VORTEX TOOLS: KEEPING PRODUCTION TANKS IN COMPLIANCE WITH E.P.A. AIR QUALITY STANDARDS

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ABSTRACT

Since 2001, over 1,500 patented Vortex tools have been sold into oil & gas markets worldwide. On surface lines, these tools set up a stable spiraling flow that keeps liquids from dropping out, prevents freezing, reduces pressure loss and mitigates paraffin and salt build-up. Downhole, Vortex tools enable wells to flow unaided below the critical rate, as well as lowering the flowing bottom hole pressure and reducing surfactant and other chemical use by up to 50%. With no moving parts, all Vortex tools are virtually maintenance free, and no additional energy source is required.

Vortex Tools previously presented at the SWPSC in 2007 (summarizing the Department of Energy's testing of Vortex downhole tools[1]) and in 2012 (on recovering 10 times more natural gas liquids than conventional methods[2]).

In 2009, a Texas independent producer began installing Vortex tools on gathering lines to recover substantially more natural gas liquids (NGLs) than they were previously getting with pigging and/or drip systems, all with marginal impact on the energy value of the gas (7-12 BTU). After collecting 15 months' worth of comparable data—lines with Vortex to lines without Vortex—the data concluded the following: Over 1.2 million gallons of NGLs were recovered from ~16 MMCF of ~1,170 BTU gas from three gathering lines with Vortex tools in a single year, translating to over $2 million in additional revenues. An average well line with Vortex paid for itself in less than 60 days (including the cost of the Vortex tool, associated tanks and installation). There were also additional "non-revenue" benefits like reduced pigging, lower methanol use, reduced de-emulsifier use, reduced hydrate formation and zero line freeze-ups on gathering lines with Vortex. These "non-revenue" benefits (and more) have been confirmed by numerous university studies, Department of Energy (DoE) testing, case studies and various White Papers, including SPE 84136.

As a result of these additional revenues, improved ROI and operational benefits, the Vortex tools are now a part of this Texas independent producer's new well completion program. The customer continues to look for new areas to profit from the Vortex tools and has found additional success in replacing vapor recovery units (VRUs) and reducing the time to send oil and gas to sales (instead of flare) on flowbacks.

As air compliance regulations become more stringent and fines more likely, the oil and gas industry is showing increased interest in using Vortex tools to keep well sites in compliance with EPA air quality standards. Based on Vortex's ability to remove hydrocarbon vapors (in liquid form) from gas, Vortex personnel hypothecated that the same Texas independent could also use Vortex tools to spin residual gas from liquids. This led to opportunities in managing and reducing fugitive vapors at production tanks.

In over 60 installations, every tank battery with Vortex was and is in compliance with air quality emissions standards, even on days with 103° F ambient daytime temperatures.

OVERVIEW

Vortex Tools, LLC (Vortex) introduced its patented spiral flow technology to the oil & gas sector in 2001. Since that time, over 1,500 Vortex tools have been sold throughout the U.S., Canada, Australia, China, and the Middle East.

The initial focus of this proprietary process was in lowering surface line pressures in marginal gas wells, reducing liquid drop-out, reducing freeze-ups in winter, and helping to mitigate against paraffin accumulation. After an extensive study at Texas A&M, an SPE White Paper (#84136) was published detailing the benefits of this patented technology in lowering the critical rate and extending the free-flowing life of a marginal gas well.[3] Vortex started to promote benefits of its technology downhole to wellbore solutions, namely wireline retrievable intervention, clearing liquids out of horizontals, reducing soaping, and keeping coalbed methane wells free flowing.

From 2009 to 2010, Vortex Tools tested and proved the value of surface installation for increased natural gas liquids recovery. After 15 months of data, a White Paper was published and presented at the 2012 SWPSC. Recently identified benefits with this tool include recovering a greater oil cut, elimination of buildup and carry over, reduction in glycol and chemical use, and reducing flowback start-up times. As air quality laws become more stringent, Vortex tools can be used to both A) generate more revenues; and B) prevent regulatory fines by reducing fugitive emissions at production tanks.

CURRENT REGULATORY CLIMATE

Although technology continues to improve, air quality regulations often don't update to account for innovation. With the increased use of horizontal drilling, oil and gas companies are now able to complete multiple wells on a single pad. However, air quality laws either remain the same (as when there were less wells on the pad, despite the land preservation efforts which result from more wells per pad) or they've become more stringent.

