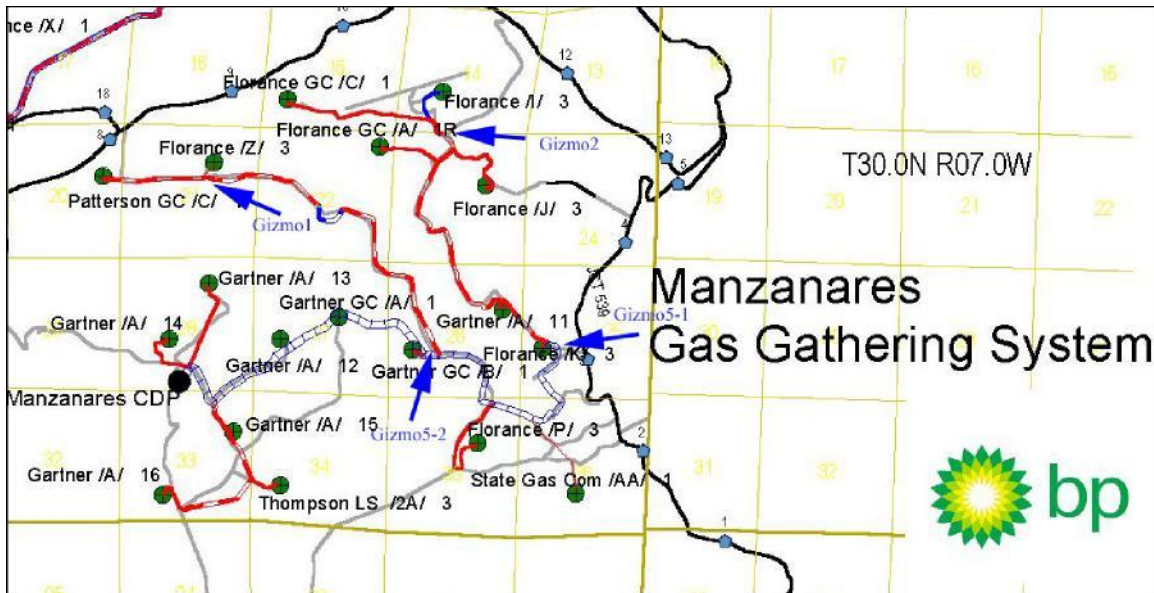


Vortex SX Tool Case Study



Introduction: BP America’s Manzanares Gas Gathering System gathers Coalbed Methane from 19 wells that have produced 58 BCF since first production in 1991. The system is a classic “fishbone” design with a backbone that starts with 1.9 miles of 8-inch pipe and ends with 2.5 miles of 10 inch. The 8-inch portion drops from 6,200 ft elevation down to 5,900 ft. The 10-inch portion then climbs back to 6,300 ft. The “ribs” of the fish are non-piggable and are primarily 4-inch and 6-inch fiberglass pipe. This system has 30.3 miles of gas pipe (153 diameter inch-miles). The nominal pressure at the “head” of the fish has always been 100 psig at the Manzanares CDP. Wells farthest from the CDP typically saw line pressures of 160-180 psig. Wells right on the 8/10 line saw 130-145 psig. The 8/10 inch line is piggable and has been on a weekly pigging schedule for several years. Total production from the system is 7-8 MMCF/d depending on where you are in the pigging schedule.

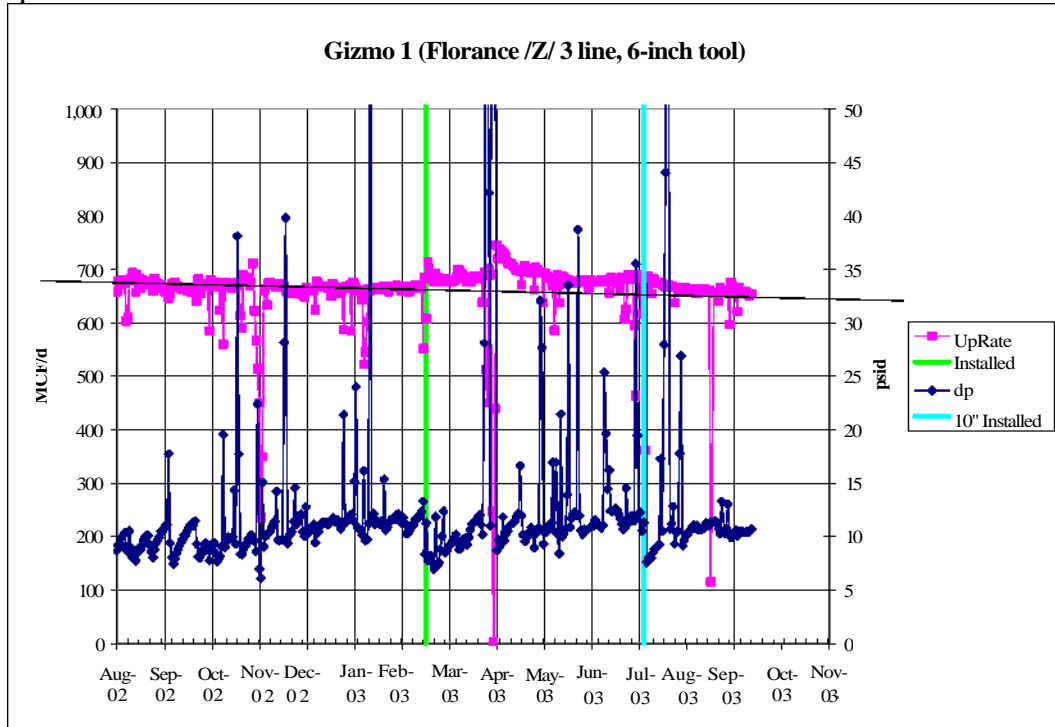
Even with this aggressive pigging schedule, pressure fluctuations were resulting in unacceptable production swings. BP considered adding pigging facilities to the lines, but in the midst of that evaluation they became aware of the Vortex Surface Line (SX) tool. Two six-inch tools were installed in February, 2003, with mixed results. There was substantially more water being pigged from the 8/10 inch line, but the pressure variation on the first tool (labeled “Gizmo 1” on the map) was worse than before the tool was installed. In July, 2003 the 8/10 pig launcher was replaced with a 10-inch SX tool (Gizmo 5-1) and a second tool was installed after the transition to 10-inch pipe (Gizmo 5-2).

