Vapor Recovery & The Capture of “Associated Gas”

Practical Applications & Case Studies

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Presented by:
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President & CEO
Hy-Bon Engineering Co.
“ASSOCIATED GAS”

Storage Tanks

Production Equipment

Casinghead Gas
OIL STORAGE TANKS

Vapor Recovery Systems
As the oil resides in the tanks, it gives off vapors, thereby increasing the pressure inside the tank.
Sources of Methane Losses

- Approximately 26.6 Bcf/yr of Methane are lost from storage tanks in the U.S. alone
  - Flash losses
    - occur when crude is transferred from containment at a high pressure to containment at a lower pressure
  - Working losses
    - occur when crude levels change and when crude in the tank is agitated
  - Standing losses
    - occur with daily and seasonal temperature and pressure changes

Source: Natural Gas STAR Partners
WHY LET $ ESCAPE INTO THE AIR?

Besides being an environmental hazard, escaping vapors result in the loss of a major revenue source for the oil company. Hundreds of oil companies have added significant money to their bottom line by capturing this valuable gas stream.
ONE INCH SENSING LINE
May be flexible PVC, fiberglass or steel, taped or banded to suction line.
CAUTION: Sensing line must be independent of suction line.

PRESSURE / VACUUM RELIEF

SUCTION LINE
Steel or Fiberglass

SCRUBBER DRAIN PUMP

V. R. UNIT SCRUBBER

BUTTERFLY OR GATE VALVE

DRIP POT ON V.R. SENSING PANEL

NOTES
All lines must be horizontal, or sloped down to V.R.U. suction as shown. Scrubber fluid is piped back to tanks or to waste.
The system must be closed — no air entry.
Standard Vapor Recovery Unit

Vent Line
Back Pressure Valve

Control Pilot

Suction Line

Crude Oil Stock Tank(s)

Suction Scrubber

Electric Control Panel

Bypass Valve

Gas Sales Meter Run

Gas

Liquid Transfer Pump

Condensate Return

Check Valve

Electric Driven Rotary Compressor

Sales

Return

Electric Driven Rotary Compressor

Gas Sales
Typical stock tank vapor recovery unit in operation. This unit is configured to capture 90 mcf/d of gas and discharge into a 40 psig sales line.
Benefits of Vapor Recovery Units

- Capture up to 95 percent of hydrocarbon vapors that accumulate in tanks
- Recovered vapors have much higher Btu content than pipeline quality natural gas
- Recovered vapors can be more valuable than methane alone
- Reduce regulatory & liability exposure
Quantifying the Gas Stream

- IDENTIFY emission sources using the FLIR GasFinder camera
- QUANTIFY emissions using chart, E&P Tank, HiFlow Sampler, bagging techniques and actual tank tests per location with turbine meters, recording manometers and mass flow meters.
- RECTIFY emission by recommending best technical alternatives available in the industry for capturing each source and adding to the revenue stream.
Estimated Volume of Tank Vapors

Vapor Vented from Tanks - SCF/BBL - GOR

Pressure of Vessel Dumping to Tank (Psig)

- Under 30° API
- 30° API to 39° API
- 40° API and Over

HY-BON®
Estimating Tank Emissions

Chart method is a quick and easy way to get a fast ballpark estimate

Notice the impact of higher gravity oil, as well as higher separator pressures

This method is VERY CONSERVATIVE and generally underestimates actual emission levels
Quantify Volume of Losses

E&P Tank Model
- Computer software developed by API and GRI
- Estimates flash, working, and standing losses
- Calculates losses using specific operating conditions for each tank
- Provides composition of hydrocarbon losses
E&P TANK INPUT SCREEN
E&P TANK EXAMPLE
OUTPUT
--- Emission Composition ---

