VRU And VRT Operability From An Engineering And Emissions Control Perspective

HY-BON/EDI

October, 2019

Heads Up : Largest Vent Gas Management Company

Production Equipment
Flares
Gas Production Units
LACT Units
Line Heaters
Oil Treating
Sand Separators
Separation
Storage Tanks
Vapor Recovery Units (VRU)
Vapor Recovery Towers (VRT)

What does VRU's do?

They take waste gas emissions and convert them into revenue, while keeping you safe and in compliance.

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Wasting resources and, most importantly, revenue!

Actual Measurement

- 530 tons per year of VOC Emissions
- $55\ \text{MSCFD} \times \frac{\$4}{\text{MSCF}} \times 2000\ \text{BTU} = \frac{\$132{,}000\ \text{Revenue}}{\text{Year}}$
- Project Cost: $100,000 (VRU, VRT, VCU and Install Estimate)
- Payout: 9 Months!

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Vapor Recovery Tower (VRT)

Vapor Recovery Tower (VRT)

What is a VRT?

- A vapor recovery tower is a tall pressure vessel which is installed between the production separator(s) and the liquid storage tanks
- “Best in Class” VRT’s are engineered for proper retention time to allow gas to separate from the liquid, and have no potential for liquid traps in gas vapor piping to VRU.
  - Although VRT’s are normally rated for pressures between 50 and 175 psig, they typically gravity feed to the liquid storage tanks at very low pressure (~1 psig)
  - In most installations, the flash gas from the liquids in the VRT flow to a vapor recovery unit for compression

Vapor Recovery Tower (VRT)

Benefits

- Captures flash vapors without contaminating the captured gas with air. No Oxygen
- Opportunity to maximize vapor capture, while reducing flash in storage tanks. Approx. 90/10
- Vapor Recovery Tower could potentially remove storage tanks from regulatory reporting.

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Retention Time

SEPARATOR DESIGN - LIQUID CAPACITY:

The liquid capacity of a separator is primarily dependent upon the retention time of the liquid within the vessel. Good separation requires sufficient time to obtain an equilibrium condition between the liquid and gas phases at the temperature and pressure of separation. The liquid capacity of a separator or the settling volume required based on retention can be determined from the following equation.

$$W = \frac{1440(V)}{t} \quad \text{or} \quad t = \frac{1440(V)}{W} \quad \text{or} \quad V = \frac{W(t)}{1440}$$

Where: W = Liquid capacity, bbl/day
V = Liquid settling volume, bbl
t = Retention time, min

Basic design criteria for liquid retention times in separators have been determined by numerous field tests. These are as follows:

Oil-gas separation	1 min.
High pressure oil-gas –water separation	2 to 5 minutes
Low pressure oil-gas-water separation	5 to 10 minutes @ 100°F and up
	10 to 15 minutes @ 90°F
	15 to 20 minutes @ 80°F
	20 to 25 minutes @ 70°F
	25 to 30 minutes @ 60°F

Texas Oil Regulator Shifts Stance on Gas Flaring

Statewide Rule 32. Texas Administrative Code (TAC). Title 16, Part 1, Chapter 3. §3.32.

The commission decided to “make a political statement saying ‘We are hearing people. We understand that this is becoming an issue and we’re going to do something about it,’” Price said in an interview. “That, coming from the chairman, has the most impact.”

The commission grants flaring permits for up to 180 days. Without that, the only alternative for some producers is the so-called shut-in of oil or gas wells to curb output. Special extensions to permits can be granted, usually for up to two years.

What the Regulators Are Looking For

Best Practices to Avoid Non-Compliance

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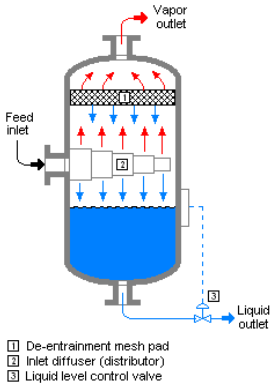
Some Engineering Solutions and Maintenance Considerations for Storage Tanks

- Reduce Liquid Pressure Prior to Transferring the Liquid to Atmospheric Storage Vessels
- Adequate Diameter of Piping Used for Vent Lines to Control Device
- Prevent Liquid Collection in Vent Lines
- Eliminate Unintentional Natural Gas Carry-Through
- Ensure Proper Maintenance and Set Points for Pressure Relief Valves
- Minimize Venting from Thief Hatches
- Adequate Sizing of Emission Control Devices

To reduce flash gas volumes and peak flowrates of vent gas during separator dumps of oil/produced water to storage tanks, use multiple stages of separation. This allows the system to operate with a smaller pressure drop between the last stage of separation (low pressure separator/heater treater) and an atmospheric storage vessel.
Of course, to reduce air emissions, the gas liberated by the intermediate stages of separation must be collected and sent to the system (fuel, sales pipeline) and not vented to the atmosphere.