In February 2014, Colorado became the first state to regulate methane emissions. The Air Quality Control Commission (ACQQ) voted to pass the measure 8-1 with help from Gov. John Hickenlooper, environmental groups, three large oil and gas operators (Anadarko Petroleum Corp., EnCana Corp., and Noble Energy Inc.), and Colorado's biggest natural gas gathering/processing company, DCP Midstream.

These are currently the most stringent air quality regulations:

- The regulations affect all of Colorado: This is a statewide approach, rather than tackling the issue county-by-county as needs warrant.
- The regulations require routine checks for leaks: Regulators can check up to once a month and any issue needs to be resolved in 15 days or the company faces ongoing fines.
- The regulations specifically target methane: Prior legislation only regulated volatile organic compounds (VOCs). Previously, no other state has regulated methane, as it was perceived to be difficult to enforce throughout the oil and gas chain. However:
- The regulations include the entire natural gas chain: This includes "the well site, storage tanks, gathering lines and compression stations as well as processing plants."[4] This will likely be enforced with infrared cameras from EPA helicopters.

Several Colorado independents were opposed to the sweeping regulations and the Colorado Oil & Gas Association (COGA) launched lawsuits based on what they perceive to be illegal methods in getting recent regulations, bans, and moratoriums passed. In addition, Chevron Corp.—who is not largely involved in Colorado—believes "there is the possibility of political taint in this rulemaking."[5] Chevron, along with COGA and the Colorado Petroleum Association, believe that the cost of complying with these new regulations will be $100 million (2.5 times higher than industry economist estimations of $40 million).

Depending on how these regulations affect Colorado, stringent air quality laws could pass in other states, and as such, cannot be ignored.

THE VORTEX SOLUTION

From 2010 to 2011 a Texas independent studied the impact of Vortex tools in their wellhead operations. Data was gathered on producing wells with and without the Vortex solution over a 15-month period.

This operator noted that there are several places in the wellhead footprint where Vortex can be utilized to address different problems such as freezing, hydrate formation, and reduced water vapor (by increasing free-water knock-out), as well as increasing production values including natural gas liquid (NGL) recovery, turning vapors to liquids, etc.

A challenge for the operator is to efficiently recover any of the higher value hydrocarbons from the natural gas without creating a delay at the point of custody transfer. Refrigeration methods such as Joules-Thompson or cryogenic processes are banned in most pipeline contracts. However, the rich NGLs entrained with the natural gas can be problematic when these liquids drop out of the natural gas (as temperatures reduce, elevation changes impact velocity, and liquids come out of the gas at low spots in the gathering lines).

In many cases, the drop-out of liquids (water, NGLs, condensates, and light oil) cause spikes in flow-line pressure, increasing compression, and creating intermittent production. The use of pigging or pressure spikes to evacuate liquids from the lines creates challenges at the process plant in terms of managing slugs of liquids. Vortex eliminates these challenges by delivering a constant flow of liquids, reducing slugging, and reducing surface line pressures.

As increased NGL recovery benefitted the customer's bottom-line the fastest, this was the initial area of interest for the operator. Interest in air quality compliance came later.

Increased Natural Gas Liquid Recovery

After natural gas has expanded from wellhead pressures through the low-pressure separator or heater-treater, much of the NGLs and condensate flash back to gas, and are compressed back to pipeline pressures as gas is sent to sales.

By adding a Vortex tool after the gas is compressed, rich natural gas passes through the Vortex tool into the gas pipeline. A phase separation of gas and liquids occurs in the Vortex tool – with heavier hydrocarbon vapors pushed to the outside and lighter gas pulled to the center of the Vortex (much like the principles of a tornado). The liquids and gases can be separated thereafter by conventional separation. Vortex tools can be installed at the beginning or end of the gas pipeline, maintain organized flow over long and short distances, and can be installed horizontally or vertically without impairing performance.

Benefits from Vortex (in terms of increased hydrocarbons such as NGLs, condensates, etc.) have been seen in lines as long as 6.5 miles and as short as 8 feet. The Vortex separation occurs immediately downstream of the device and the co-flow (of liquids and gases) continues for long distances without significant drop-out of liquids at low spots due to the temperature or elevation changes.

At the end of the gathering line, the organized vortex flow discharges into the separator. NGLs pass to the NGL bullet tank under pressure (120 PSI minimum) and gas goes to the processing plant. Recovered NGLs are cleaned of any remaining contaminants using carbon and clay filters.