<table>
<thead>
<tr>
<th>Component</th>
<th>Uncontrolled [ton/yr]</th>
<th>Uncontrolled [lb/hr]</th>
<th>Controlled [ton/yr]</th>
<th>Controlled [lb/hr]</th>
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</thead>
<tbody>
<tr>
<td>H2S</td>
<td>12.137</td>
<td>2.771</td>
<td>0.607</td>
<td>0.139</td>
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<tr>
<td>O2</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
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<tr>
<td>CO2</td>
<td>85.667</td>
<td>19.559</td>
<td>85.667</td>
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<td>N2</td>
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<td>0.521</td>
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<td>C1</td>
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<td>27.943</td>
<td>6.120</td>
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<td>C2</td>
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<td>C3</td>
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<td>n-C4</td>
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<td>C8</td>
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<td>0.515</td>
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<td>C9</td>
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<td>0.475</td>
<td>0.104</td>
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<td>C10+</td>
<td>0.544</td>
<td>0.124</td>
<td>0.027</td>
<td>0.006</td>
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<tr>
<td>Benzene</td>
<td>2.029</td>
<td>0.463</td>
<td>0.101</td>
<td>0.023</td>
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<tr>
<td>Toluene</td>
<td>0.250</td>
<td>0.057</td>
<td>0.013</td>
<td>0.003</td>
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<td>E-Benzene</td>
<td>0.032</td>
<td>0.007</td>
<td>0.002</td>
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<td>Xylenes</td>
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<td>0.060</td>
<td>0.013</td>
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<td>n-C6</td>
<td>19.202</td>
<td>4.384</td>
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<tr>
<td>224Trimethylp</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
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<tr>
<td>Total</td>
<td>1424.579</td>
<td>325.246</td>
<td>71.229</td>
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## Emission Summary

<table>
<thead>
<tr>
<th>Item</th>
<th>Uncontrolled [ton/yr]</th>
<th>Uncontrolled [lb/hr]</th>
<th>Controlled [ton/yr]</th>
<th>Controlled [lb/hr]</th>
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<tbody>
<tr>
<td>Total HAPs</td>
<td>21.780</td>
<td>4.973</td>
<td>1.089</td>
<td>0.249</td>
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<tr>
<td>Total HC</td>
<td>1324.491</td>
<td>302.395</td>
<td>66.225</td>
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<td>VOCs, C2+</td>
<td>1202.100</td>
<td>274.452</td>
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<td>VOCs, C3+</td>
<td>1043.029</td>
<td>238.134</td>
<td>52.151</td>
<td>11.907</td>
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</tbody>
</table>

### Uncontrolled Recovery Info.

- Vapor: 71.3400 [MSCFD]
- HC Vapor: 66.3900 [MSCFD]
- GOR: 35.67 [SCF/bbl]
A chart recorder is set up on the tank battery for a 24-hour pressure test. The resultant chart is brought into the office for evaluation. Information such as ambient temperature, test apparatus size and orifice size is recorded and used in the calculation of volume of tank vapors.
Ultrasonic meters, Turbine meters and Mass flow meters are also highly effective.

The key is DURATION – a minimum of 24 hours of emissions must be charted for accurate results.
CASE STUDIES
&
EXAMPLES
Industry Experience: Oxy

Oxy Case Study - Vapor Recovery
Wasson Tank Battery (CDU 1 & 2)
Denver City, Texas
Installed in 2004

Oxy purchased two vapor recovery units in August 2004 for capturing vapors from two separate tank batteries at their Wasson facility. Each battery produces approximately 450 MCFD of tank vapors, which Oxy needed to gather and compress into a 45 psig sales line. Due to the low discharge pressure, Oxy selected rotary vane compressor packages capable of moving 500 MCFD. In order to minimize maintenance, Oxy selected electric drive units (75 horsepower electric motors on each unit).
Oxy Wasson Tank Battery 1 (CDU 1)
Oxy Wasson Tank Battery 2 – CDU2
## Industry Experience: Oxy

