Installing Vapor Recovery Units

Lessons Learned from the
Natural Gas STAR Program

Source Reduction Training

Interstate Oil and Gas
Compact Commission

Charleston, West Virginia
February 27, 2009

epa.gov/gasstar

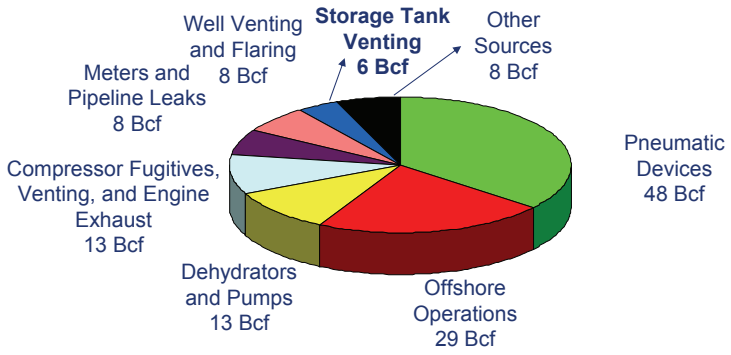
Reduction Opportunities: Agenda

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

1

Methane Losses from Storage Tanks

- U.S. natural gas production sector emissions in 2006



EPA. *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 – 2006.* April, 2008. Available on the web at: epa.gov/climatechange/emissions/usinventoryreport.html
Natural Gas STAR reductions from gathering and boosting operations have been moved to the production sector.

2

Sources of Methane Losses

- A storage tank battery can vent 5,000 to 500,000 thousand cubic feet (Mcf) of natural gas and light hydrocarbon vapors to the atmosphere each year
- Flash losses
  - Occur when crude oil or condensate is transferred from a gas-oil separator at higher pressure to a storage tank at atmospheric pressure
- Working losses
  - Occur when crude or condensate levels change and when liquid in tank is agitated
- Standing losses
  - Occur with daily and seasonal temperature and barometric pressure changes

3

Tank Venting Emissions

- Video recording of tank venting emissions

Video provided by Hy-Bon Engineering

4

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

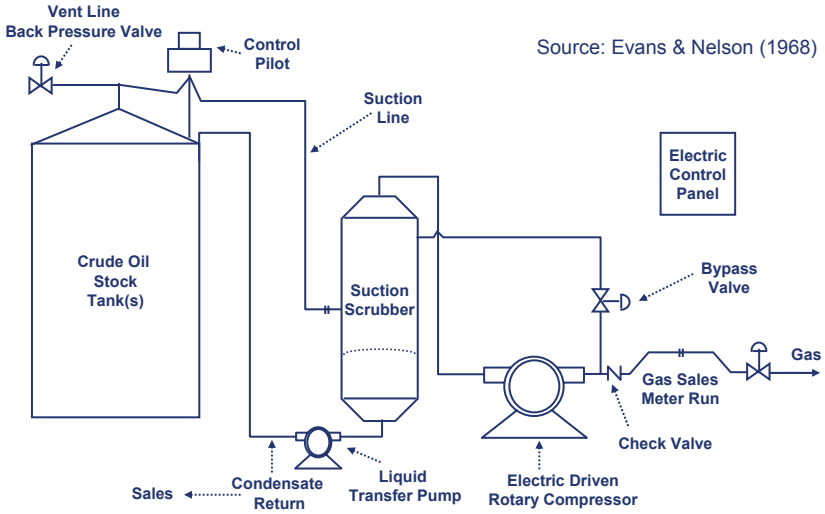
5

Types of Vapor Recovery Units

- Conventional vapor recovery units (VRUs)
- Venturi ejector vapor recovery units (EVRU™) or Vapor Jet
  - Use Venturi jet ejectors in place of rotary compressors

6

Conventional Vapor Recovery Unit



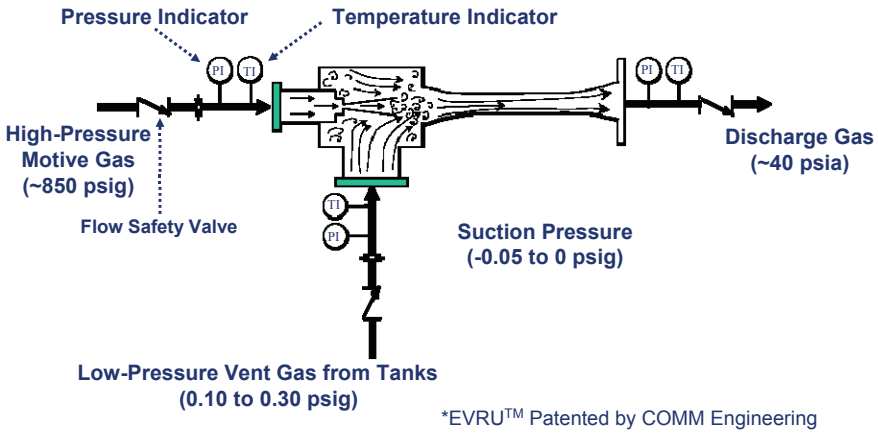
Source: Evans & Nelson (1968)

