Installing Vapor Recovery Units

Lessons Learned from the
Natural Gas STAR Program

Montana Petroleum Association
Producers and Processors
Technology Transfer Workshop

Billings, Montana
August 31, 2009

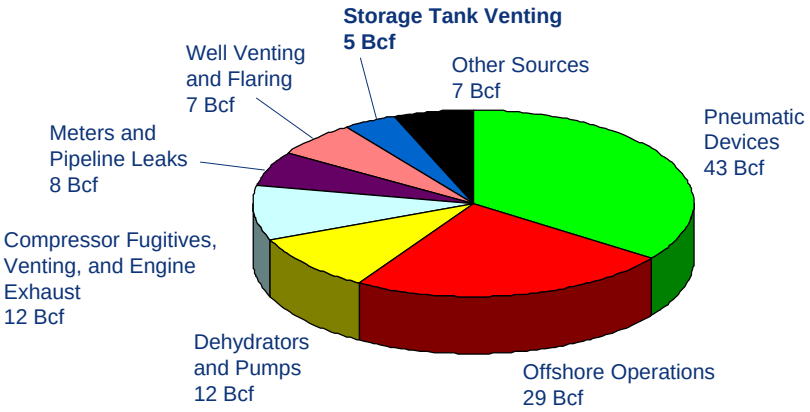
epa.gov/gasstar

Reduction Opportunities: Agenda

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

Methane Losses from Storage Tanks

- U.S. natural gas production sector emissions in 2007



EPA. *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 – 2007.* 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 to 500 thousand cubic feet (Mcf) of natural gas and light hydrocarbon vapors to the atmosphere each day
- 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

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

4

Types of Vapor Recovery Units

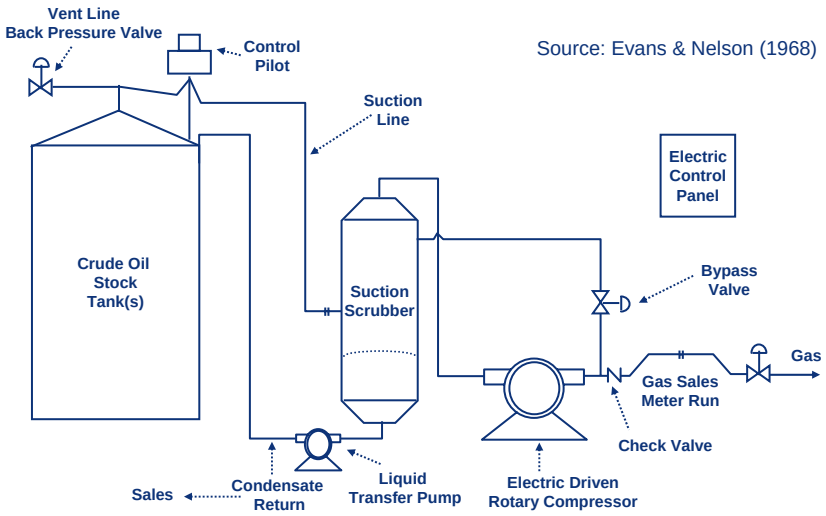
- Conventional vapor recovery units (VRUs)
- Venturi ejector vapor recovery units (EVRU™) or Vapor Jet Systems
  - Use Venturi jet ejectors in place of rotary compressors

Scroll VRU Installation

Courtesy of Hy-bon Engineering

5

Conventional Vapor Recovery Unit



Source: Evans & Nelson (1968)

