Optimizing Vapor Capture and Emissions Profiles at Upstream Production Sites

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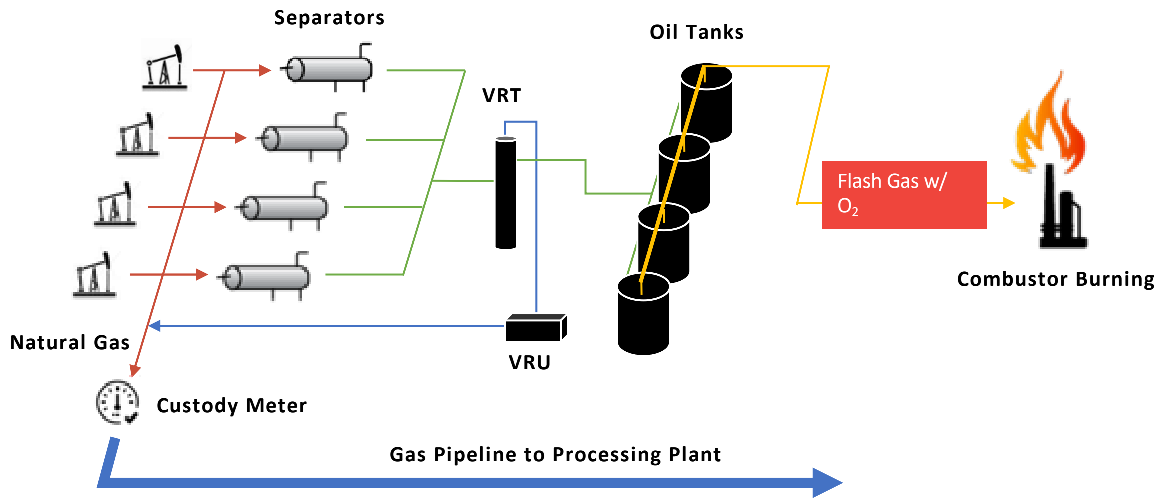
Regulatory background

In August 2012, the U.S. Environmental Protection Agency (EPA) first issued New Source Performance Standards for the upstream oil and gas industry under the Clean Air Act. Part of the Standards focused on reducing emissions from atmospheric storage tanks and requiring new production sites to reduce the gas vented from tanks by 95%. This gas, or “flash vapor,” evolves as the hydrocarbon constituents in the tanks change from the liquid to vapor phase when pressure is reduced from phase separation to atmospheric storage. Tank emissions are also the result of working, breathing and loading losses, but the largest contributor to the gas volume in the oil and water storage tanks is the “flashing” of the hydrocarbon liquid to the vapor phase.

One method for addressing these emissions is to collect the relatively rich vapor and destroy the hydrocarbons through flaring, and the Standards provide direction for acceptable destruction methods. Although flaring, including combustion, is sometimes the only alternative, it is viewed today as an inappropriate method to handle vapor. Flaring destroys the potential value of the gas and results in volatile organic compounds (VOCs such as propane and ethane) and greenhouse gas emissions (water vapor, methane, nitrous oxide, and carbon dioxide). An alternative developed by the industry to recover a portion of the flash vapor uses a low-pressure vapor recovery tower (VRT) combined with a compressor (vapor recovery unit, or VRU) to increase the stream pressure to the sales line requirement. The VRT partially de-gases the produced oil prior to entering the storage tanks since oxygen is a common contaminant in the atmospheric tanks. Pipeline specifications for oxygen are normally low—typically a maximum of 10 ppm O_2.

An alternative to vapor recovery towers

The use of VRTs to capture a portion of the relatively rich flash gas is the most common method employed in the industry to monetize the gas volume and reduce flaring.



A typical site configuration using a VRT.

In a typical configuration, produced oil is discharged from phase separation directly to the VRT, where partial flashing of the liquid occurs with reduced risk of oxygen ingress. The gas captured by the VRT is then compressed and is typically comingled with the produced gas from separation for sale. Oil in the VRT flows to the atmospheric pressure storage tanks where additional flashing occurs. Vapor is also liberated in the tanks due to working loss (displacement and agitation) and breathing loss (thermally induced vapor liberation). Breathing typically contributes 1 scf/hr per bbl of oil stored and approximately 75% of that for produced water tanks (reference API 2000). Working vapors for produced water tanks are often underestimated due to lack of sampling or inadequate sample analysis.