7

Vapor Recovery Installations

8

Venturi Jet Ejector*

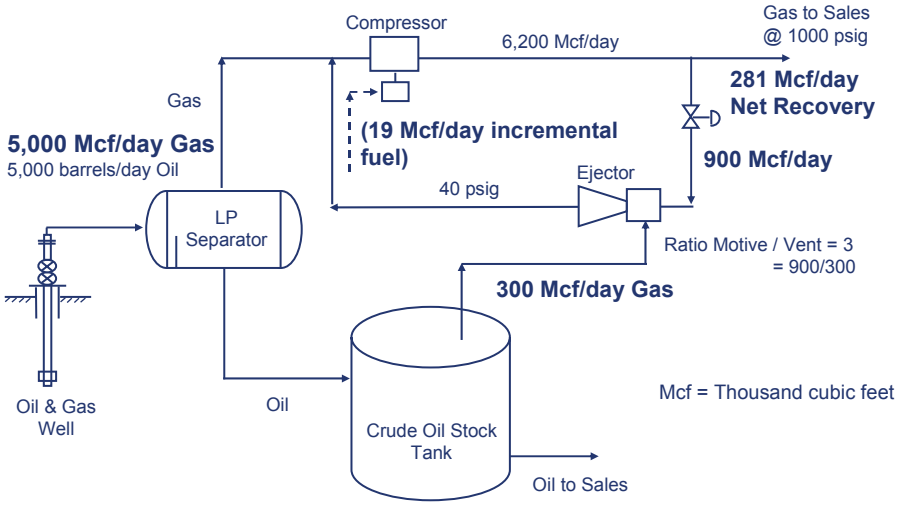


*EVRU™ Patented by COMM Engineering

Adapted from SRI/USEPA-GHG-VR-19
psig = pound per square inch, gauge
psia = pounds per square inch, absolute

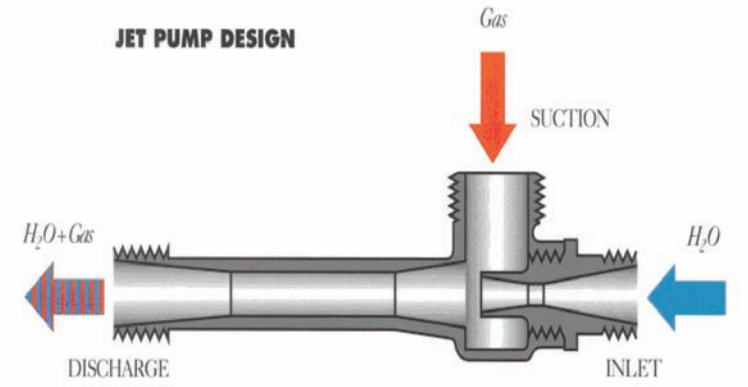
9

Vapor Recovery with Ejector



10

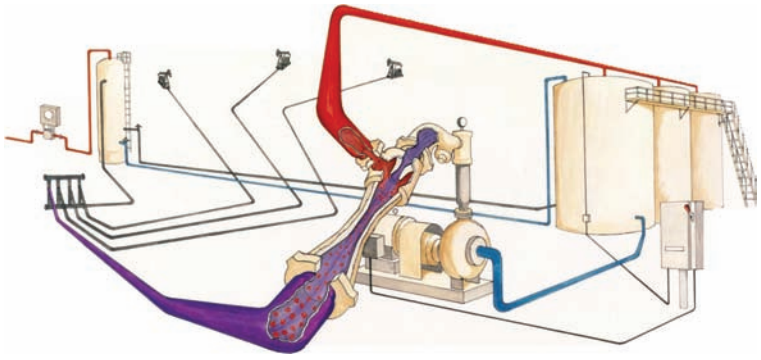
Vapor Jet System*



*Patented by Hy-Bon Engineering

11

Vapor Jet System*



- Utilizes produced water in closed loop system to effect gas gathering from tanks
- Small centrifugal pump forces water into Venturi jet, creating vacuum effect
- Limited to gas volumes of 77 Mcf/day and discharge pressure of 40 psig

*Patented by Hy-Bon Engineering

12

Criteria for Vapor Recovery Unit Locations

- Steady source and sufficient quantity of losses
- Outlet for recovered gas
- Tank batteries not subject to air regulations