Gizmo 1: The characteristics of this installation were:

Number of wells	2
Gas rate before installation (MSCF/d)	750
Water production after wellsite separation (bbl/day)	0.3
Gas specific gravity (air=1.0)	0.6875
Pressure at the tool location (psig)	145
Temperature at the tool (°F)	85
Line size (inches I.D.)	6.4
Line length (miles)	3.2

Velocity (based on mass flow rate, ft/sec)	3.8
Reynolds Number	162,726
Weber Number	26
Standard Deviation of dP before tool installation (psi)	5.52
Standard Deviation of dP after tool installation (psi)	24.83
Standard Deviation of dP after mainline tool installation (psi)	10.28

The production and dP data looked like:



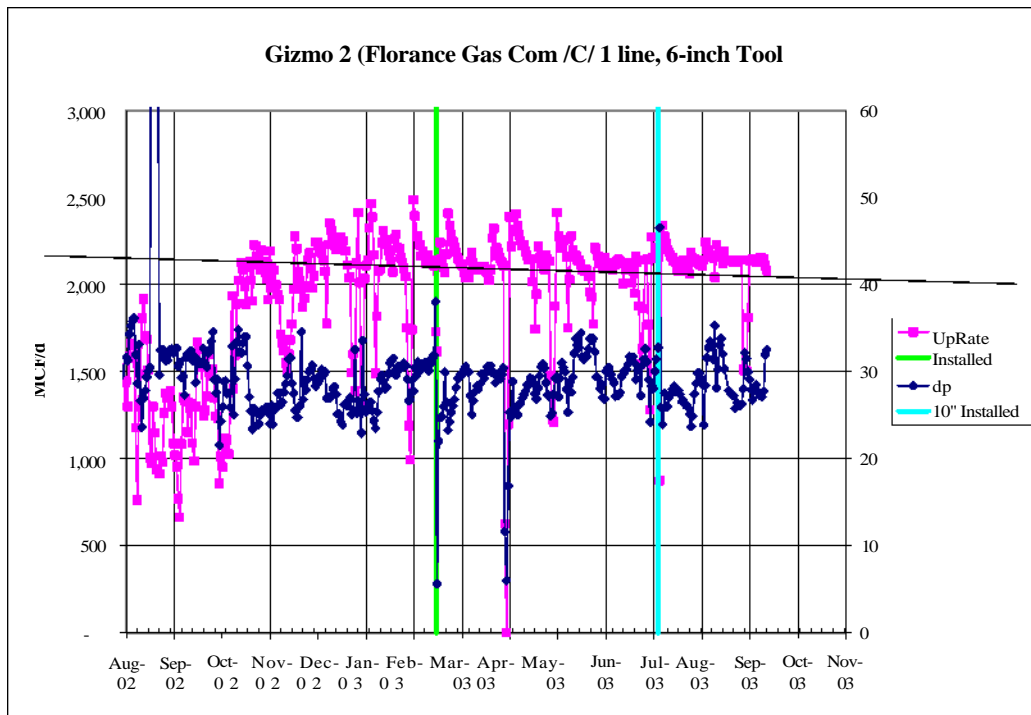
This tool clearly did not improve the flow characteristics of the line, nor did it improve the production from the wells behind the tool. The deterioration in the standard deviation of the dP data was most likely due to the significantly increased water production into the 8/10 line caused by Gizmo 2.