<table>
<thead>
<tr>
<th></th>
<th>First Year</th>
<th>Second Year</th>
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<tr>
<td>Purchase Cost</td>
<td>$92,500</td>
<td>$185,000</td>
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<tr>
<td>Installation Cost</td>
<td>$9,500</td>
<td>$19,000</td>
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<tr>
<td>Installed Cost</td>
<td>$102,000</td>
<td>$204,000</td>
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<tr>
<td>Gas Volume (mcfd)</td>
<td>450</td>
<td>900</td>
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<tr>
<td>Value @ $6 / mcf</td>
<td>$2,700</td>
<td>$5,400</td>
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<tr>
<td>Annual Revenue</td>
<td>$985,500</td>
<td>$1,971,000</td>
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<tr>
<td>(with NO btu adjustment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>and no liquid sales)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monthly Incr. Revenue</td>
<td>$82,125</td>
<td>$164,250</td>
</tr>
<tr>
<td>Payout (in Months)</td>
<td>1.24</td>
<td>1.24</td>
</tr>
</tbody>
</table>
This is one of 3 Vapor Recovery Units that will be used to capture 25 Million cubic feet of gas in Angola for the Chevron Cabinda project – commissions in 2008.
Installed November 2007

Angola

Chevron Cabinda Flare Reduction Project - 25 MMCFD
Project Overview – Chevron Cabinda Project (Angola)

- This project was the Chevron’s largest flare reduction project in 2007 – Angola Cabinda
- Hy-Bon Vapor Recovery Units are scheduled to be commissioned in Fall 2008.
- The 25 MMCFD of flare and vent gas recovered has the same greenhouse gas effect of removing 812,000 cars from the road or planting 1.1 million acre of trees.
This flare in Venezuela was causing a variety of health and environmental concerns. Billions of cubic feet of methane are vented and flared from oilfield separators and storage tanks in almost every producing country.
Project Overview - PDVSa

This dual flooded screw package for PDVSA is designed for volumes to 5.0 MMSCFD; moving tank vapors from 0 to 200 psig in Eastern Venezuela.
Project Overview - PDV Sa

At this location, three of our compressor packages were set in tandem to move 15 MMSCFD of 2500-2600 BTU tank vapors.
Vapor recovery units currently capture over 75 million cubic feet of previously vented and flared gas across 7 facilities.

Gas Anaco project, begun in 2006, targets over one billion cubic feet of gas across eastern Venezuela.

Conversion of much of the power and transportation infrastructure to natural gas is underway.
Eni installed vapor recovery systems in their Dacion East and West facilities in Venezuela, each designed to move 1.4 MMSCFD of gas at pressures to 230 psig.
Vapor recovery units were installed to capture up to 1.4 MMCFD per site.

White paper was written shortly after installation on the economic success of the project.

A highly valuable 70 API gravity condensate was recovered from the gas stream and used to blend with the primary low API gravity oil production – at an approximate daily rate of 100 to 150 barrels of condensate per unit.
M2M Project Update

Oxy Colombia
Initial project will be capturing approximately 350 mcfd of vent gas from the Caricare oil storage and production facility.

Purpose of the project will be incremental capture of natural gas liquids from this gas stream.

Two additional sites are planned following successful installation of the first project.

Subsequent project to utilize flare gas is also being evaluated by Oxy Colombia.
Gas can also be captured from separators and other field equipment. This unit is capturing natural gas off several separators for sale down a high pressure line.
This unit captures a 98% CO2 gas stream in a field outside Snyder, Texas. Flooded screw compressor for volumes to 1.5 MMSCFD. The CO2 is captured and re-injected into the formation, dramatically reducing operating costs.
CASINGHEAD PRESSURE REDUCTION

In the effort to wrench additional dollars from existing production, more and more producers are turning to the use of low horsepower compression to enhance production from mature wells.
Relieving Back Pressure

**BEFORE COMPRESSION**

Restricting Back pressure holds back the flow of Hydrocarbons into the well bore.

**AFTER COMPRESSION**

Back pressure is relieved from the face of the formation allowing more hydrocarbons to flow into the well bore.
Casinghead gas is usually piped 30 to 90 feet from the wellhead and quietly vented to atmosphere.
Multiple Casinghead Pressure Reduction Case Studies and 2 published articles available at www.hy-bon.com
In Conclusion …

- Hydrocarbon “Spills in the Air”
- Shareholder “Lost Product”
- Truly Unique Opportunity
HY-BON ENGINEERING COMPANY, INC.

Setting a New Standard!!

www.hy-bon.com