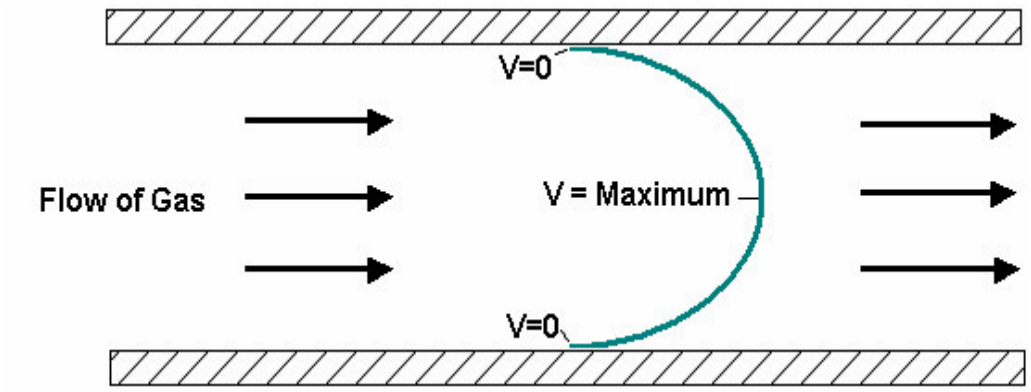
- High Differential Pressure Equals High Flash Potential



HY-BON/EDI's IQR Emission Survey includes an optional assessment of an oil and gas process to optimize pressure drops to atmospheric storage tanks and reduce flash emissions.

Use vent piping between storage tanks and emission control devices that has a diameter designed to handle the potential instantaneous peak flow of vent gas increase flash gas during separator dumps. If the piping is inadequate, then a portion of the will not be collected by the VRU and/or combustor. This will increase the chance of creating back pressure on the storage tank and result in venting to the atmosphere at the thief hatches and/or pressure relief valves (PRV).

- Internal Gas Flow Pipe Friction Causes Problems: <u>Oversize It</u>



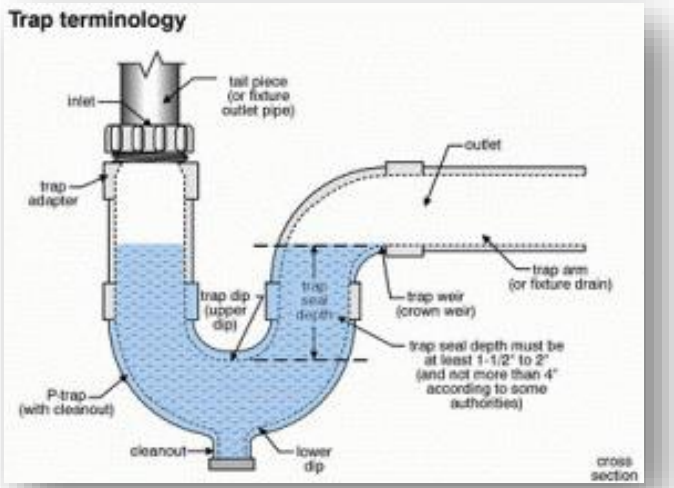
$$C_d = 0.5961 + 0.0261\beta^2 - 0.216\beta^8 + 0.000521\left(\frac{10^6\beta}{\mathrm{Re}_D}\right)^{0.7} +$$
$$+\left(0.0188 + 0.0063\left(\frac{19000\beta}{\mathrm{Re}_D}\right)^{0.8}\right)\left(\frac{10^6}{\mathrm{Re}_D}\right)^{0.3}\beta^{3.5} +$$
$$+\left(0.043 + 0.08e^{-10L_1} - 0.123e^{-7L_1}\right)\left(1 - 0.11\left(\frac{19000\beta}{\mathrm{Re}_D}\right)^{0.8}\right)\frac{\beta^4}{1-\beta^4} -$$
$$-0.031\left(\frac{2L_2}{1-\beta} - 0.8\left(\frac{2L_2}{1-\beta}\right)^{1.1}\right)\beta^{1.3} + 0.011(0.75-\beta)\left(2.8 - \frac{d_1}{0.0254}\right)$$