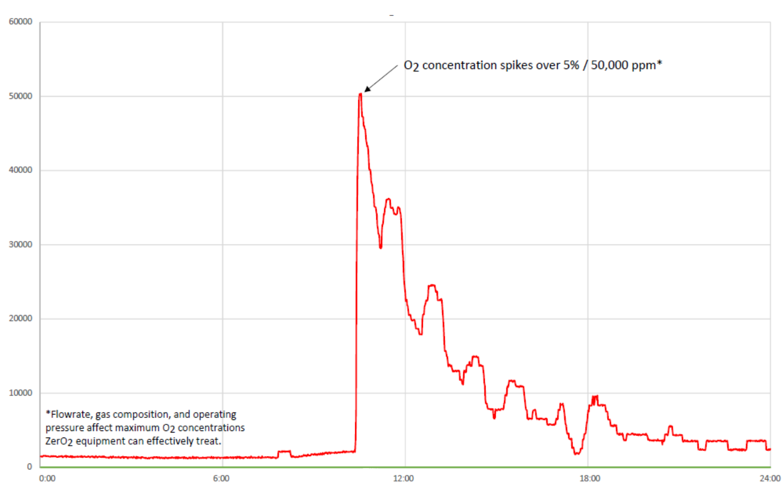
Not only is displacement considered in the oil streams but also vapors liberated by flow agitation. API 2000 recommends accommodating for 12 scf/bbl (double the amount water produces). Flash vapors liberated in the oil stream are a function of composition and upstream source (separator) pressure and temperature. Flash vapors in the water stream are also a function of the efficiency and effectiveness of the upstream separation equipment. Flash liberation studies of pressurized water samples from separation equipment have shown that flash from the water stream should consider 1 to 4 scf/bbl of water. Some states and other regulatory guidelines require engineers to consider 1% oil (by volume) carryover into the water stream as part of their vapor control sizing estimates.

Data from field trials and other installations, comparing gas sales volumes using a VRT to a configuration where the VRT is not used, indicate that the towers typically only capture between 60% and 80% of the vapors arising downstream of phase separation—an efficiency lower than simulation models suggest. This inefficiency is caused by

- Improper sizing, resulting in less-than-adequate time to de-gas the oil; simulation models often assume perfect separation and underestimate the transient time required for separation
- Improper installation, operation and pressure regulation
- Typical variability in oil production (slug flow, plunger lift, etc.)
- No capture of vapor from the produced water—water may be sent directly back to the tank battery from the primary separator
- Working and breathing losses occurring in the oil tanks.

Working with VRU compressors and vapor recovery systems, EcoVapor Recovery Systems examined whether there was a method other than flaring to capture the remaining 20% to 40% of the total vapor stream. Capturing this richest and most valuable saleable vapor stream from storage tanks, however, leads to the issue of oxygen migration into the vapor stream. Oxygen enters the capture system by way of leaks, seals, fittings, thermal inbreathing due to ambient cooling, truck loading and other potential sources. Given typical pipeline specifications of 10 ppm O_2 or less, the presence of oxygen in the capture system can eliminate the significant economic benefit of capturing the entire vapor stream.

EcoVapor's proven patented $ZerO_2$ solution removes oxygen from a gas stream to concentrations well below pipeline limits. The catalytic reactor designed by EcoVapor is capable of treating a gas stream composed of up to 25% air (~50,000 ppmv O_2) and reducing it to a typical outlet concentration of less than 2 ppm.



$ZerO_2$ oxygen removal performance demonstrated comparing maximum inlet tank oxygen concentration of 50,400 ppm to maximum outlet concentration of 9 ppm.

In an effort to evaluate and demonstrate the effectiveness of this technology, field trials were conducted to prove the effectiveness and compare system configurations where a VRT was in use and where the VRT was removed.

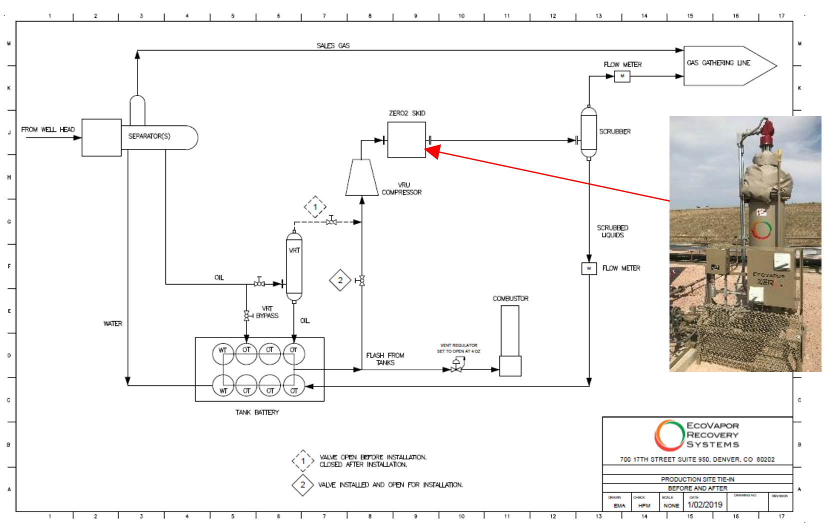
Multisite VRT vs ZerO$_2$ field trial description

Two major oil and gas production companies partnered with EcoVapor to conduct a direct comparison of the environmental, economic and efficiency benefits between two sets of operating conditions on four sites.

