Methane to Markets

Reducing Methane Emissions with Vapor Recovery on Storage Tanks

Technology Transfer Workshop

PEMEX &
Environmental Protection Agency, USA

April 25, 2006
Villahermosa, Mexico

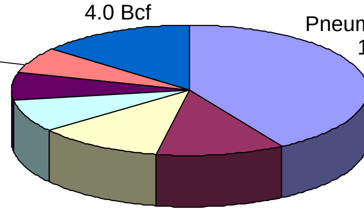
Methane to Markets

Vapor Recovery Units: Agenda

- Methane Losses
- Methane Savings
- Is Recovery Profitable?
- Industry Experience
- Project Summary for Mexico
- Discussion Questions

Methane Losses from Storage Tanks

- We estimate 1.7 billion cubic feet (Bcf) of methane lost from crude oil storage tanks each year in Mexico



Sources: *US Natural Gas STAR program success points to global opportunities to cut methane emissions cost-effectively*, Oil and Gas Journal, July 12, 2004
Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004

- A storage tank battery can vent 4,900 to 96,000 thousand cubic feet (Mcf) 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

Sources of Methane Losses

- 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

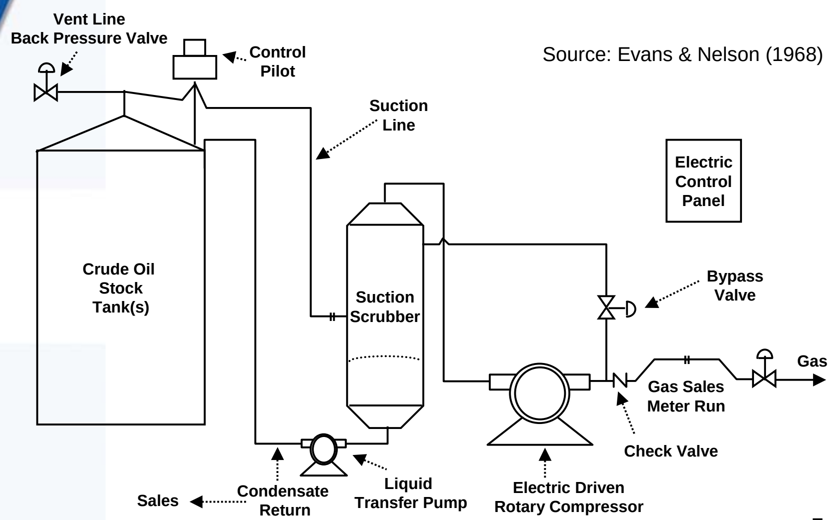
Methane Savings: Vapor Recovery

- 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

Types of Vapor Recovery Units

- Conventional vapor recovery units (VRUs)
  - Use rotary compressor to suck vapors out of atmospheric pressure storage tanks
  - 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 source of high pressure gas and intermediate pressure system
  - Vapor Jet requires high pressure water motive

Conventional Vapor Recovery Unit



Source: Evans & Nelson (1968)

Vapor Recovery Installations

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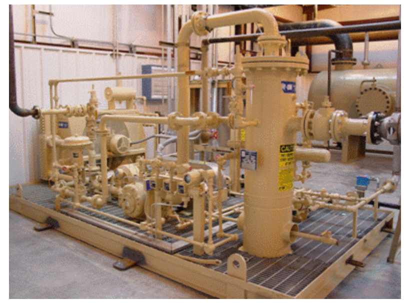
Vapor Recovery Installations