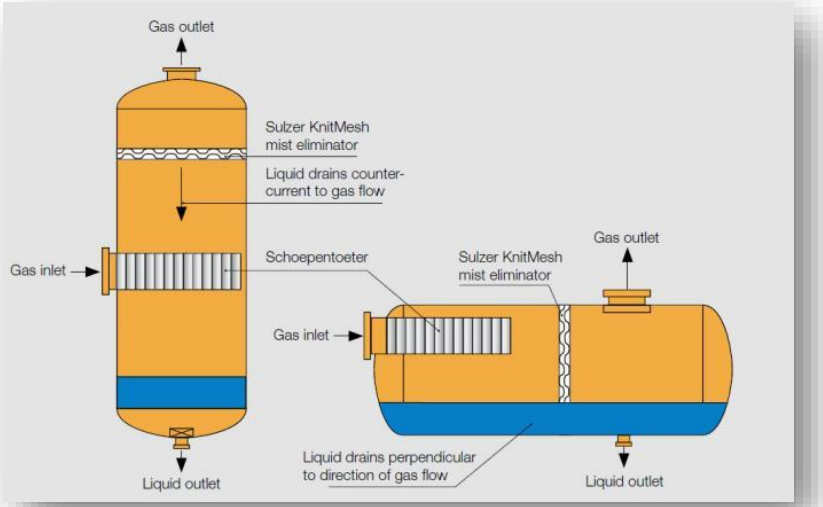
HY-BON/EDI includes this as a standard design criteria when sizing VRUs and combustors for a facility.

3. Prevent Liquid Collection in Vent Lines

The collection efficiency of vent gas control systems will be reduced if rich gas in to vent line between the storage tank and emission control device condenses and collects in vent lines – especially in low spots along the path.

- No Liquid Traps to Gas Control Devices





In HY-BON/EDI's VRU and combustor lines, we recommend using a sloping piping of adequate inner diameter from the storage tank that is routed to a drip pot (i.e., scrubber) to ensure that liquids do not collect in the line creating a blockage. Also, the scrubber can remove liquids that can harm vapor recovery compressors and cause smoking conditions in enclosed combustors/flares.

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4. Eliminate Unintentional Natural Gas Carry-Through

- When storage tank pressure relief devices (PRD) are opening and venting gas on a regular basis due to pressure increase in storage vessel and this caused by unintentional natural gas carry-through, take corrective action to reduce/stop venting.
- This can be due to pressure increase during normal separator dump events and can also occur from separator dump valves stuck in open position (i.e., valve failed to reseat) and leaking gas into storage tanks.
- If repeated PRD venting is not from unintentional natural gas carry-through, the following corrective actions are offered:
- Increase the PRD pressure set points if there is sufficient margin between the set point and the rated pressure of the storage vessel to do so while continuing to safeguard storage vessel integrity-
- Take steps to decrease the liquid's pressure drop experienced at the storage vessel
- Replace the storage vessel with a storage vessel that is rated to a higher pressure and use higher pressure set points.

- Find Them, Document Them and Fix Them

HY-BON/EDI's design services will take into account production rates, operating pressures in sizing VRUs and combustors. Our IQR services include onsite inspections for carry-through of vent gas due to stuck dump valves.

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5. Ensure Proper Maintenance and Set Points for Pressure Relief Valves

- By design, pressure relief valves (PRVs) are safety devices that protect vessels from over-pressurization and should remain closed during normal operations. They are not process vents that should discharge during normal operations.
- The EPA alert states that PRVs should have a pressure setting that is low enough to protect vessel structural integrity and avoid over-pressurization. Also, the pressure setting should be high enough to exceed storage vessel operating pressures during normal operation.
- When a PRV is found to be venting to the atmosphere actions should be taken to verify proper valve reseating after opening.

- Critical to All Operations of VRU and Control Devices. Check, Monitor and Maintain to Stay in Compliance

Division Now Issuing Immediate Notice of Violation for Visible Emissions from a Flare and/or Open Thief Hatch

"The Division has determined that improperly secured thief hatches, visible emissions from a flare, and audible emissions from a thief hatch or PRV are violations of Regulation No. 7. The Division has determined that the minimum fine for an open thief hatch, visible emissions from a flare or audible emissions from a thief hatch or PRV will be $15,000 per day. The duration of each such violation will be at least one day, unless evidence gathered by the Division and/or provided by the source proves otherwise." (emphasis in original).

DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT
Air Quality Control Commission; REGULATION NUMBER 7 ; CONTROL OF OZONE VIA OZONE PRECURSORS

Noble Energy Reaches Agreement With Federal And State Regulators To Improve Air Emission Controls In DJ Basin Operations

The company will pay about $13.5 million in civil penalties and $60 Million to support environmental mitigation projects, according to the consent decree. Noble also agreed to upgrade its equipment in the DJ Basin to reduce emissions, with the work expected to be complete in 2019.

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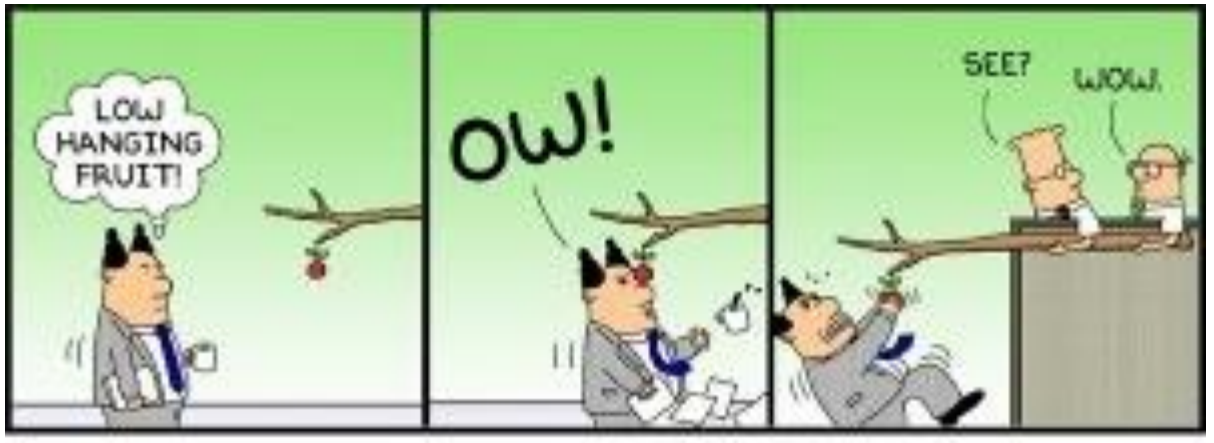
6. Minimize Venting from Thief Hatches

Inspect gauging/thief hatches and pressure relief devices regularly to ensure good seals. Install quality gaskets on thief hatches and regularly inspect those gaskets to ensure a tight seal. Implement procedures to ensure thief hatches are properly closed after vessel gauging, sampling and unloading.

- Inspectors Go After Low Hanging Fruit. Always Pick and Fix It First.



HY-BON/EDI routinely inspects and replaces gaskets for thief hatches and leaking pressure relief devices as a part of our IQR services.

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7. Proper Sizing of Emission Controls

- Ensure that vent gas control devices are properly designed/sized for the specific facility's operations. The design should be sized and operated to control for the full range of gas flowrates that are expected.
- Key to ensuring proper sizing of emission controls is appropriate sampling, measurement and/or modeling to estimate potential maximum flow of vent gas from storage tanks.

- You Don't Know What You Don't Know. Get Good Data. Allows for Management Decisions Based On Fact

HY-BON/EDI's engineers can run process simulation calculations to estimate the potential range of flowrates of vent gas for various operating scenarios. The assessment will take into account production rates, storage tanks used and operating pressures in sizing VRUs and combustors.

Low Bid Cost More

After flyover of an oil and gas production site by the TCEQ using FLIR Camera, an O&G Operator observed visible vent gas emissions. TCEQ gave the operator the opportunity to correct the emissions without monetary penalty.

Low Bid Cost More

The operator contacted HY-BON/EDI for an IQR measurement and bid for a vapor recovery unit (VRU). HY-BON/EDI engineered a system for the application and quoted a wet, flooded screw VRU and vapor recovery tower (VRT).

PAYBACK for HY-BON/EDI system estimated at 9 MONTHS.

