



Vortex Tools for Increased Condensate Recovery

Abstract

Since 2001, over 1,600 patented Vortex tools have been sold into energy markets worldwide. These patented tools set up a stable, spiraling flow that keeps liquids from dropping out, prevents freezing, reduces pressures, and mitigates paraffin build-up while keeping production tanks in air quality compliance. Vortex tools set in the wellbore enable wells to flow unaided below critical rate, as well as reducing flowing bottom hole pressure and chemical/surfactant use by up to 50%. With no moving parts, all Vortex tools are virtually maintenance free.

From 2013 to 2015, a major U.S.-based oil and gas independent installed Vortex tools to increase condensate recovery. Previously, this customer used pigging and drip collectors to capture liquids, but with changes in elevation, temperature, and declining production, liquids dropped out at low spots, pressures increased, and valuable production was not being recovered. Vortex compared field condensate recovery data both prior to and after the Vortex installation (2012 through early 2015—when this report was completed). Comparative data was gathered from two different installations.

Installation #1 was in a declining gas field (1,450 btu) on a vacuum with mature production (245 MCD/day through 4" and 6" lines). After installing Vortex surface inline (SX-I) tools, the operator had their best liquid recovery months ever on these lines in January and February 2014. Overall, 2014 showed 183% increase in condensate production over 2012 (the last full calendar year without Vortex). The 20-month condensate recovery rate without Vortex was 1,131.9 barrels (averaging 56.6 barrels a month). The 20-month condensate recovery rate with Vortex was 3,362.6 barrels (averaging 168.1 barrels a month). Overall, condensate production increased by 180% and recovery benefits were better at high temperatures: The summer increase in condensate was 597% and the winter increase was 149%.

Installation #2 had richer gas (1,840 btu) that was high in condensate, averaging 150-200 MCF/day with four drips in the 8" line. A new large drip was added near the wellhead (66 barrel capacity) to collect most/all condensate before the meter run. Compression from the wellhead ranged from 6 psi to 20 psi. In addition, the customer added a cooler after the compressor (to enhance condensate recovery) and the Vortex tangential liquids recovery (SX-NGL) tool. In *two months*—January and February 2015—Vortex recovered nearly 3.5 times more condensate than in the *three years* previous in drip #5 (270 barrels with Vortex compared to 82 barrels prior).

In each application, the Vortex tools (and associated equipment) had an ROI of mere days, lowered the recovery costs, and increased the condensate recovered by up to 3x. These valuable liquids were then sold to create an additional lucrative revenue stream for the operator without any increase in OpEx.

The Vortex Tools Solution

The Vortex technology was extensively tested at Texas A&M University (SPE paper #84136), Texas Tech, the Department of Energy's Rocky Mountain Oilfield Testing Center (RMOTC), the Stripper Well Consortium (SWC—Penn State), and by large, independent and multi-national oil and gas companies.

The Vortex condensate recovery solution is a field processing solution in which the beneficial spiraling flow developed by Vortex maintains condensates, NGLs, and other liquids in a helical flow, separating them from the gas over long distances. Using the principles of a spiraling, organized flow, components of a two- or three-phase flow are separated by this "tornado in a pipe," and then travel as a co-flow for long distances (up to six miles measured from one tool depending on the application).

From 2013 to 2015, a major oil and gas independent tested Vortex surface tools on two gathering lines to see if Vortex tools would increase the amount of monetizable condensates recovered over their existing recovery methods (pigging and drip systems) while improving the gathering line efficiency:

Installation #1 Data

This declining gas field had the following characteristics:

- 1.57 miles long with 154 feet in elevation changes and 15-18 psi in pressure.
- Gas production began at 105 MCF/day in 4" lines with a large drip, rose to 140 MCF/day and a 6" line, then increased to 245 MCF/day (still 6") by the end of the line with another large drip. Gas BTU was 1,450.
- Condensate recovery averaged around 30 barrels a month in the summer and 75 barrels a month in the winter in 2012.
- With this mature production, declining rates, and low pressures, the field operated on a vacuum (to move this low production through these larger lines). Previous methods of condensate recovery (pigging/drips) were inefficient and caused gathering costs to increase as liquids dropped out in the line.



**Note that the image (gas flow) goes from right to left (uphill).*

The customer wanted to eliminate the drips (and their associated costs) with a solution that would allow them to recover all the liquids at a single collection point while handling changes in production, elevation, line size, etc. The Vortex surface inline (SX-I) tool (pictured above) was installed in October 2013. The customer elected to go with this SX-I tool over Vortex's tangential SX-NGL tool due to height restrictions and the line being buried.