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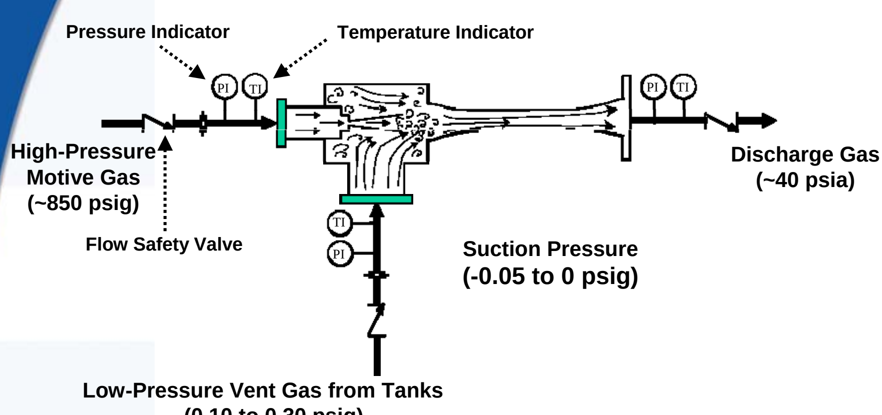
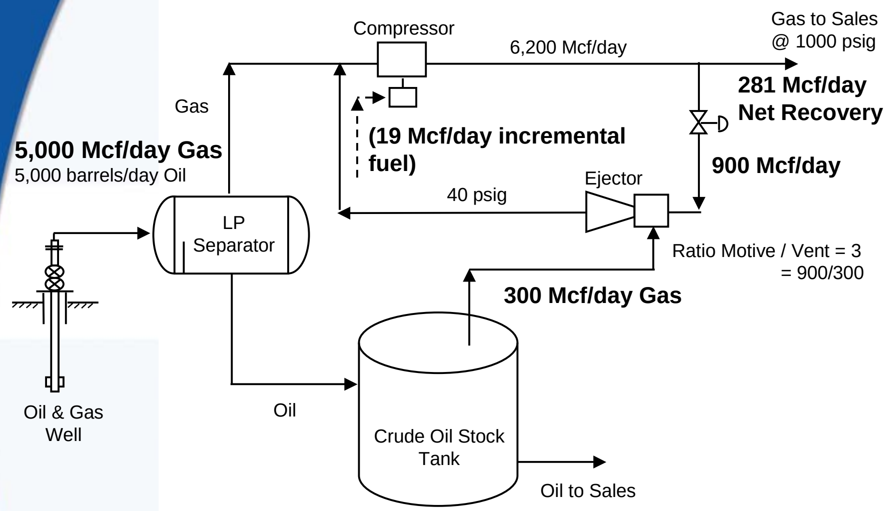
Venturi Jet Ejector*