The base case utilized a VRT with the captured gas compressed and sold using a VRU and the remaining vapor liberated in the tank battery flared.

The comparison case involved bypassing the VRT, with oil flowing directly to storage tanks where the liberated vapor is collected, compressed and sold by the same VRU, which was re-allocated to capture tank vapors instead of VRT vapors. Gas was processed by the EcoVapor ZerO$_2$ unit where O_2 concentration was continuously monitored. A scrubber was placed in series downstream from the VRU and upstream of the ZerO$_2$ unit to remove compressor oils and condensed liquids, which were returned to the tanks. The increase in liquid sales from scrubbed NGLs was verified by custody transfer measurements.

Test conditions required that each scenario be operated a minimum of 21 days, with measurements of gas sales, flared volumes and oil production.



Process configuration for the test site that demonstrated environment, economic and efficiency benefits of ZerO$_2$ units.

Trial results

The four trials were operated from 67 to 128 days, and the additional gas and oil volumes made possible by capturing vapor directly from atmospheric storage indicated a significant improvement in incremental revenue for the operators.

$ZerO_2$ Enhanced Capture from Tanks vs. VRT

Site	Days Operated	Oil		Gas		O_2 Equipment Uptime
		BOPD Increase	Increase	Mcf/D Increase	Increase	
A	77	24.1	3.2%	51.0	37.2%	98.7%
B	128	4.3	13.5%	46.8	15.1%	99.2%
C	124	6.8	11.0%	46.0	14.6%	98.4%
D	67	15.7	18.9%	29.6	19.7%	99.2%

With the measurement of flared volumes with the VRT as well as when the VRU was not operating, a comparison of the VOC and NOx emissions was also compiled using emission factors from AP 42, Section 13 (Table 13.5).

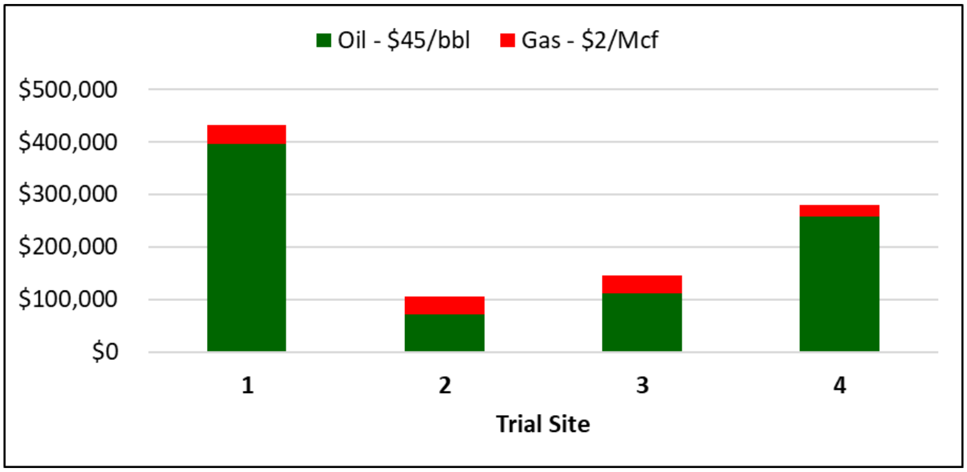
VOC and NOx Emissions Profile

Site	Base Case (VRT) VOC and NOx (tons/yr)	Tank Recovery VOC and NOx (tons/yr)	Emissions Reduction
A	16.7	0.4	97.6%
B	15.2	0.3	98.0%
C	15.0	0.3	98.0%
D	9.6	0.2	97.9%

When using the VRT, emissions are higher since the incremental gas captured with tank recovery was previously flared with subsequent VOC and NOx emissions. Note that other greenhouse gases emitted are not listed. The substantial reduction in emissions occurs because flaring is almost eliminated since it occurs only when the VRU or ZerO2 unit is not operating. Uptime for the ZerO2 unit is usually 99% or higher so flaring rarely occurs.