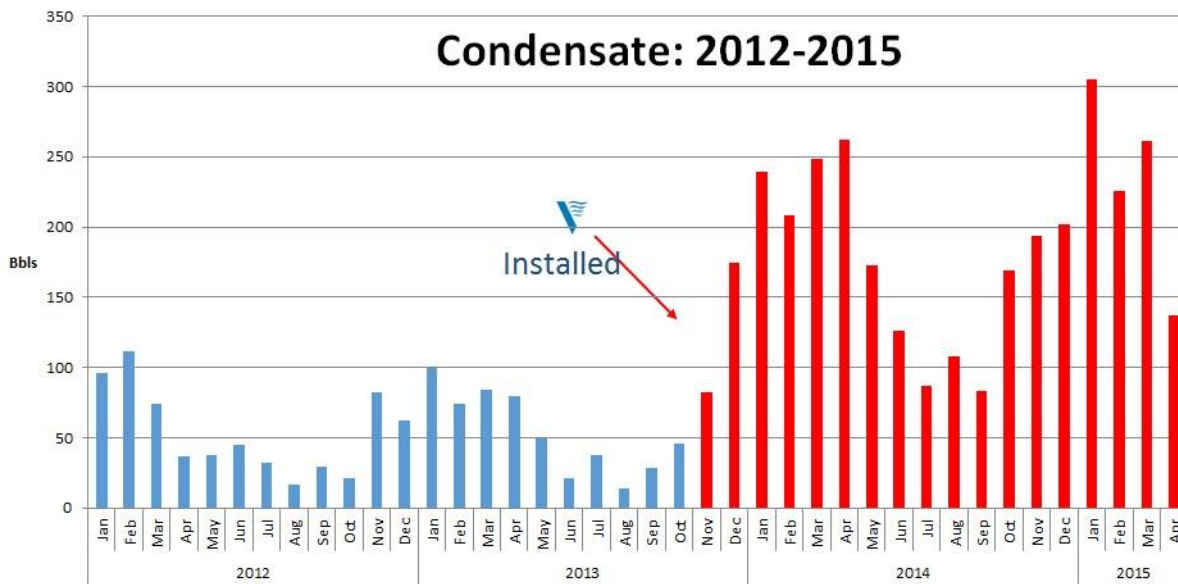
As part of defining success for this application, the customer wanted to know:

- Could the Vortex tool carry liquids and gas 1.57 miles over 154' increase in elevation with *zero* drips to the main line?
- Would Vortex reduce the high pressure requirements on the compressor?
- Would Vortex decrease line pressure by eliminating the pooling of liquids?

The answer to all three was yes:

- The SX-I Vortex Tools successfully moved gas with condensate liquids over 1.57 miles through a 154' increase in elevation.
- Line pressures upstream of the project increased; however, upon daily pulling of the drip, the pressure was relieved.
- The new larger drip installation was not enough to contain all of the excess liquids now dumped into the line by the Vortex tools (they saw carryover of condensate downstream of new drip).
- The customer had their best ever January and February condensate recovery from this gathering line (in 2014) with Vortex. These benefits were sustained throughout 2014 with 183% increase in condensate production over 2012.
- Overall condensate production increased by 180% and there was significant increase in summer condensate production as well (597%) – showing improved stabilization of condensate.

Here is a three-year comparison (2012-early 2015) of condensate recovery at the end of the line:



In addition to the 20 months with Vortex vs. the 20 months without Vortex data comparison, Vortex Tools compared a full calendar year with Vortex to the last full year without. As the tools were installed in October 2013, 2012 (12 months with no Vortex) was compared to 2014 (12 months with Vortex):

<i>Condensate</i>	<i>Production</i>	<i>Monetary Value</i>
<i>2012 calendar year (no Vortex):</i>	664 bbls	\$51,520
<i>2014 calendar year (with Vortex):</i>	2,079 bbls	\$166,320
<i>Increase with Vortex:</i>	+223%	+\$114,800

- The increase in winter condensates was 149% (comparing January 2013 to January 2014).
- The increase in summer condensates was 597% (comparing August 2012/2013 to August 2014).

