having a stuck packer assembly in the well. A one way check valve or special seal device that prevents flow from below is all that is needed with the tail pipe to force the formation liquid/gas mixture up the tail pipe. If liquid from above the pack-off assembly should accumulate from unsteady state flow and then fall from above the Isolator through the Isolator (the Isolator only stops flow in the upward direction), the liquid downward flow would wash sand and debris downward below the Isolator, and the downward flow will soon stop as the pressure above the isolator decreases. Then the normal flow pattern of the formation fluids flowing up the tail pipe and the gas accumulating between the isolator and the top of the perforated sub is restored. The casing annulus between the Isolator Cups and the top of the perforated sub is filled with gas. This is a large storage space for reservoir fluids to flow into and be stored until the wellbore pressure pushes this fluid into the bottom of tail pipe. This storage space smooths the flow of formation fluids into the gas separator and pump. The tail pipe tends to smooth the flow of liquids to the pump.

An isolator was designed to accomplish this task. If sand or debris did collect above the isolator, the Isolator is tapered and sand and debris might be washed downward by simply flushing liquid down past the Isolator by pouring water down the casing or unseating the pump that will dump liquid down the casing. Figure 7 shows a 5.5 inch one-way Isolator cup. Note that the seal is designed to prevent flow from below the isolator to above the Isolator so the opening on the cup’s face is downward. Two cups are used for additional security. Most cups are made from premium HNBR and XHNBR elastomers depending upon the temperature and wear requirements. The lower cup is stronger than the upper cup. The upper cup will seal at lower pressures. Even 5 PSI pressure difference across the cups will cause the elastomer to seal on the pipe wall and stop upward flow.

Figure 7 – Special Design Flow Isolator cups are used to control flow in the casing annulus.

AFLAS or VITON elastomers are used for higher temperatures up to 400 F. The elastomer is formulated to resist wear in rough conditions and harsh chemicals. Special durometer cups are available. For some applications a higher durometer stronger cup is used on the bottom of the isolator and a softer lower durometer cup is used for the upper cup. These cups were designed and made especially for the UPS tail pipe application. Abundant water or other lubricant should be used during installation of the Isolator cups to keep the cups cool and lubricated.

Figure 8 Isolator with Dual Elastomer Cups with Centralizer and Adapter to tail pipe

Dual Cups are facing downward to prevent casing annulus flow upward at the location of the Isolator. The wellbore pressure below the Isolator is higher than the wellbore pressure above the Isolator during normal operation. The Adapter connects the Isolator to the tail pipe and the tail pipe connects to the perforated sub that is positioned in the lower curved portion of the wellbore where the slant is approximately 75 degrees. The Isolator with Centralizer and Adapter are about 36 inches long.

- The Centralizer shown in Figure 8, is placed immediately below the Isolator.

The OD is approximately the drift diameter of the casing. The Centralizer guides the Isolator cups into the wellbore in case of a change of casing size. A Cross/over is shown for connecting the 2 3/8 equipment to the smaller tail pipe.

- Tool Saver for Control of Settling Sand.

A Tool Saver is used to prevent sand and debris from collecting on the TAC and the Isolator. The Tool Saver has two HNBR or VITON discs that seal only at low differential pressures to prevent contaminants from settling on the TAC and Isolator. The Tool Saver is 22 inches long.