The drop-out of liquids from rich natural gas (example: North Dakota [Bakken] gas is 1800+ BTU) can lead to significant process plant problems – with large slugs of liquids overwhelming the slug catchers and in some cases causing carry-over to the fractionation towers. In early 2014, a gas processing plant in North Dakota had to flare gas and condensates for 14 days due to the excessive flow of water to the slug catcher, causing the flaring of over $3,000,000 of product. A second gas processing plant had a pipeline explosion caused by trying to heat and vent-off hydrates in the gas. Both of these situations would be preventable with Vortex.

To the gas processor, the biggest benefit with Vortex is the consistent constant flow of liquids, including water, to the slug catcher instead of the large slugs experienced with drips, pigging, and pressure differentials alone.

Increased NGL Recovery Results

Using the Vortex tool resulted in more NGLs in the operators' tanks. Data collected indicated the gas was 1,150-1,275 BTU. The higher the BTU, the more liquids were recovered in the operators tanks.

Like most processing plants, the price for the NGLs in the operators' tanks ($73/bbl at the time) was substantially higher than what was allocated for NGLs recovered by the plant. NGLs from the processing plant were based on $42/bbl (after transportation and processing fees, shares, etc.) and are often shared between operators on a theoretical (as opposed to actual) basis. With this in mind, the Vortex solution is now being deployed in high BTU/liquids areas such as the Bakken in North Dakota.

The results of the field trial were significant, with over 1.2 million gallons of additional NGLs recovered from three gathering lines in a single year, translating to over $2 million of additional revenues. An average well line with Vortex paid for itself in less than 60 days (including the cost of the Vortex tool, its associated tanks and installation).

There were additional "non-revenue" benefits like less pigging, reduced methanol use, reduced hydrate formation and zero line freeze-ups on the gathering lines with Vortex.

The NGL experience also led the operator to consider using the Vortex tool in new well flowbacks to enhance well recovery rates and improve well payback through reduced pit flaring. Vortex tools were also used to replace vapor recovery units (VRUs) and to keep vapors in a liquefied form.

Based on Vortex's ability to remove hydrocarbon vapors (in liquid form) from gas, Vortex personnel hypothecated that the same Texas independent could also use Vortex to spin residual gas from liquids. This led to opportunities in managing and reducing fugitive vapors at production tanks.

Removing Entrained Gas from Oil / Reducing Vapors at Production Tanks

The Vortex air quality compliance solution is a field processing solution in which the beneficial spiraling flow developed by Vortex recovers fugitive vapors at the wellhead site. Deploying Vortex on the liquid leg of the high-pressure separator can help remove entrained gas from oil production, thereby eliminating fugitive vapors going to the production tanks. In a typical US oil well, full-flow production (oil and gas) combine into a co-mingled line at the tree that then goes to the HP separator. At the HP separator, gas is removed and sent to the sales line. Oil from the HP separator goes through the Vortex tool on the liquid dump line to the LP separator or heater-treater. During transfer to the heater-treater, the Vortex tool spins entrained gas out of the oil. Therefore, gases and vapors normally liberated by the pressure drop through the separation vessels and tank are removed by the heater-treater or low-pressure separator.

Benefits of adding Vortex include:

- improved air quality and reduced emissions
- better oil cut
- reduced emulsion in the oil and reduced chemical use
- less BS&W in oil tanks
- burner on heater-treater reduced or turned off

With Vortex, the customer recovers additional production and eliminates the need for more expensive vapor management solutions.

By adding a Vortex tool before the heater-treater, entrained gas is separated out of the liquids going to production tanks. One Texas customer is recovering 55 gravity condensate from flash gas previously going to flare, thereby reducing pollution and enhancing oil recovery with less entrained vapors to the production tanks.

This Vortex solution is being used on conventional oil wells in Texas to spin residual (entrained and dissolved) gas out of the oil, thereby reducing vapors at the production tanks. The Vortex tool is placed between the high-pressure separator and the low-pressure separator or heater-treater. (In this case, oil/condensate [at about 550 PSI] is dumped from the high-pressure separator to the low-pressure separator/heater-treater at 35 PSI.) With this pressure drop, entrained gasses are liberated. When the low-pressure separator dumps to the production tank at atmospheric pressure, additional entrained gas is liberated. By going through the Vortex tool first, the entrained gas that would be liberated at atmospheric pressure is removed prior to going into the tank.