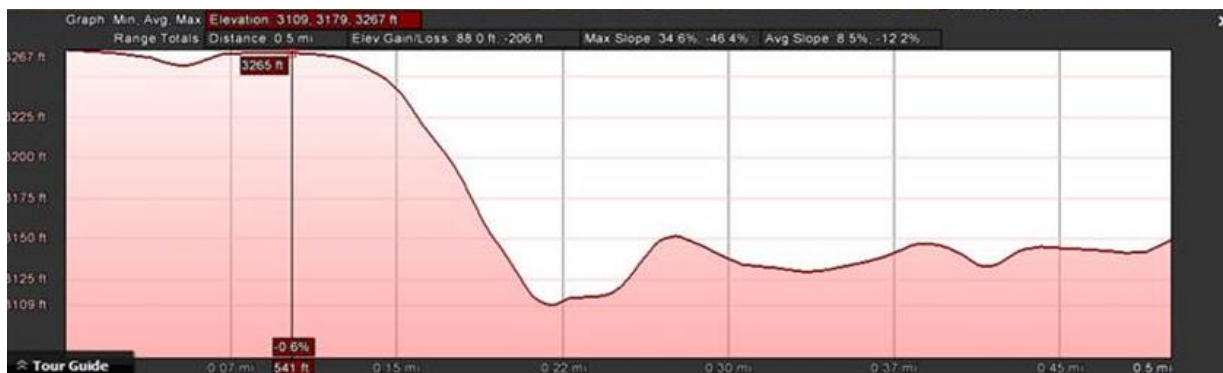
While an increase in condensate was expected in the cooler winter months, Vortex also increased summer production. Prior to Vortex, August 2012 and August 2013 produced 17 and 14 barrels of condensate respectively. After Vortex, August 2014 produced 108 barrels of condensate.

Installation #2 Data

Line #2 had the following conditions:

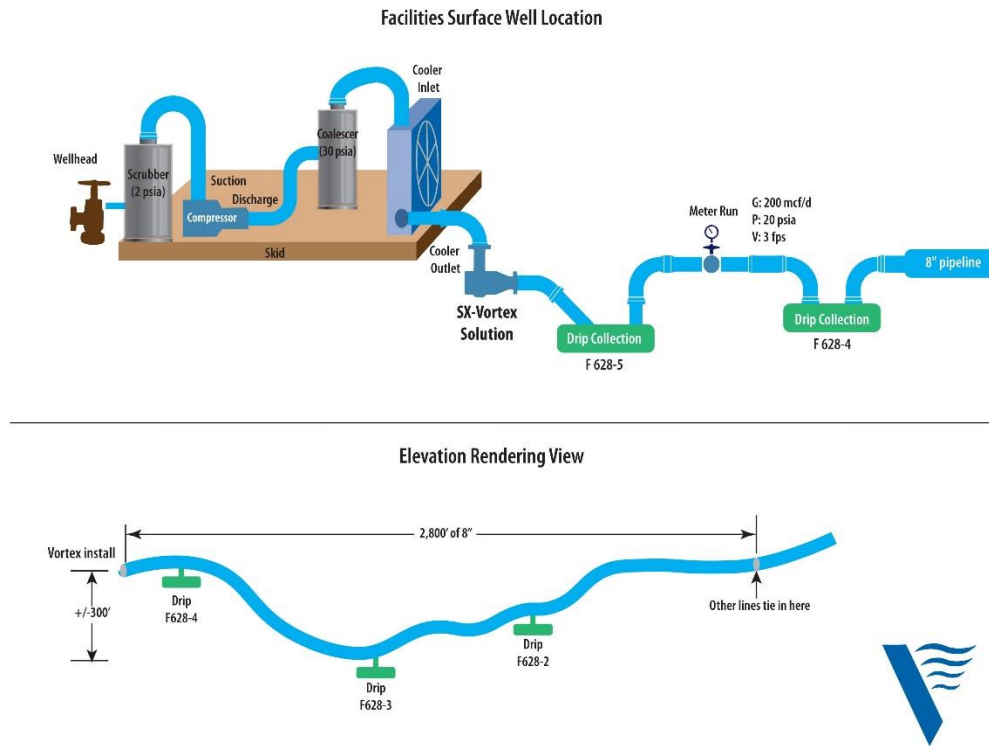
- Rich gas (1,840 btu), high in condensate, averaging 150-200 MCF/day.
- Had an elevation drop of 165 feet, an incline of 76 feet, and a line length total of 2,800 ft. (see image below).
- Had four drips in the system, but most of the liquids were collected at drip #2 at the end of the line. Drips #2-4 were below grade collectors downstream of the well. Drip #2 was possibly getting some “run-off” from a downstream well due to its position downhill from the main pipeline tie-in.
- Replaced small #5 drip with new large capacity drip at beginning of line to collect most/all condensate before meter run. This was added near the wellhead (66 barrel capacity).
- Compression from wellhead ranged from 6 psi to 20 psi.

