USE OF VAPOR RECOVERY TOWERS & VRU'S TO REDUCE EMISSIONS

Larry S. Richards
HY-BON Engineering

Heightened regulations and enforcement on air emissions from oil and condensate tank batteries have many companies evaluating new technologies for capturing these vented natural gas emissions. For most of the past 3 decades, oil production facilities have focused on dividing the production stream into three main categories. Production flows from the wells into 3 phase separators. Oil flows from the separator to the oil storage tanks, produced water to the saltwater tanks, and gas flows directly into the gas sales line or a boosting station. As the oil and produced water is dumped under pressure into the atmospheric pressure storage tanks, additional natural gas vents from the liquids. This extremely low pressure gas is typically vented to atmosphere at the location. Technology advancements in seeing and analyzing these vented gas streams in the past decade have led to heightened scrutiny of this practice. These gas streams are a challenge to capture effectively, especially on truck loaded batteries. This paper will focus on "best in class" technologies to capture these gas streams effectively and consistently – with no oxygen ingress into the gas sales lines – and stay below regulatory limits of VOC's and emissions required by new statutes.

First, it is important to understand why these vented gas streams are problematic. As pressure is reduced on the liquids, heavier hydrocarbon gases are released. While the gas from a 100 psig separator may be 95% methane and 1,000 BTU, the gas venting from an atmospheric pressure tank has large percentages of ethane, propane and butane. These heavier gases have a higher concentration of volatile organic compounds (VOC's), which are regulated by state and federal agencies due to their negative impact on human health. They also at times contain higher concentrations of benzene and other contaminants, which are potentially linked to leukemia and other diseases. As more research has been conducted on these vented gas streams in the past five years, there is increased concern that the VOC levels historically associated with these low pressure vent sources from oil and condensate storage tanks is much higher than previously estimated.

The one silver lining is that the higher BTU content of these hydrocarbon gas streams often allow the gas to be sold at much higher prices than typicaly NYMEX gas prices. In many of the new liquid rich shale plays, this vent gas exceeds 2,500 BTU – which means it can often be sold at 2.5X the normal sales price of natural gas with an MMBTU contract. This high BTU content results in premium prices for the gas, but ONLY if it is effectively captured and put into the gas sales line. New EPA regulations in 2011 require all tank batteries with the "potential to emit" more than 6 tons of VOC's annually to capture or destroy these vapors. Six tons can equate to as little as 20 to 50 barrels of oil a day production, or as little as a few barrels of condensate. Most companies would not invest in a new tank battery at production levels below this volume, so it effectively includes almost all new tank batteries installed since August 2011. The challenge becomes to make a financial return with these hydrocarbon vapors and view them as product, rather than strictly spend money from a compliance standpoint.

The challenge becomes capturing the gas in a consistent and cost effective manner. There are several technical challenges to overcome. First, the gas stream is extremely wet and heavy – requiring natural gas compressors specifically designed for wet gas. You must also insure you evaluate the dew point of the gas, in order to keep it in gaseous form throughout compression. Second, the volume of gas to compress spikes and drops with each separator dump into the tanks. This variable gas volume (and it's range) is critical to understand when sizing equipment. Third, the liquids flow into the tank battery will change as old wells deplete, and new wells are added – suggesting a very versatile design approach is called for. Finally, it is imperative that you never pull oxygen into the pipeline system. As a result, the tank system must be "closed loop". While fairly easy to achieve on LACT loading batteries with a gas blanketing system, this can be an incredible challenge in truck loaded facilities.

