Methane Emissions Reductions through Vapor Recovery from Oil and Condensate Storage and Holding Tanks

Methane to Markets Partnership Expo

March 4, 2010, New Delhi, India

Larry Richards, President
Hy-Bon Engineering Company

Methane to Markets

Vapor Recovery: Agenda

- Methane Losses
- Methane Savings
- Is Recovery Profitable?
- Industry Experience
- Lessons Learned
- Discussion

Methane to Markets

Storage Tank Methane Losses

- A storage tank battery can vent 140 m^3 to 2,720 thousand m^3 (Mcm) of natural gas and light hydrocarbon vapors to the atmosphere each year
  - Vapor losses are primarily a function of oil throughput, gravity, and gas-oil separator pressure
- Flash losses
  - Occur when crude is transferred from a gas-oil separator at higher pressure to a storage tank at atmospheric pressure
- Working losses
  - Occur when crude levels change and when crude in tank is agitated
- Standing losses
  - Occur with daily and seasonal temperature and barometric pressure changes

Methane to Markets

Methane Savings: Vapor Recovery

- Vapor recovery can capture up to 95% of hydrocarbon vapors from tanks
- Recovered vapors have higher heat content than pipeline quality natural gas
- Recovered vapors are more valuable than natural gas and have multiple uses
  - Re-inject into sales pipeline
  - Use as on-site fuel
  - Send to processing plants for recovering valuable natural gas liquids