The customer added Vortex and a cooler after the compressor to enhance condensate recovery at the larger #5 drip.



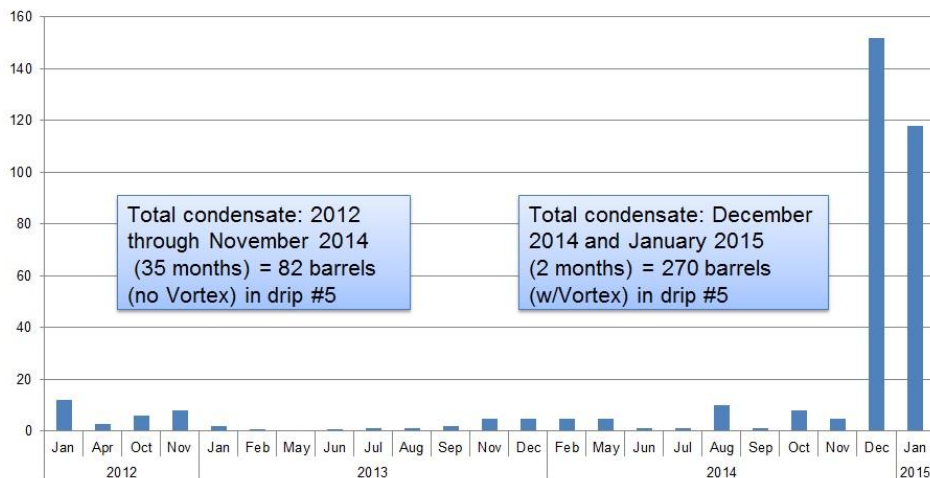
**Note that the image (gas flow) goes from left to right (large downhill dropped followed by elevation challenges).*

Wellhead layout (showing the Vortex SX-NGL tool):

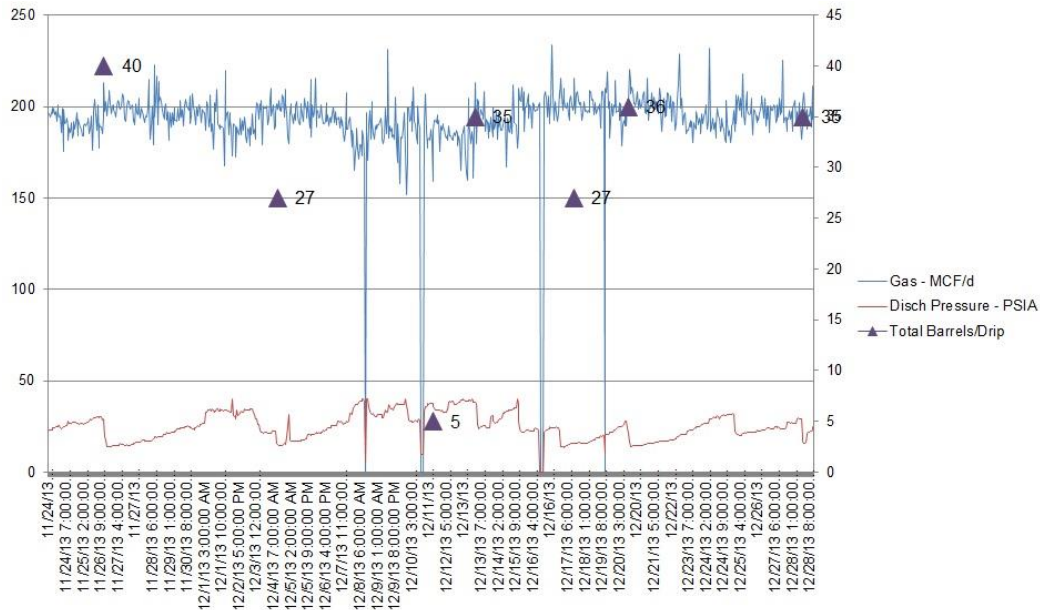


The customer noted, “There will be only about 14” between the back pressure valves and the Vortex tool. We may have lots of hydrates going in to the Vortex tool. But we have to cool the gas dramatically to aid in liquid fall-out. I am hoping the Vortex tool can handle ice.” Based on testing with the Rocky Mountain Oilfield Testing Center (RMOTC) in Gillette, WY, research shows that Vortex surface tools can prevent freezing as low as -20°C (whereas lines without Vortex have already frozen). Vortex tools also reduce glycol and methanol use by as much as 80%.