This majority of this low pressure gas is produced at the time of the pressure drop in the liquid from the separator to the tanks. A cost effective method for capturing 90% + of this gas stream is the use of vapor recovery towers,

coupled with a properly designed vapor recovery unit. The vapor recovery tower is an atmospheric pressure tower that is used to effectively capture the flash gas from the pressure drop, and then gravity feed to the tanks. The typical tower is 36" diameter by 30' to 45' tall. Oil dumps directly from the separator into the tower. As oil splashes in, entrained gas is released from solution. The tower fills, until it simply gravity feeds to the storage tanks at one to two psig pressure. With a minimum 25 to 30 minute retention time in the tower, the flash gas is released from the pressurized liquid and exits the top of the tower to the Vapor Recovery Unit (VRU). The oil exit line from the tower has a downcomer that extends to within a few feet of the bottom of the tower. This downcomer eliminates the potential for oxygen or gas to enter the tower from the tanks, as this pipe is filled with liquid by design. This basic "pea trap" design effectively isolates the flash gas in the tower to the VRU; making the VRU/VRT a closed loop system for the gas. The relatively "dead" oil gravity feeds from the tower to the tanks, with minimal flashing from 2 psig to atmospheric. In most instances, the residual vent gas on the tanks is below federal and state regulatory limits for VOC emissions – as the majority of the volume is being captured from the tower. The VRU/VRT combination is considered a "process" piece of equipment rather than a "control" piece of equipment, eliminating the requirement to provide annual reporting to the EPA under the new Subpart OOOO regulations in most instances.

The critical element of a VRU/VRT combination is the use of a "real" vapor recovery unit. As noted, correct compressor selection is critical. The Natural Gas STAR program, the EPA and most state regulatory agencies define the minimum criteria of a VRU versus a compressor package to be:

1. Correct compressor selection, including rotary screw, rotary vane, vapor jet or educator
2. Pressure sensing devices off the tanks or tower
3. An automated bypass system
4. Ability to vary the speed of the compressor based on changing volumes

In order to meet compliance requirements (and more importantly, to make money with the unit) operators must document that the VRU is running consistently. While dry gas, piston style reciprocating compressor packages typically used in wellhead applications are cheap, they simply don't work effectively in this wet gas application. Equally important, they don't meet the minimum definition of a VRU in most state or EPA definitions. In addition to proper compressor selection, variable frequency drives are recommended to increase compressor rpm's as the volumes of gas increase in the tower. Although the initial purchasing cost is somewhat higher, the return on investment is dramatically higher for a real VRU that is specifically designed for this wet gas application.

When using a VRT/VRU combination, typically 90% to 95% of the total vent gas is usually captured in the tower. As the oil dumps to the tanks, some residual flash losses, combined with standing and working losses will still vent from the oil tanks. In instances where tank vapors still exceed statutory limits, but are less than 20 mcfd, an enclosed combuster is recommended. Enclosed combusters burn the residual gas at 99%+ control efficiency, and certain models meet all state and federal guidelines for regulatory compliance. Manifold the tanks together in a common gas vent line, sloping down to the enclosed combuster. On tank batteries where the residual gas volumes still exceed 6 tons, a data logging package is recommended so detailed run reports of the enclosed combuster can be documented.

The key is to factor in the capture and compliance of vent gas from the initial design of the tank battery. On existing batteries, an emission survey which directly measures the true vent volumes and takes an extended gas analysis is highly recommended. By proactively evaluating and designing for low pressure vent gas streams, costly fines and "shut in" production notices can effectively be eliminated. More importantly, hydrocarbon product that is currently being vented can be captured and sold to help mitigate the cost of compliance, and can provide a profitable, additional revenue stream at many locations.

References

Texas Commission on Environmental Quality; Chapter 106 - Permits by Rule Rule Project No. 2010-018-106-PR; ***SUBCHAPTER O: OIL AND GAS [§106.352]***

49490 Federal Register / Vol. 77, No. 159 / Thursday, August 16, 2012 / Rules and Regulations
Overview of Final Amendments to Air Regulations for the Oil and Natural Gas Industry Fact Sheet, EPA-HQ-OAR-2010-0505, U.S. Environmental Protection Agency, Washington D.C. 2012.

Anadarko Improves Operations with Vapor Recovery Towers; Natural Gas STAR Partner Update Fall 2007; page 4,5.

Vapor Recovery Technology Creates Revenue Stream while Mitigating Emissions; The American Oil and Gas Reporter; May 2012