Low Bid Cost More

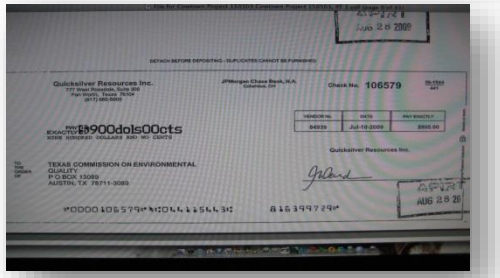
The operator decided to go with another vendor based on cost/low bid for a reciprocating compressor VRU (which was NOT designed the wet gas service it would encounter.)

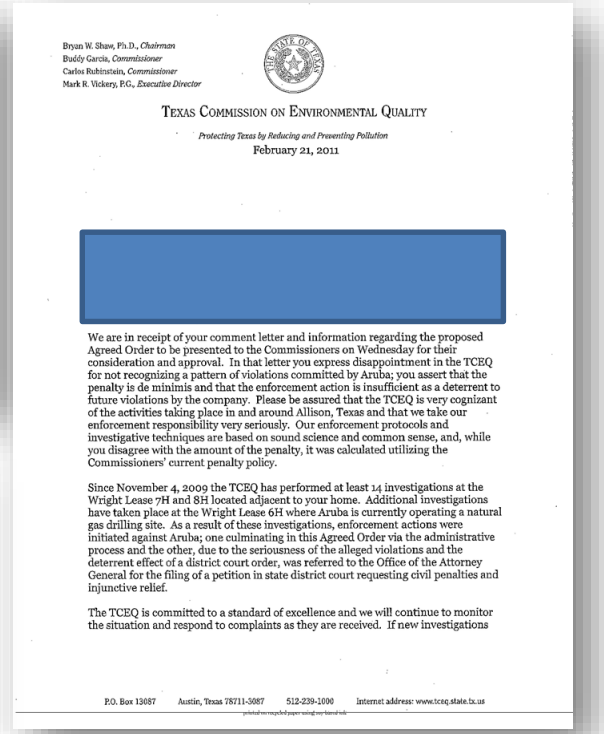
HY-BON/EDI gave a “HEADS UP” of possible failure using reciprocating compressors in wet gas service.

Low Bid Cost More

TCEQ inspectors conducted a follow-up inspection for the production facility and found the site venting natural gas due to failure of the reciprocating VRU compressor.

TCEQ issued a notice of violation and the company was fined $300,000.





Bryan W. Shaw, Ph.D., *Chairman*
Buddy Garcia, *Commissioner*
Carlos Rubinstein, *Commissioner*
Mark R. Vickery, P.G., *Executive Director*

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

February 21, 2011

[redacted]

We are in receipt of your comment letter and information regarding the proposed Agreed Order to be presented to the Commissioners on Wednesday for their consideration and approval. In that letter you express disappointment in the TCEQ for not recognizing a pattern of violations committed by Aruba; you assert that the penalty is de minimis and that the enforcement action is insufficient as a deterrent to future violations by the company. Please be assured that the TCEQ is very cognizant of the activities taking place in and around Allison, Texas and that we take our enforcement responsibility very seriously. Our enforcement protocols and investigative techniques are based on sound science and common sense, and, while you disagree with the amount of the penalty, it was calculated utilizing the Commissioners' current penalty policy.

Since November 4, 2009 the TCEQ has performed at least 14 investigations at the Wright Lease 7H and 8H located adjacent to your home. Additional investigations have taken place at the Wright Lease 6H where Aruba is currently operating a natural gas drilling site. As a result of these investigations, enforcement actions were initiated against Aruba; one culminating in this Agreed Order via the administrative process and the other, due to the seriousness of the alleged violations and the deterrent effect of a district court order, was referred to the Office of the Attorney General for the filing of a petition in state district court requesting civil penalties and injunctive relief.

The TCEQ is committed to a standard of excellence and we will continue to monitor the situation and respond to complaints as they are received. If new investigations