Figure 9 – Tool Saver

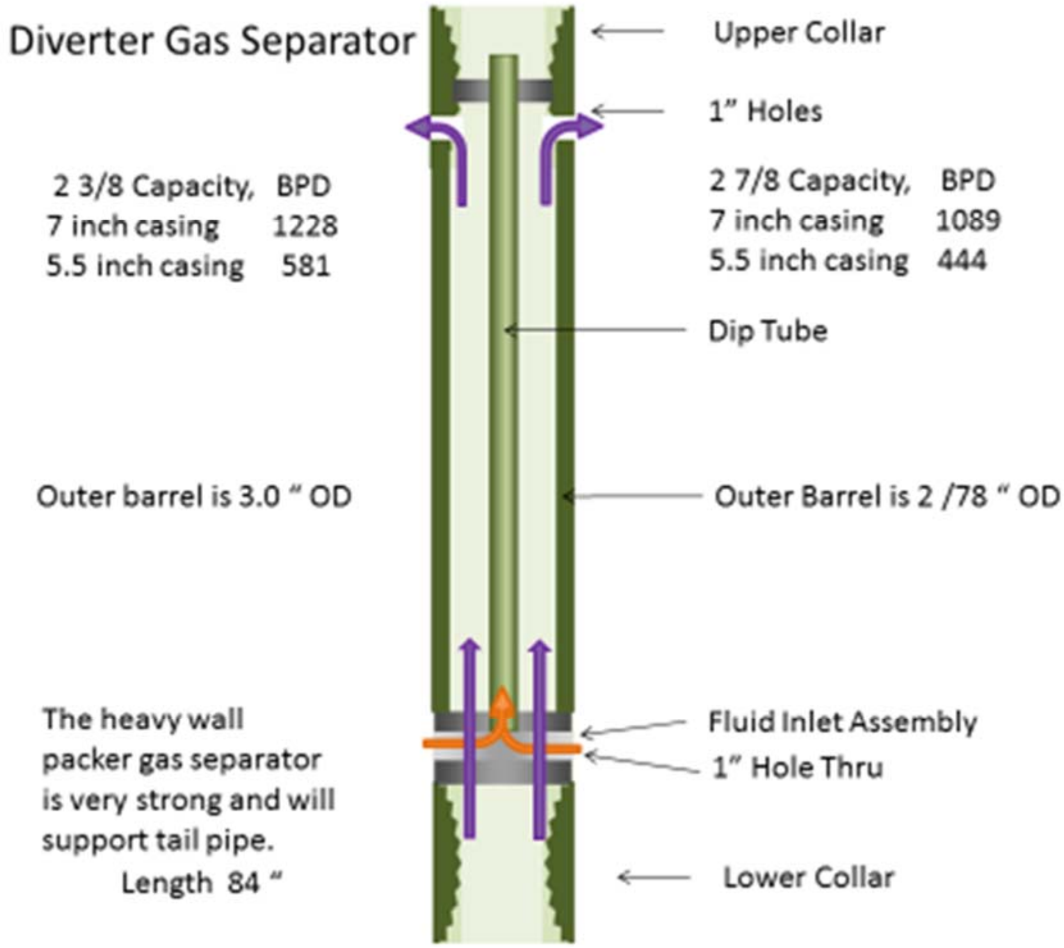


Figure 10 – schematic Diagram of the Echometer Diverter Gas Separator

- UPS Echometer Diverter Gas Separator

The high efficiency Echometer Diverter Gas Separator shown schematically in Figure 10 is used to separate the gas from the liquid before reaching the pump intake. Its liquid capacity is maximized by using the full casing annular area between the casing ID and the 3 inch OD 2-3/8 inch gas separator for separation of the gas and liquid. The OD of the separator is 3 inches as shown in Figure 9. Using the Echometer gas separator capacity software program, the 2-3/8 gas separator liquid capacity is 1128 BPD when used in 7 inch casing, 581 BPD when used in 5.5 casing and 229 BPD when used in 4.5 casing.

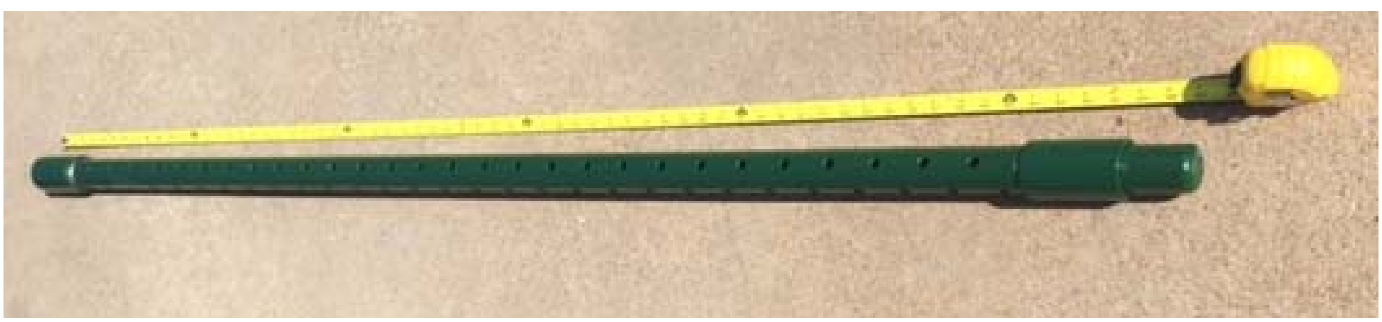


Figure 11 Perforated sub for installation at bottom of Tail Pipe.

- Perforated Sub for bottom of tail

A bull plugged perforated sub that is the same size as the tail pipe is supplied for limiting the size of contaminants that enter the tail pipe, and also to prevent plugging of the tail pipe when the lower portion of the tail pipe is pushed into sand and debris at or near the bottom of the wellbore.

- Equipment Installation Report

A report showing suggested running procedure is included with the equipment including tail pipes size, tail pipe depth, pump depth, separator depth, tubing anchor catcher depth and Isolator depth. In addition, a recommendation for the rate of water to be deposited down the casing annulus when the elastomer cups are being run in the well to cool and lubricate the Isolator cups is given. When the cups enter the static liquid level in the well, the addition of water to the casing annulus is not needed.

Patents were applied for beginning in 2013 and the first patent was issued as US9,022,106. Other patents pending.

Please contact Brian Ellithorp or Jim McCoy for additional information or pricing.

Brian Ellithorp	Jim McCoy
Brian.ellithorp@echometer.com	Jim@echometer.com
Phone 405-837-0173	Phone 940-733-4334

Reference: McCoy, J. N., O. L Rowlan, D. Becker, Echometer Company, and A. L. Podio, University of Texas, “Optimizing Downhole Packer-Type Separators,” Proceedings of the 2013 Annual Meeting of the SWPSC.

Echometer Company 5001 Ditto Lane Wichita Falls, Texas

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