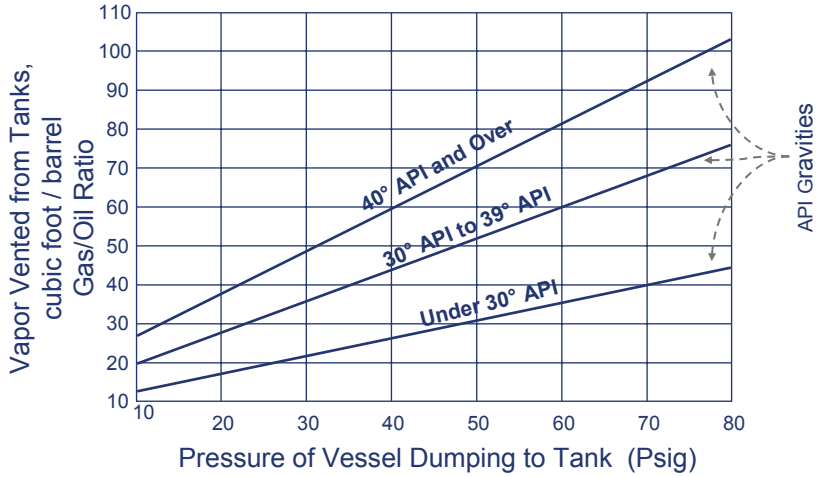
13

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%)

14

Estimated Volume of Tank Vapors



° API = API gravity

15

Estimated Volume of Tank Vapors

- Atmospheric tanks may emit large amounts of tank vapors at relatively low separator pressure

Vasquez-Beggs Equation

$$GOR = A \times (G_{flash\ gas}) \times (P_{sep} + 14.7)^{B} \times \exp\left(\frac{C \times G_{oil}}{T_{sep} + 460}\right)$$

where,

GOR	=	Ratio of flash gas production to standard stock tank barrels of oil produced, in scf/bbl oil (barrels of oil corrected to 60°F)
$G_{flash\ gas}$	=	Specific gravity of the tank flash gas, where air = 1. A suggested default value for $G_{flash\ gas}$ is 1.22 (TNRCC; Vasquez, 1980)
G_{oil}	=	API gravity of stock tank oil at 60°F
P_{sep}	=	Pressure in separator, in psig
T_{sep}	=	Temperature in separator, °F

For $G_{oil} \leq 30°API$: A = 0.0362; B = 1.0937; and C = 25.724

For $G_{oil} > 30°API$: A = 0.0178; B = 1.187; and C = 23.931

psig – pounds per square inch, gauge
scf – standard cubic feet
bbl – barrels

16

What is the Recovered Gas Worth?

- Value depends on heat content of gas
- Value depends on how gas is used
  - On-site fuel
  - Natural gas pipeline
  - Gas processing plant
- Gross revenue per year = (Q x P x 365) + NGL
  - Q = Rate of vapor recovery (Mcf per day)
  - P = Price of natural gas
  - NGL = Value of natural gas liquids

17

Value of Natural Gas Liquids

	1 Btu/gallon	2 MMBtu/ gallon	3 $/gallon	4 $/MMBtu[1,2] (=3/2)
Methane	59,755	0.06	0.42	7.00
Ethane	74,010	0.07	0.37	5.21
Propane	91,740	0.09	0.68	7.58
n Butane	103,787	0.10	0.86	8.60
iso Butane	100,176	0.10	0.91	9.08
Pentanes+*	105,000	0.11	1.01	9.14

	5 Btu/cf	6 MMBtu/Mcf	7 $/Mcf (=4*6)	8 $/MMBtu	9 Vapor Composition	10 Mixture (MMBtu/Mcf)	11 Value ($/Mcf) (8*10)
Methane	1,012	1.01	$7.07	7.00	82%	0.83	$5.81
Ethane	1,773	1.77	$9.23	5.21	8%	0.14	$0.73
Propane	2,524	2.52	$19.10	7.58	4%	0.10	$0.76
n Butane	3,271	3.27	$28.11	8.60	3%	0.10	$0.86
iso Butane	3,261	3.26	$29.58	9.08	1%	0.03	$0.27
Pentanes+	4,380	4.38	$40.02	9.14	2%	0.09	$0.82
Total						1.289	$9.25

1 – Natural Gas Price assumed at $7.00/MMBtu
2 – Prices of Individual NGL components are from Platts Oilgram for Mont Belvieu, TX February 17, 2009

18

Cost of a Conventional VRU

Vapor Recovery Unit Sizes and Costs				
Capacity (Mcf/day)	Compressor Horsepower	Capital Costs ($)	Installation Costs ($)	O&M Costs ($/year)
25	5 to 10	20,421	10,207 to 20,421	7,367
50	10 to 15	26,327	13,164 to 26,327	8,419
100	15 to 25	31,728	15,864 to 31,728	10,103
200	30 to 50	42,529	21,264 to 42,529	11,787
500	60 to 80	59,405	29,703 to 59,405	16,839
Cost information provided by United States Natural Gas STAR companies and VRU manufacturers, 2006 basis.				