A customer noted:

"We have a well producing 20 mmcf of gas and 4,000 barrels of oil per day. The volume of volatile vapors, (high btu flash gas), coming off of the production tanks was tremendous. Even though a road had been built for the landowner that avoided this location and the vapors, he insisted on using his old road that went right by the production tanks. Foggy mornings in East Texas allow the accumulation of vapors and can create an explosive situation. A Vapor Recovery Unit was installed on the tanks, but proved unreliable.

"By installing a Vortex Tool as described above, the escaping vapors were eliminated. Instead, they were taken to a compressor and sold. Problem solved!

Use of Vortex in Flowbacks and VRU Replacement

With the Vortex tool, the operator is able to spin volatile organic compounds (VOCs) back into the oil. This is a cost-effective and efficient way to remain in compliance with today's emissions standards. By spinning vapors back into the oil and condensates, Vortex surface tools allow the operator to cost-effectively replace vapor recovery units with an environmentally responsible, cost-effective, efficient solution that meets air quality compliance. The stable flow reduces turbulence, provides a better separation of fluids and vapors, increased volume and more value, and the (flash) gas is recovered and sent to compression and to gas sales. The Vortex tool eliminates vapors (making most of them liquids), so there is minimal gas going to flare and what little does go is "clean."

After witnessing the efficacy of the tools, the operator started thinking about other applications and provided the following comments:

"We put a Vortex tool between the high and low pressure separators on our well testing units. These wells are horizontal in fractured carbonates. They have a hyperbolic decline curve and start out between 10 and 20 mmcf/d with 1,000-5,000 b/d of condensate, and 2,000-4,000 b/d of water and 12.5-18.0# drilling mud. The wells used to take three to ten days to clean up enough to go through the production system. We could sell gas after the second day and recover some oil, with chemical treatment on the third or fourth day. The first two days were through a hydraulic choke and straight to the burn pit.

"With the Vortex Tool we were able to break the condensate/water/drilling mud emulsion so much more quickly that we went to sales in one day or less. On the first well that amounted to $500,000 to sales rather than the burn pit, 18 mmcf/d gas and 4,600 bbls condensate. That, obviously, is the way it has been done since, saving/making literally millions of dollars rather than watch it all go up in smoke. Emissions were reduced tremendously as well, as a consequence of the Vortex solution.

"With the high volumes, we were having a flash gas emissions problem, explosion and environmental risk at the production tanks. Vapor Recovery Units (VRUs), are expensive and have their own set of operational problems. We decided to try a Vortex Tool instead of a VRU. We had gone to a two phase HP sep, (900 psi), to a three phase LP sep, (60 psi), to the tanks with a VRU. Now, it is a two phase HP sep, (900 psi), with a Vortex Tool on the liquid discharge line, to a three phase HtrTrtr, (30 psi), and to the tanks.

"The Vortex tool liquefies the flash vapors on the way to the HtrTrtr and they blend with the condensate to eliminate flash off of the tanks. The flash from the HtrTrtr goes to a LP compressor, which we had anyway, and down the gas line. Our flash flare is from pilot light to 6" high, at the most.

"Additionally, the flash is sold at liquid prices instead of gas prices. By the way, on wells where this system was used, there has never been a load of condensate turned down because of BS&W where on wells without this system, there were one or two every other month."

Vortex Reduces Glycol Use and Increased Free Water Knock-Out

Throughout the wellhead configuration, Vortex, in addition to enhancing production of hydrocarbons, also converts water vapors to liquid for recovery and removal.

One of the less tangible benefits of using Vortex to control and enhance liquids recovery at the well site is the recovery of free water. With Vortex at each stage of the separation process, more free liquids are removed from water vapors ahead of the dehydrator. Consequently, this operator used 80% less glycol with Vortex tools (at wells and on pipelines) when compared to wells without Vortex tools.

Benefits are perhaps obvious: Drier gas/reduced water vapors with better filter life, less contaminated glycol, as well as improved capacity and dehydrator efficiency.

Additional Benefits – Less Line Freezing, Reduced Methanol Use and Reduced Hydrates

Another less tangible benefit of reduced water vapors is the reduction in hydrate formation in gathering lines. Gas is typically 130-210° F at the tree in E. Texas. De-emulsifiers are water based and these create a higher hydrate point. As a consequence, gas will freeze at 55° F.