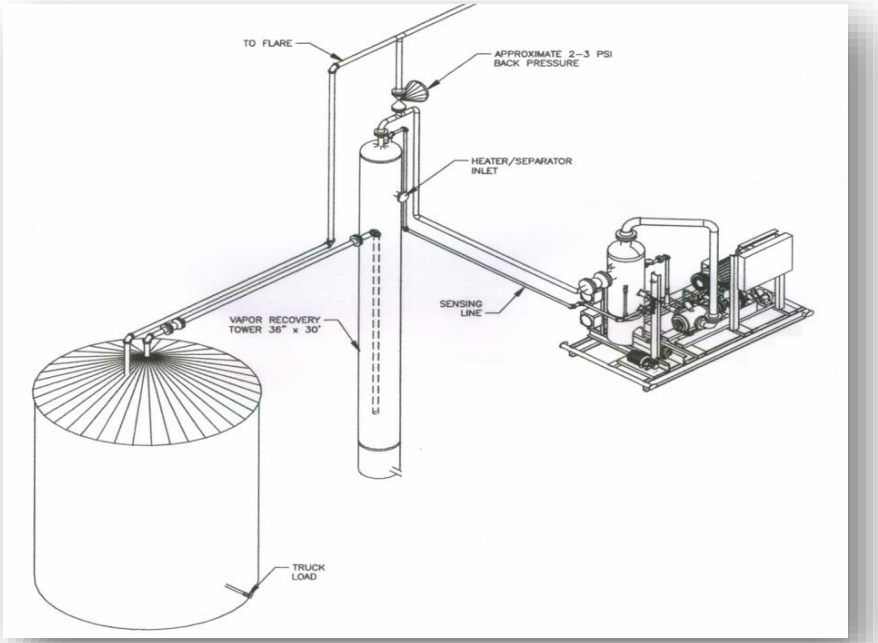
P.O. Box 13087 Austin, Texas 78711-3087 512-239-1000 Internet address: www.tceq.state.tx.us

Low Bid Cost More

The operator contacted HY-BON/EDI to correct the low bid system that did not function properly.

HY-BON/EDI supplied the proper VRU design for the application.

The production site is NOW producing and operating in compliance with TCEQ air quality regulations.



Low Bid Cost More

Engineered designs have the lowest downtime and operating costs in the oil and gas industry.

Doing It Right The First Time Will Make Your Company Money and Keep You In Compliance.

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YOU DON'T KNOW WHAT YOU DON'T KNOW


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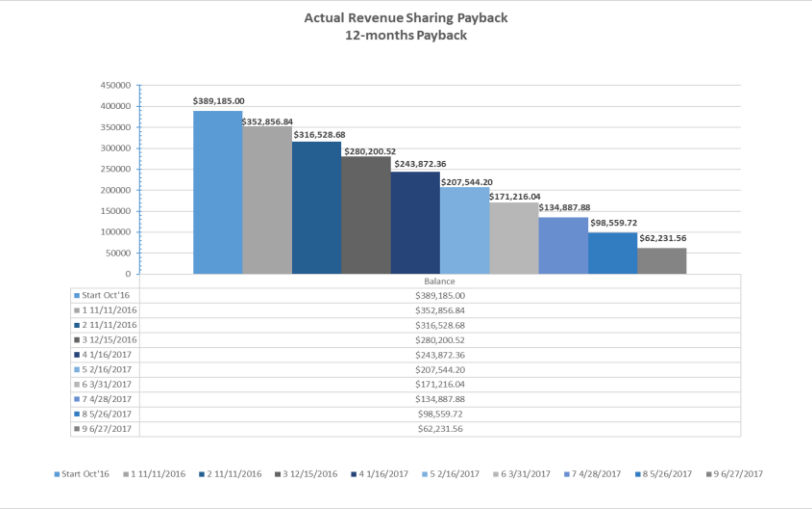
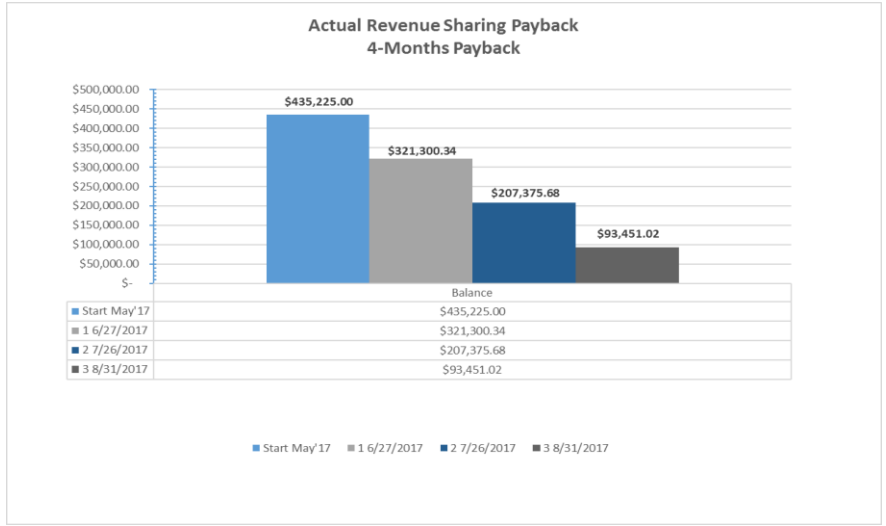
WHAT GETS SEEN, GETS MEASURED