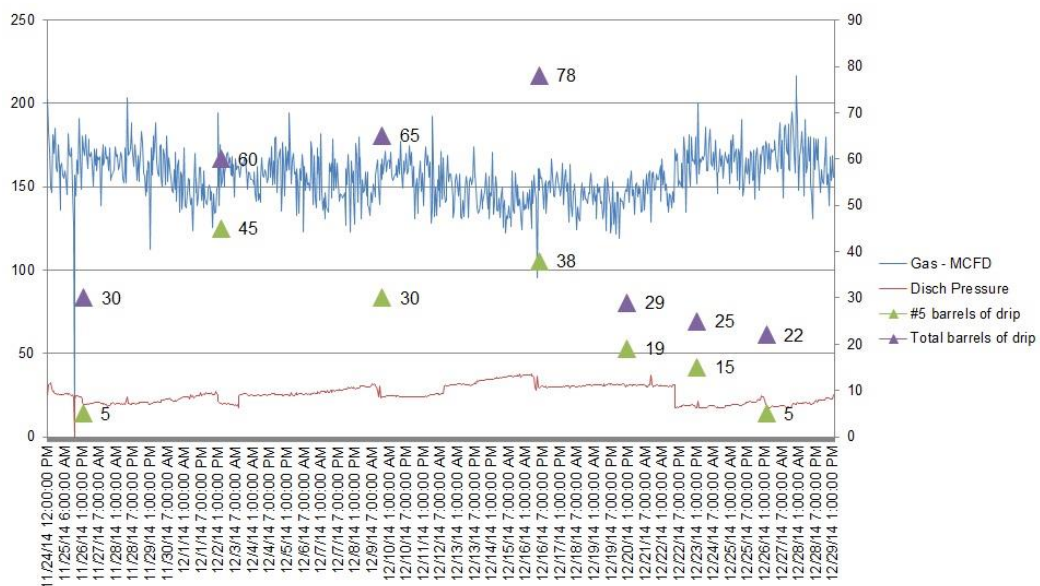
After installing Vortex on line #2, the Vortex SX-NGL tools immediately and vastly increased the condensate recovered while improving the efficiency (note that Vortex recovered nearly 3.5 times more condensates in two months than in almost the three years prior).



The following chart shows the gas (blue), condensate (purple), and operating line pressures (red) in November and December 2013 at drip #5 before Vortex. The total condensate recovered in that period was 205 barrels. The average was 6.03 bpd in time period with a wide pressure range of 14 to 39 psi:



The following chart shows the comparable gas, condensate, and operating pressures in the same line November and December 2014 after the Vortex installation. The total condensate recovered in the comparative period was 320 barrels. The average condensate collected was 8.89 bpd (+47.4%) with smoother changes in operating line pressures. Note that the line pressures are significantly reduced when condensate is collected. This indicates high levels of condensates in drips (lower differentials when collected more often). The #5 drip (green) is the drip collector immediately after Vortex, in which 157 barrels were collected in the time period—compared to only 10 barrels in the same time frame in 2013 without Vortex. Gas rates were about 20% lower in 2014 as compared to 2013.



Summary

With lower oil prices, Vortex Tools offer a cost-efficient technology solution with increased values from oil and gas wells through improved efficiency in collection. Installed in surface gathering lines with liquids-rich natural gas, Vortex surface tools increase condensate recovery in summer and winter alike. With lower collection costs, an ROI of a few days, and a 2-3 times increase in oil condensate recovered, Vortex tools enhance the economic value of oil and gas wells. With summertime condensate increasing substantially—with recorded daytime temperatures of over 100° F—the Vortex tool is also helping to stabilize condensate at higher temperatures (reducing loss to flash).

With no moving parts, requiring no maintenance, and using no chemicals, these patented and proven Vortex tools can operate in all surface gathering line sizes, offer flow optimization benefits, and several monetizable opportunities. In low commodity prices, every increase in revenues is vital.

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