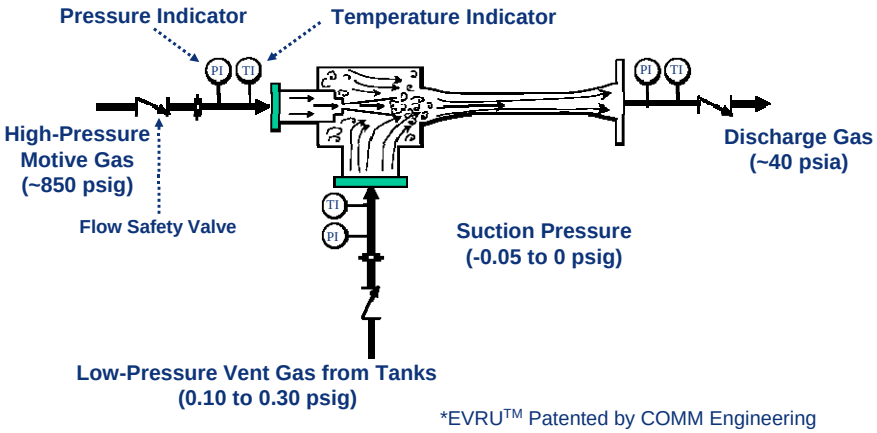
6

Vapor Recovery Installations

Rock Springs, WY Rotary Vane VRU Installation
Courtesy of Hy-bon Engineering

7

Venturi Jet Ejector*

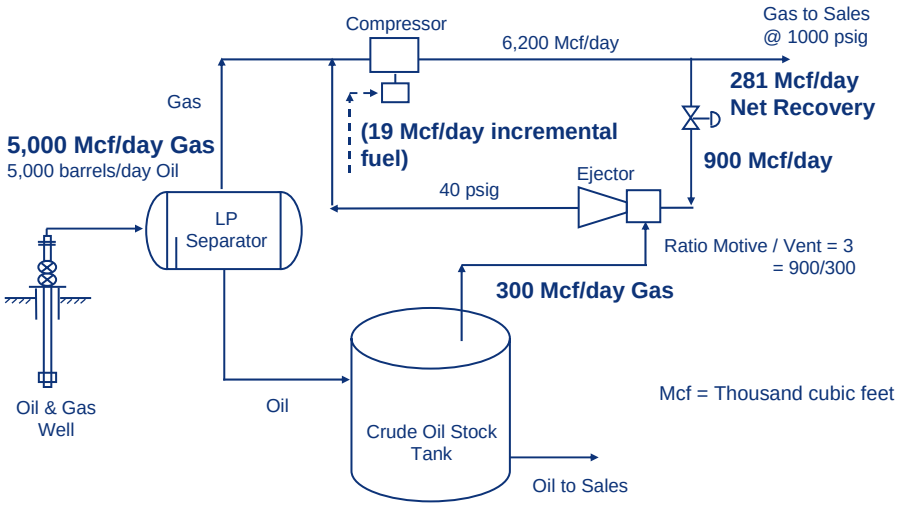


*EVRU™ Patented by COMM Engineering

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

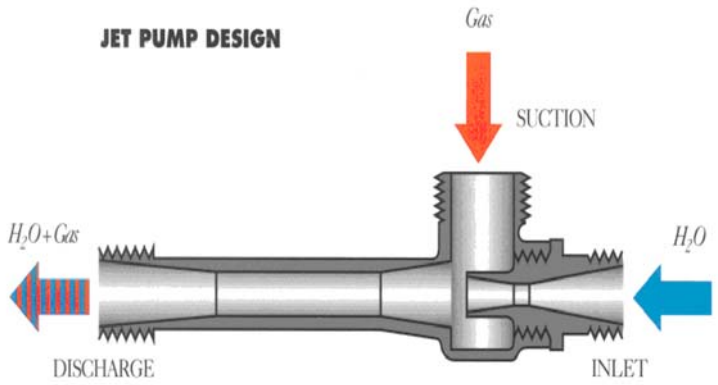
8

Vapor Recovery with Ejector



9

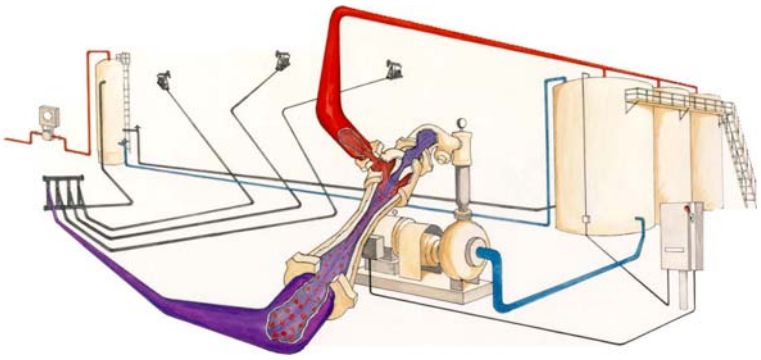
Vapor Jet System*



*Patented by Hy-Bon Engineering

10

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

11

Criteria for Vapor Recovery Unit Locations

- Steady source and sufficient quantity of losses
- Outlet for recovered gas; or possible onsite use
- Tank batteries subject to air regulations