19

Is Recovery Profitable?

Financial Analysis for a Conventional VRU Project						
Peak Capacity (Mcf/day)	Installation & Capital Costs[1] ($)	O&M Costs ($/year)	Value of Gas[2] ($/year)	Annual Savings ($)	Simple Payback (months)	Internal Rate of Return
25	$35,738	$7,367	$77,106	$69,739	10	121%
50	$46,073	$8,419	$154,213	$145,794	6	204%
100	$55,524	$10,103	$308,425	$298,322	4	352%
200	$74,425	$11,787	$616,850	$605,063	3	537%
500	$103,959	$16,839	$1,542,125	$1,525,286	2	974%

1 – Unit cost plus estimated installation of 75% of unit cost
2 – $16.90 x ½ peak capacity x 365, Assumed price includes Btu enriched gas (1.289 MMBtu/Mcf)

20

Industry Experience: EnCana Oil & Gas

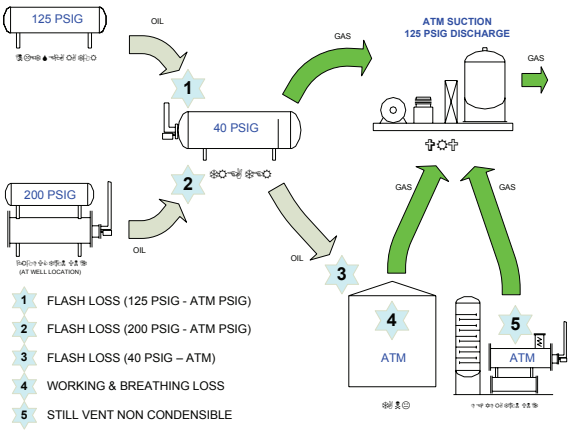
- Vapor recovery unit installed in Frenchie Draw, WY
- Captures vapors from
  - Separators
  - Crude oil storage tank
  - Non-condensable dehydrator still gas
- VRU designed to handle 500 Mcf/day
  - Additional capacity over the estimated 284 Mcf/day of total gas from all emission sources

21

Industry Experience: EnCana Oil & Gas

- Quantify the volume of vapor emissions

Total Emissions- 284 MSCFD



Source: EnCana Oil & Gas (USA) Inc.

22

EnCana Oil & Gas: Project Costs

- Determine the cost of VRU project

Installation

VRU Unit (500 Mcfd) -	$90,000
Generator-	$85,000
Vent Header-	$25,000
Labor-	$200,000
TOTAL	$400,000

O & M

VRU Unit (500 Mcfd) -	$15,000
Generator-	$18,000
Fuel-	$73,000
TOTAL	$106,000

23

EnCana Oil & Gas: Project Economics

- Evaluate VRU economics

Capacity–	500 Mcfd
Installation Cost -	$400,000
O&M-	$106,000/year
Value of Gas*-	$788,400/year
Payback-	7 months
Return on Investment-	170%

*Gas price assumed to be $ 7.60 by Encana

24

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: 1 psi to 5 psi
  - Compressor (VRU) is used to capture gas from VRT
  - Oil/Condensate gravity flows from VRT to storage tanks

25

Industry Experience: Anadarko

- VRT reduces pressure drop from approximately 50 psig to 1-5 psig
  - Reduces flashing losses
  - Captures more product for sales
  - Anadarko netted between $7 to $8 million from 1993 to 1999 by utilizing VRT/VRU configuration

Courtesy of Anadarko

26

Industry Experience: Anadarko

- Standard size VRTs available based on oil production rate
  - 20” x 35’
  - 48” x 35’
- Anadarko has installed over 300 VRT/VRUs since 1993 and continues on an as needed basis
- Equipment Capital Cost: $11,000

Courtesy of Anadarko

27

Lessons Learned

- Vapor recovery can yield generous returns when there are market outlets for recovered gas
- Potential for reduced compliance costs can be considered when evaluating economics of VRU, EVRU™, or Vapor Jet
- 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™ recommended where there is a high pressure gas compressor with excess capacity
- Vapor Jet recommended where there is produced water, less than 75 Mcf per day gas and discharge pressures below 40 psig

28

Discussion

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

29