The customer confirmed he is getting 70% more liquids with Vortex, along with reduced emulsion, reduced de-emulsifier, chemicals use, and no freezing. Lines with Vortex tools have not frozen since install. Lines downstream of Vortex discharge to the gatherer have frozen. In addition to the benefits of reduced water vapors at the wellhead, the Vortex tool also prevents liquids from dropping out at low spots in the gathering lines, reducing the incidence of hydrates forming and reducing the use of methanol in winter.

On lines that have to be pigged to manage liquid loading, the Vortex tool can reduce/eliminate the need for pigging of lines and provides a more stable flow of liquids (with reduced slugging and reduced need for drips).

2010/2011 was an unusually harsh winter in the East Texas area. With the Vortex tools in place, the operator saw significantly less cold weather problems on lines with Vortex tools.

The words of the operator best describe these benefits:

“During last winter, the ambient temperature got down to 9° F. The gas temperature got as low as 34° F. With the Vortex tool in the line, water vapors were liquefied and formed a "slush" that the separators dumped to the water tank instead of forming hydrate blocks. We never froze up on lines with Vortex tools. The low ambient temperatures and the Vortex Tools helped the operator legally recover more NGLs in its tanks.

“We were still pumping some methanol, but not nearly as much as we had in the year before and the year before, it was not nearly as cold as this past winter.”

TECHNICAL DESCRIPTION OF THE VORTEX TOOLS

"*As a stream of gases and liquids enters the flow modifying device, it is forced by a “bluff body” in the flow stream to spin rapidly. The high angular acceleration slings the heavier liquid towards the pipe wall. As this spinning flow moves through the device, the configuration allows the spin angle to relax to a very efficient value.*

"This efficient helix-angle will propagate very long distances. The consequence of the liquid moving (like the rifling on a gun barrel) is that the no-flow boundary at the edge of the central gas flow is moving, resulting in a lower differential velocity between the bulk flow and the outer edge of the flow, which yields a lower shear force and a lower pressure drop due to friction.

"A second benefit is provided by eliminating the slip between liquid droplets in the flow and the gas stream. Removing this slip force reduces the amount of work the gas must do as it moves – reducing the total pressure drop."

-- Source: David Simpson, P.E. Muleshoe Engineering

How Long Do the Vortex Benefits Last?

In air quality applications, the effects of the organized flow in the Vortex tool are immediate, and vapors will remain entrained in the created flow as long as pressures are stable (or until such time as these liquids and gasses are recovered at the separators).

In other applications, Vortex has developed a database of successful installations. Using this information together with specific customer data, Vortex believes that the benefits of the Vortex flow last several miles – even though the visual of the spiral disappears after a relatively short distance. Vortex Tools’ prior test data suggested that the benefits, in some cases, diminish after 1-2 miles (especially in heavy paraffin applications). However, in this case, the multi-phase flow benefits continued for longer distances:

"On one line in particular we know that the "spin" from the Vortex flow continued over six miles in a line that had many elevation changes from creek bores and wetlands bores. You can imagine the centrifugal action that would occur over that distance."

SUMMARY

In this producer's operations, the Vortex tools made money by knocking out NGLs in the gathering lines, reducing line freeze ups, eliminating free liquids in gas meters, yielding better measurement and lowering maintenance and repairs, reducing free liquids through dehydrators, reducing glycol use (by as much as 80%) and filter cost, and tremendously reducing production tank flash emissions, thereby avoiding fines from increasingly stringent air quality compliance regulations.

Over 1.2 million gallons of additional NGLs recovered from three gathering lines in a single year, translating to over $2 million of additional revenues. An average well line with Vortex paid for itself in less than 60 days (including the cost of the Vortex tool and associated tanks and installation). Additional "non-revenue" benefits like less pigging, reduced methanol use, reduced hydrate formation and zero line freeze-ups on gathering lines with Vortex also bolstered the value of these tools.

The Vortex tools are now a part of this customer's new well completion program, with a Vortex tool between the high-pressure and low-pressure separators on flowbacks, a Vortex Tool between the high-pressure separator and the HtrTrtr in the production system, and a Vortex surface line tool placed on each new flowline.

With over 60 installations, all of the customers' wells with Vortex are in compliance with EPA regulations. As air quality laws continue to become more stringent across the nation, the compliance benefits garnered from the Vortex tool will become more important.

The customer continues to look for new areas to profit from the Vortex tools and Vortex is expanding to markets both in the U.S. and globally based on these results.

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