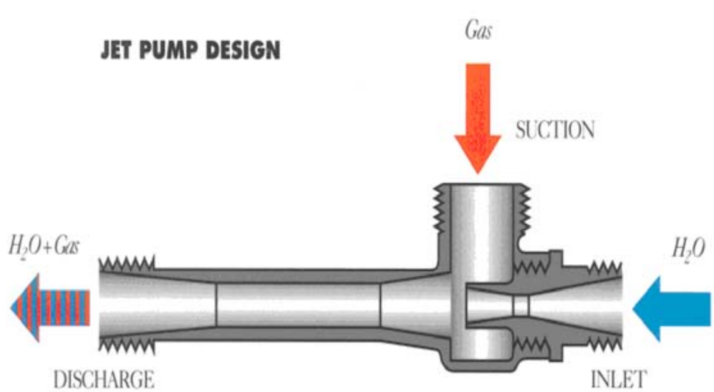
*EVRU[TM] Patented by COMM Engineering

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

Vapor Recovery with Ejector

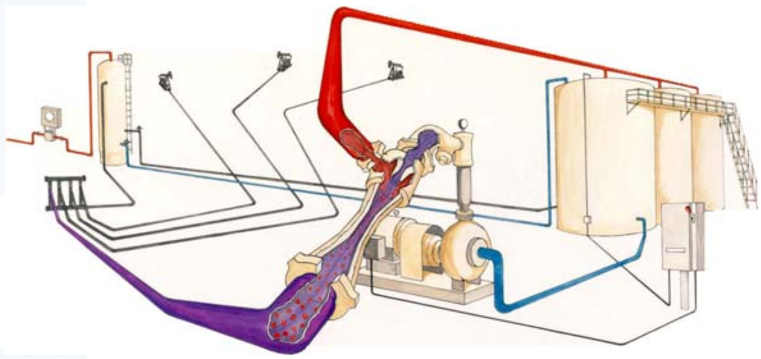


Vapor Jet System*



*Patented by Hy-Bon Engineering

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

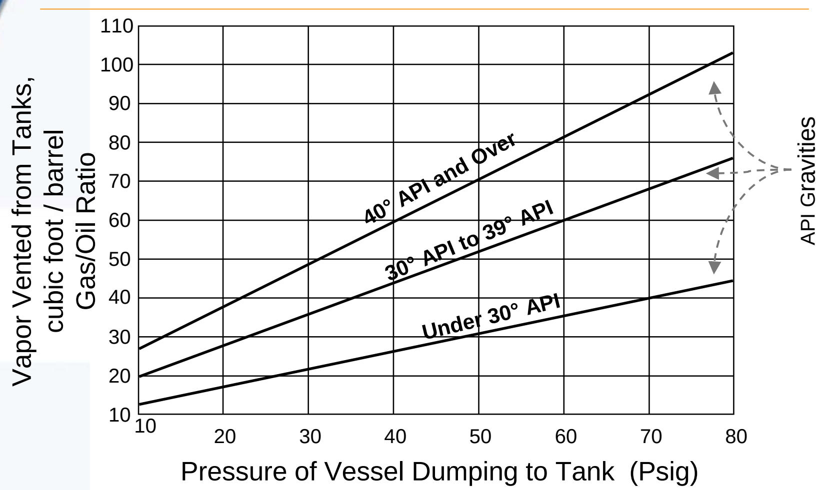
Criteria for Vapor Recovery Unit Locations

- 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
- Tank batteries not subject to air regulations

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%)
- Measure losses using recording manometer and well tester or ultrasonic meter over several cycles (± 5%)
  - This is the best approach for facility design

Estimated Volume of Tank Vapors



° API = API gravity

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

Value of Recovered Gas

- 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

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Value of Natural Gas Liquids

	1 Btu/gallon	2 MMBtu/ gallon	3 $/gallon	4 $/MMBtu[1,2] (=3/2)
Methane	59,755	0.06	0.43	7.15
Ethane	74,010	0.07	0.64	9.14
Propane	91,740	0.09	0.98	10.89
n Butane	103,787	0.10	1.32	13.20
iso Butane	100,176	0.10	1.42	14.20
Pentanes+	105,000	0.11	1.50	13.63

	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	$ 7.22	7.15	82%	0.83	$ 5.93
Ethane	1,773	1.77	$ 16.18	9.14	8%	0.14	$ 1.28
Propane	2,524	2.52	$ 27.44	10.89	4%	0.10	$ 1.09
n Butane	3,271	3.27	$ 43.16	13.20	3%	0.10	$ 1.32
iso Butane	3,261	3.26	$ 46.29	14.20	1%	0.03	$ 0.43
Pentanes+	4,380	4.38	$ 59.70	13.63	2%	0.09	$ 1.23
Total						1.289	$ 11.28

1 Natural Gas Price assumed at $7.15/MMBtu as on Mar 16, 2006 at Henry Hub
2 Prices of Individual NGL components are from Platts Oilgram for Mont Belvieu, TX, January 11,2006
3 Other natural gas liquids information obtained from Oil and Gas Journal, Refining Report, March 19, 2001, p-83
Btu = British Thermal Units, MMBtu = Million British Thermal Units

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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	5-10	15,125	7,560 - 15,125	5,250
50	10-15	19,500	9,750 - 19,500	6,000
100	15 - 25	23,500	11,750 - 23,500	7,200
200	30 - 50	31,500	15,750 - 31,500	8,400
500	60 - 80	44,000	22,000 - 44,000	12,000
Cost information provided by Unite States Gas STAR companies and VRU manufacturers, 1998 basis.				

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)	Return on Investment
25	26,470	5,250	$ 51,465	$ 46,215	7	175%
50	34,125	6,000	$ 102,930	$ 96,930	5	284%
100	41,125	7,200	$ 205,860	$ 198,660	3	483%
200	55,125	8,400	$ 411,720	$ 403,320	2	732%
500	77,000	12,000	$ 1,029,300	$ 1,017,300	1	1321%

1 Unit Cost plus estimated installation at 75% of unit cost

2 $11.28 x 1/2 capacity x 365, Assumed price includes Btu enriched gas (1.289 MMBtu/Mcf)

Industry Experience

Top five United States companies for emissions reductions using VRUs in 2004

Company	2004 Annual Reductions (Mcf)
Company 1	1,273,059
Company 2	614,977
Company 3	468,354
Company 4	412,049
Company 5	403,454

Industry Experience: Chevron

- Chevron installed eight VRUs at crude oil stock tanks in 1996

Project Economics – Chevron				
Methane Loss Reduction (Mcf/unit/year)	Approximate Savings per Unit[1]	Total Savings	Total Capital and Installation Costs	Payback
21,900	$153,300	$1,226,400	$240,000	3 months

[1]Assumes a $7 per Mcf gas price; excludes value of recovered natural gas liquids. Refer to the Gas STAR ***Lessons Learned*** for more information.