Methane to Markets

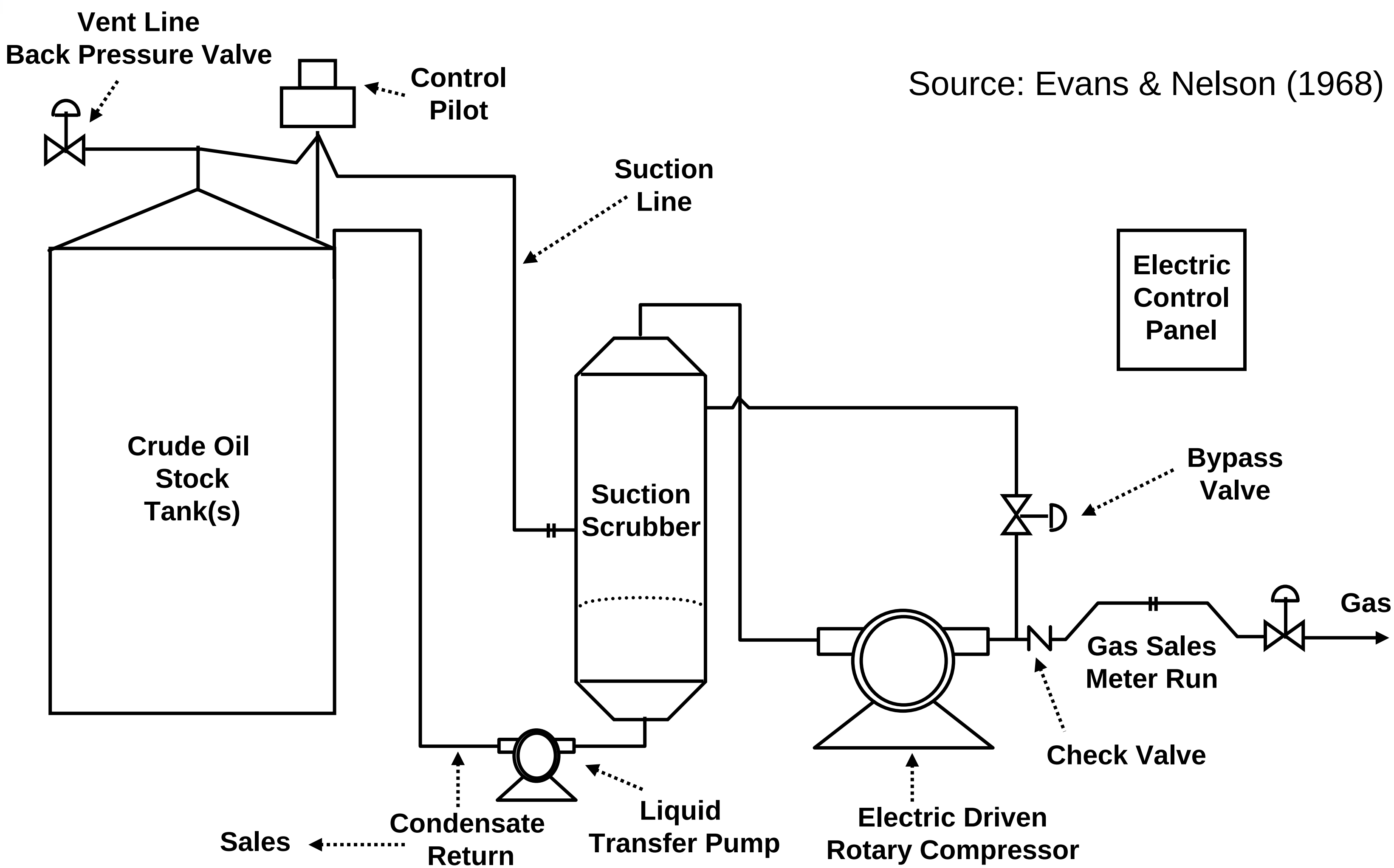
Types of Vapor Recovery Units

- Conventional vapor recovery units (VRUs)
  - Use special designed packages configured to capture low pressure, wet gas streams with no oxygen ingress
  - Use rotary screw or rotary vane compressor for wet gas
  - Scroll compressors are new to this market & work well
  - Require electrical power or engine driver
- Venturi ejector vapor recovery units (EVRU™) or Vapor Jet
  - Use Venturi jet ejectors in place of rotary compressors
  - Contain no moving parts
  - EVRU™ requires a source of high pressure motive gas and intermediate pressure discharge system
  - Vapor Jet requires a high pressure motive water

Methane to Markets

Conventional Vapor Recovery Unit

Source: Evans & Nelson (1968)



Vapor Recovery Installations

Source: Hy-Bon Engineering

Methane to Markets

Criteria for Vapor Recovery Unit Locations

- Steady source and sufficient quantity of losses
  - Crude oil stock tank
  - Flash tank, heater/treater, water skimmer vents
  - Gas pneumatic controllers and pumps
- Outlet for recovered gas
  - Access to low pressure gas pipeline, compressor suction, or on-site fuel system

Dual VRU bound for Venezuela - one of 17 units capturing gas currently for Petroleos de Venezuela. Flooded screw compressor for volumes to 0.14 million m^3 per day; up to 15 atm.
Source: Petroleos de Venezuela S.A

Methane to Markets

Quantify Volume of Losses

- Estimate losses from chart based on oil characteristics, pressure, and temperature at each location (± 50%)
- Estimate emissions using the E&P Tank Model (± 20%)
- Engineering Equations –
- Vasquez Beggs (± 20%)
- Measure losses using recording manometer and well tester or ultrasonic meter over several cycles (± 5%)
  - This is the best approach for facility design

Petroleos de Venezuela S.A has installed vapor recovery in the majority of its production facilities in Eastern Venezuela.
Source: Petroleos de Venezuela S.A

What is the Recovered Gas Worth?

- Value depends on heat content of gas
- Value depends on how gas is used
  - On-site fuel
    - Valued in terms of fuel that is replaced
  - Natural gas pipeline
    - Measured by the higher price for rich (higher heat content) gas
  - Gas processing plant
    - Measured by value of natural gas liquids and methane, which can be separated
- Gross revenue per year = (Q x P x 365) + NGL
  - Q = Rate of vapor recovery (m^3 per day)
  - P = Price of natural gas
  - NGL = Value of natural gas liquids

Value of Natural Gas Liquids

Recovered Btu-rich tank vapors worth approximately $207/Mcm ($5.87/Mcf)

	1 Btu/gallon	2 MMBtu/ gallon	3 $/gallon	4 $/MMBtu[1,2] (= 3/2)	5 Btu/cf	6 MMBtu/Mcf	7 $/Mcf (= 4*6)
Methane	59,755	0.06	0.18	2.96	1,012	1.01	$3.00
Ethane	74,010	0.07	0.37	5.00	1,773	1.77	$8.86
Propane	91,740	0.09	0.68	7.41	2,524	2.52	$18.71
n Butane	103,787	0.10	0.86	8.29	3,271	3.27	$27.10
iso Butane	100,176	0.10	0.91	9.08	3,261	3.26	$29.62
Pentanes+*	105,000	0.11	1.01	9.62	4,380	4.38	$42.13