Gizmo 2: The characteristics of this installation were:

Number of wells	2
Gas rate before installation (MSCF/d)	2,200
Water production past wellsite separation (bbl/day)	0.8
Gas specific gravity (air=1.0)	0.7371
Pressure at the tool location (psig)	160
Temperature at the tool (° F)	60
Line size (inches I.D.)	6.4
Length (miles)	2.1
Velocity (based on mass flow rate, ft/sec)	10.4
Reynolds Number	520,082
Weber Number	218
Standard Deviation of dP before tool installation (psi)	17.62

Standard Deviation of dP after tool installation (psi)	3.94
Standard Deviation of dP after mainline tool installation (psi)	2.63

The production and dP data look like:

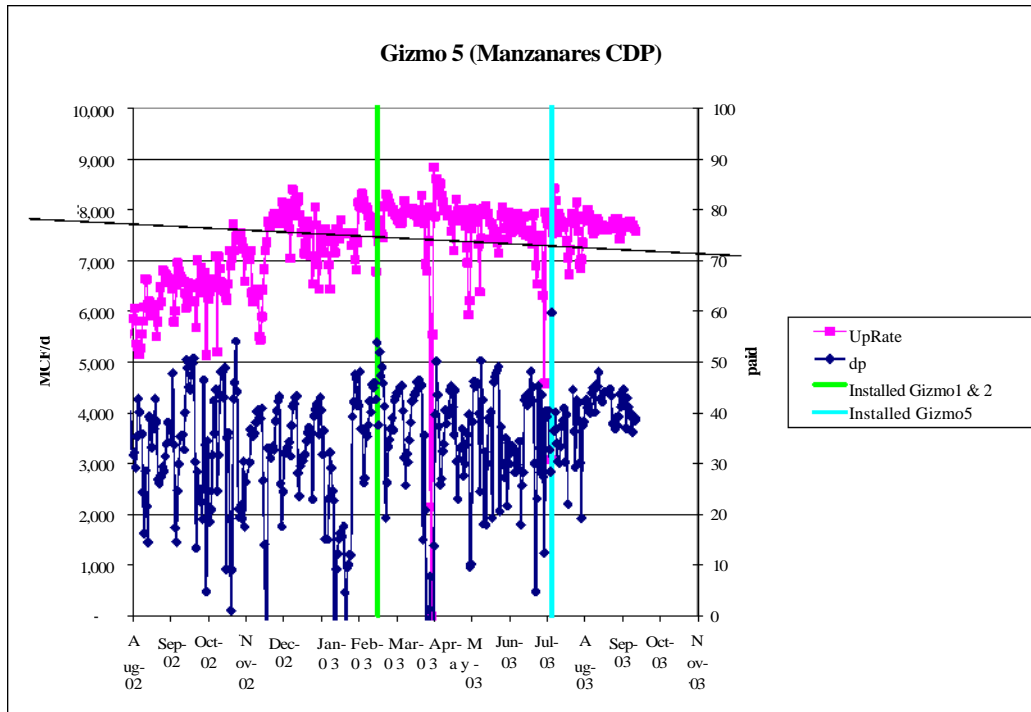


After the installation of the 6-inch Vortex tool, the pressure variability was reduced and the production was better. This installation paid for the cost of both 6-inch tools and their installation within 6 weeks of installation. The big benefit came after the 10-inch tools were installed on the 8/10 inch line. At that point the line pressure at the farthest well became low enough and steady enough to replace a 535 Hp compressor with a 340 Hp machine with lower rental costs and lower fuel consumption.

Gizmo 5: The characteristics of this installation were:

	Gizmo 5-1	Gizmo 5-2
Number of wells	6	11
Gas rate before installation (MSCF/d)	3,784	7,800
Water production past wellsite separation (bbl/day)	2.0	4.2
Gas specific gravity (air=1.0)	0.7371	0.7140
Pressure at the tool location (psig)	128	116
Temperature at the tool (°F)	60	60
Line size (inches I.D.)	7.981	10.020
Length (miles)	1.9	2.5
Velocity (based on mass flow rate, ft/sec)	10.4	18.5
Reynolds Number	520,082	1,145,860
Weber Number	218	856
Standard Deviation of dP before 6" tool installation (psi)	12.72	
Standard Deviation of dP after 6" tool installation (psi)	26.61	
Standard Deviation of dP after mainline tool installation (psi)	4.69	

The production and dP data look like:



The variability of dP has been improving for all of the 3 months since installation and expectations are that it will continue to improve as the last of the puddles of water evaporate and/or are shifted to line drips. The water collected in drips has significantly increased since the installation of the 10-inch tool from 5-10 bbl/month to 60-90 bbl/month. The 10-inch portion of the 8/10 line goes up a 400 ft vertical legoff (total exposed pipe is close to 700 ft). This line has been a source of partial line-freezes most winters since it has been in service. BP is watching closely to see if the line will tend to freeze with the tools installed. The payoff on these two tools was less than 2 weeks.

Conclusion: The three tools that worked provided a significant benefit both in improved pressure stability, rate increases, the ability to collect water into convenient locations, and reduced manpower requirements from eliminating a weekly pig run. BP has additional tools on order for the Coalbed Methane gathering systems in the San Juan Basin.