Economic impact of the new configuration

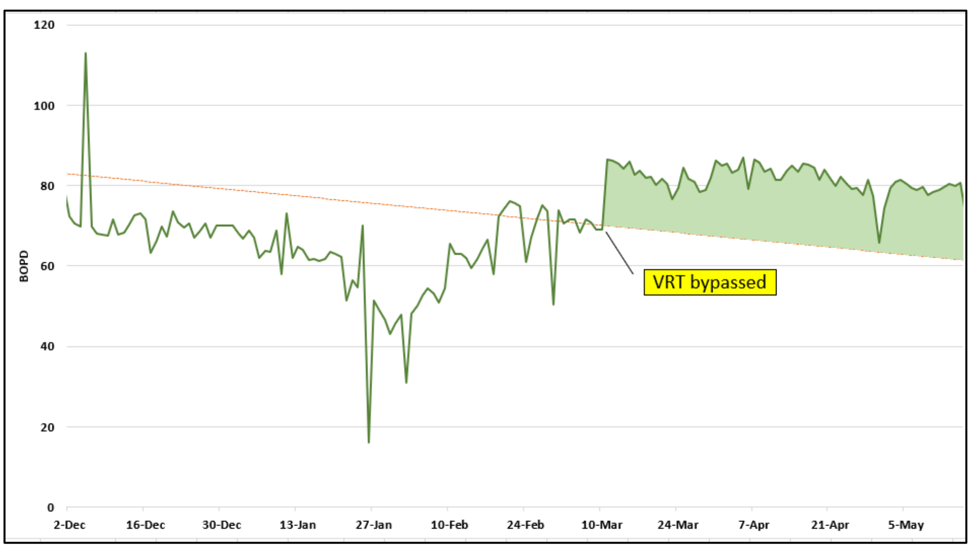
To gauge the economic significance of this change in equipment configuration, the value of the incremental volumes was calculated using commodity prices at the time of the field trials: oil $45/bbl and gas $2/Mcf.



Incremental revenue from $100,000 to $400,00 from higher vapor and NGL recovery.

The four trial sites varied by facility configuration and production. None were prolific producers—volumes varied from 30 to 750 BOPD with 150 to 300 Mscf/D of flash gas. Nevertheless, the additional contribution of the increased oil and gas with vapor recovery directly from storage exceeded the cost of the ZerO2 equipment and its installation with payout within months for each operator.

The increase liquid sales was an unexpected finding in the trials. Oil production data was measured at custody transfer, not by a Coriolis meter on the scrubber's liquid dump line. The data collected throughout the trial proves a noticeable increase in volumes was captured once the VRT was bypassed.



Production and trend data for one of the trial sites.

Since the degree of increased liquids had not been anticipated, direct measurements of temperatures and scrubber volumes were not collected. The scrubber placed downstream of the $ZerO_2$ unit allowed for the recovery of valuable natural gas liquids that were returned to the tanks. Alternatively, the liquids could have been collected as a side stream for separate sale (NGL bullet tanks, for example).

Key findings and implications

Utilizing oxygen removal equipment and bypassing VRTs can produce significant benefits:

- Improved profitability and ROI from higher saleable volume captured
- Substantial reduction in greenhouse gas emissions
- Reduction and near elimination of routine flaring
- De-risking of the production site from shut-in due to oxygen contamination of the sales gas.

In addition, active operational control of tank pressure, using instrumentation that maintains tank pressures at low levels, reduces the risk of tank vent emissions from reliefs and hatches.

About EcoVapor Recovery Systems

EcoVapor Recovery Systems provides solutions to pressing oil and natural gas production problems. EcoVapor's technical team provides complete STEP-UP emissions management solutions including site assessment, FEED studies and implementation, commissioning, monitoring and maintenance, and innovative vapor control and gas processing technologies. EcoVapor patented $ZerO_2$ units operate with third-party vapor recovery units (VRU to help reduce greenhouse gas emissions, flaring and combusting, and to capture tank and loading truck flash gas. $ZerO_2$ systems maintain a low vapor pressure in storage tanks and destroy oxygen downstream of the tanks prior to entry into the gas sales line. This capability reduces risk and helps avoid midstream operational integrity problems in pipelines and compressor stations. In addition to the safety benefits, operators improve asset value by adding high-BTU tank vapor and truck-loading vapor to the sales lines. Operators adopting this technology easily meet all federal and state regulatory requirements and can complete more wells per pad. EcoVapor also offers the absorbent-based Sulfur Sentry unit that affordably and effectively sweetens the production stream. EcoVapor is headquartered in Denver, Colorado, and has offices in Greeley, Colorado, Oklahoma City, Oklahoma, and Midland, Texas.

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