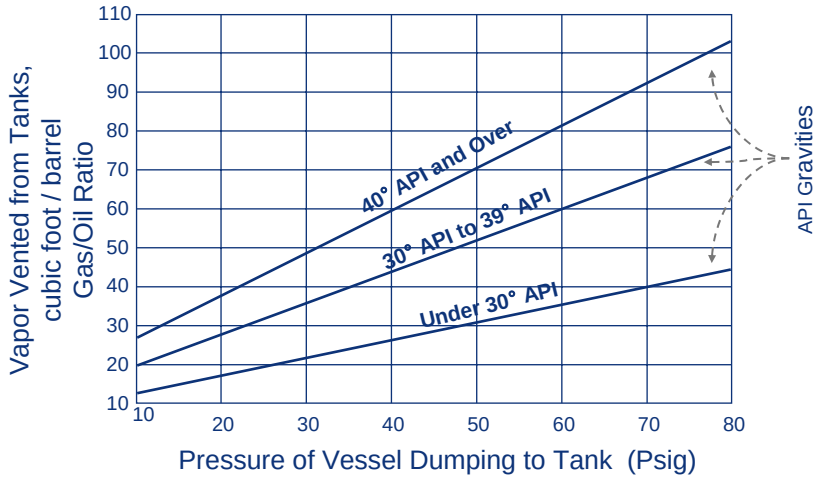
12

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%)

13

Estimated Volume of Tank Vapors



° API = API gravity

14

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

15

Value of Natural Gas Liquids

	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	0.42	7.00	1,012	1.01	$7.07
Ethane	74,010	0.07	0.37	5.21	1,773	1.77	$9.23
Propane	91,740	0.09	0.68	7.58	2,524	2.52	$19.10
n Butane	103,787	0.10	0.86	8.60	3,271	3.27	$28.11
iso Butane	100,176	0.10	0.91	9.08	3,261	3.26	$29.58
Pentanes+*	105,000	0.11	1.01	9.14	4,380	4.38	$40.02

	8 $/MMBtu	9 Vapor Composition	10 Mixture (MMBtu/Mcf)	11 Value ($/Mcf) (8*10)
Methane	7.00	82%	0.83	$5.81
Ethane	5.21	8%	0.14	$0.73
Propane	7.58	4%	0.10	$0.76
n Butane	8.60	3%	0.10	$0.86
iso Butane	9.08	1%	0.03	$0.27
Pentanes+	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

16

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	$42,203	$34,836	13	94%
50	$46,073	$8,419	$84,406	$75,987	8	164%
100	$55,524	$10,103	$168,812	$158,709	5	286%
200	$74,425	$11,787	$337,625	$325,838	3	438%
500	$103,959	$16,839	$844,062	$827,223	2	796%

1 – Unit cost plus estimated installation of 75% of unit cost
2 – $9.25 x ½ peak capacity x 365, Assumed price includes Btu enriched gas (1.289 MMBtu/Mcf)

17

Industry Experience: ConocoPhillips

- Vapor recovery units installed in Baker, MT
- Anticipated multiple sites, so detailed technical review of options was conducted
- Volumes per site ranged from 30 Mcfd to 350 Mcfd
- Pipeline pressure ranged from 20 to 40 psig
- Captures vapors from
  - Crude oil storage tanks
  - Produced Water tanks
  - All manifolded together in closed loop system
  - Gas blanket system used to backfill tanks

18

Industry Experience: ConocoPhillips

- Evaluated rotary screw, rotary vane, vapor jet and EVRU
- Selected rotary vane VRU's due to wide range of volumes of gas and low discharge pressure across the sites
- Pilot project on 3 locations, then added 6 addt'l sites
- Designed for optimum gas capture
  - Pressure transmitter on the tanks
  - Sloping lines to the VRU
  - Package specifically designed for vapor recovery service
  - Automated liquid handling and bypass systems

19

Baker, MT ConocoPhillips VRU installation; Picture Courtesy of Hy-bon Engineering

Baker, MT ConocoPhillips VRU installation; Picture Courtesy of Hy-bon Engineering

Baker, MT ConocoPhillips VRU installation; Picture Courtesy of Hy-bon Engineering

Baker, MT ConocoPhillips VRU installation; Picture Courtesy of Hy-bon Engineering

Baker, MT ConocoPhillips VRU installation; Picture Courtesy of Hy-bon Engineering

Baker, MT ConocoPhillips VRU installation; Picture Courtesy of Hy-bon Engineering

Baker, MT ConocoPhillips VRU installation; Picture Courtesy of Hy-bon Engineering

Industry Experience: ConocoPhillips

- Payback Economics – Project for 9 Tank Batteries
  - Purchase Price for 9 VRU's $475,000
  - Estimate Install Cost $ 237,500
  - Total Capital Costs $ 712,500
- Approx Gas Revenue
  - 1,050 mcfd x $6/Mcf (2005 & 6) X 30 days = $189,000/ mo
  - Payback on Capital Investment < 4 months
  - Installed in 2005 & early 2006 – all locations continue to generate incremental revenue and meet environmental compliance goals today

27

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

28

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

29

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
- (does not include VRU)

Courtesy of Anadarko

30

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

31

Discussion

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

32