	8 $/MMBtu	9 Vapor Composition	10 Mixture (MMBtu/Mcf)	11 Value ($/Mcf) (= 8*10)
Methane	2.96	82%	0.83	$2.46
Ethane	5.00	8%	0.14	$0.71
Propane	7.41	4%	0.10	$0.75
n Butane	8.29	3%	0.10	$0.81
iso Butane	9.08	1%	0.03	$0.30
Pentanes+	9.62	2%	0.09	$0.84
Total			1.29	$5.87

1 – Natural Gas Price assumed at $106/Mcm ($3/Mcf)
2 – Prices of Individual NGL components are from Platts Oilgram for Mont Belvieu, TX February 17, 2009

Methane to Markets

Natural Gas EPA Pollution Preventer

Is Recovery Profitable?

- Economics of installing vapor recovery units are attractive, particularly for larger units

Financial Analysis for a conventional VRU project[1]						
Capacity		Installation and Capital Costs[2]	Operating and Maintenance	Value of Gas[3]	Payback	Internal Rate of Return
(m^3/day)	(Mcf/day)	($)	($/year)	($/year)	(Months)	(%)
700	25	35,738	7,367	25,000	25	40
1,400	50	46,073	8,419	50,000	14	86
2,800	100	55,524	10,103	101,000	8	162
5,700	200	74,425	11,787	205,000	5	259
14,200	500	103,959	16,839	510,000	3	474

1 - All costs and revenues are represented in U.S. economics
2 - Unit cost plus estimated installation at 75% of unit cost
3 - $207/Mcm x 1/2 capacity x 365 x 95%
Mcf = thousand cubic feet

Industry Experience: Anadarko

- Vapor Recover Tower (VRT)
  - Add separation vessel between heater treater or low pressure separator and storage tanks that operates at or near atmospheric pressure
    - Operating pressure range: 0.07 atm to 0.34 atm
  - Compressor (VRU) is used to capture gas from VRT
  - Oil/condensate gravity flows from VRT to storage tanks
    - VRT insulates the VRU from gas surges with stock tank level changes
    - VRT more tolerant to higher and lower pressures
    - Stable pressure allows better operating factor for VRU

Methane to Markets

Industry Experience: Anadarko

- VRT reduces pressure drop from approximately 4.4 atm to 1.1 to 1.3 atm
  - Insulates the VRU from crude tank oil movements
  - Captures more product for sales
  - Anadarko netted between $7 to $8 million from 1993 to 1999 by utilizing VRT/VRU configuration
- Equipment Capital Cost: $11,000
- Standard size VRTs available based on oil production rate
  - 51 by 10.7 meters
  - 10.7 by 1.2 meters
- Anadarko has installed over 300 VRT/VRUs since 1993 in the U.S. and continues on an as needed basis

VRT/VRU Photos

Source: Anadarko

Methane to Markets

VRT/VRU Photos

Source: Anadarko

Lessons Learned

- Vapor recovery can yield generous returns when there are market outlets for recovered gas
  - Recovered high heat content gas has extra value
  - Vapor recovery technology can be highly cost-effective in most general applications
- Venturi jet models work well in certain niche applications, with reduced operating and maintenance costs

Lessons Learned (continued)

- VRU should be sized for maximum volume expected from storage tanks (rule-of-thumb is to double daily average volume)
- Rotary vane, screw or scroll type compressors recommended for VRUs where Venturi ejector jet designs are not applicable
- EVRU^{TM} recommended where there is a high pressure gas compressor with excess capacity
- Vapor Jet recommended where there is produced water, less than 2.1 Mcm per day gas and discharge pressures below 3.7 atm

Discussion

- Industry experience applying these technologies and practices
- Limitations on application of these technologies and practices
- Actual costs and benefits

Methane to Markets

NaturalGas EPA POLLUTION PREVENTER

Contact Information

Larry Richards
President
Hy-Bon Engineering Company
lrichards@hy-bon.com
+1 (432) 697-2292

www.methanetomarkets.org

http://www.epa.gov/gasstar/