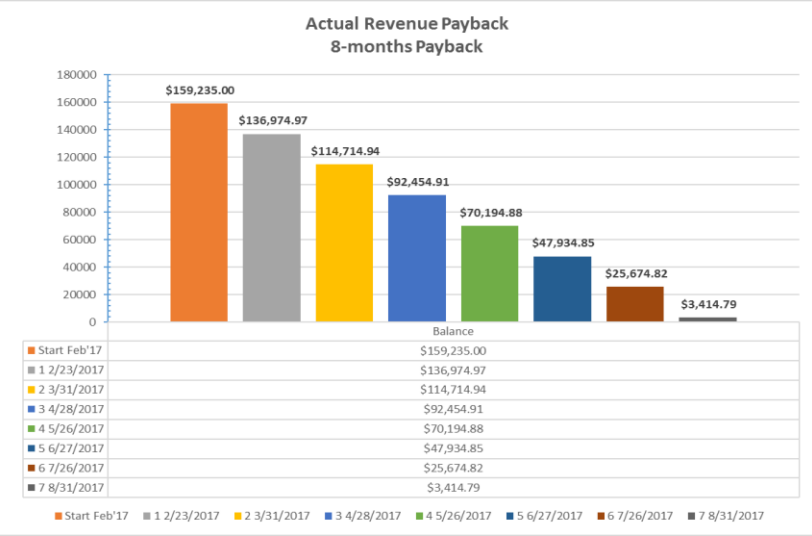
WHAT GETS MEASURED, GETS CONTROLLED

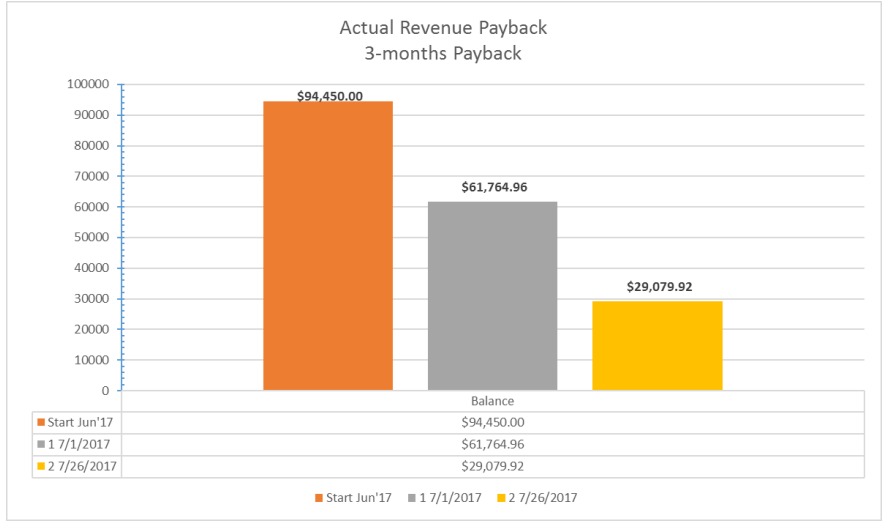
WHAT GETS CONTROLLED, CAN MAKE YOU MONEY

Actual Revenue Sharing Payback









Not Always the answer!

See http://www.cimarron.com/products/ or Product Brochures for further information on our capabilities!

Contacts

Marty Hughes
Cimarron Energy Inc | Account Manager
Phone- 281-917-5131
mhughes@cimarronenergy.com

Inayat Virani
VP International Sales
ivirani@hy-bon.com
(432)670-2292

Butch Gidney
IQR Manager
bgidney@hy-bon.com
(432)553-4911

Greg Cervantes
Houston Account Manager
gcervantes@hy-bon.com
(713)213-9279

Jeff Voorhis
Regulatory Engineer
jvoorhis@hy-bon.com
(512)694-8455

Ray Munoz
Houston Account Manager
rmunoz@hy-bon.com
(432)553-5005

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