Industry Experience: Devon Energy

- For 5 years, Devon employed the Vapor Jet system and recovered more than 55 MMcf of gas from crude oil stock tanks
- Prior to installing the system, tank vapor emissions were about 20 Mcf per day
- Installed a system with maximum capacity of 77 Mcf per day, anticipating production increases
- Revenue was about $91,000 with capital cost of $25,000 and operating expenses less than $0.40 per Mcf of gas recovered
  - At today's gas prices, payback is less than 5 months

MMcf = million standard cubic feet

Industry Experience: EVRU™

<u>Facility Information</u>

- Oil production: 5,000 Barrels/day, 30° API
- Gas production: 5,000 Mcf/day, 1060 Btu/cf
- Separator: 50 psig, 100°F
- Storage tanks: Four 1500 barrel tanks @1.5 ounces relief
- Measured tank vent: 300 Mcf/day @ 1,850 Btu/cf

<u>EVRU™ Installation Information</u>

- Motive gas required: 900 Mcf/day
- Gas sales: 5,638 MMBtu/day
- Reported gas value: $28,190/day @ $5/MMBtu
- Income increase: $2,545/day = $76,350/month
- Reported EVRU™ cost: $75,000
- Payout: <1 month

Vapor Recovery

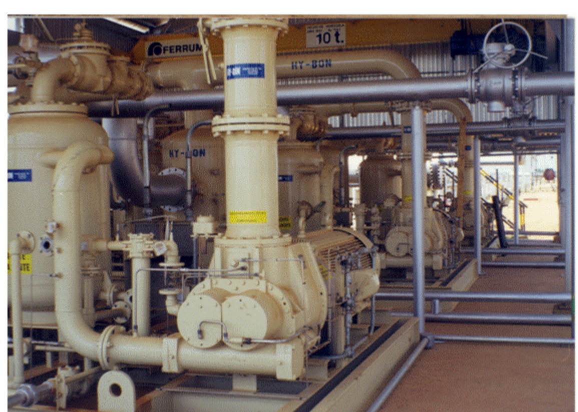
Dual VRU bound for Venezuela… one of 17 units capturing gas currently for Petroleos de Venezuela. Flooded screw compressor for volumes to 5.0 MMSCFD; up to 200 psig.

Vapor Recovery

PDVSa has installed vapor recovery in the majority of their production facilities in Eastern Venezuela.

Vapor Recovery

At this PDVSa installation, three dual rotary screw compressor packages were set in tandem to move 15 MMSCFD of 2500-2600 BTU/cu ft. tank vapors. Project economics were based primarily on the condensate recovery from these high BTU gas streams.



Vapor Recovery

Two large rotary screw vapor recovery compressor systems manufactured for ENI – Venezuela designed to capture 1.4 MMcfd of tank vapor gas (per skid) and discharge to aftercoolers at a pressure of 230 psig.

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Vapor Recovery

ENI installed their vapor recovery systems with large aftercoolers in order to maximize condensate production. Each unit now captures over 100 bbls of 70 api gravity condensate per day.

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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
- Potential for reduced compliance costs can be considered when evaluating economics of VRU, EVRU™, or Vapor Jet

Lessons Learned (cont'd)

- VRU should be sized for maximum volume expected from storage tanks (rule-of-thumb is to double daily average volume)
- Rotary vane or screw 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 less than 75 Mcf per day and discharge pressures below 40 psig

Project Summary for Mexico

- Install Vapor Recovery on Crude Oil Storage Tanks

Project Description: 100 Mcf per day of vapor recovery capacity installed on a crude oil stock tank battery.

Gas Saved:	17.3 MMcf per year (491 thousand cubic meters per year)
Sales Value:	$91,000 ($5.25 per Mcf gas)
Capital and Installation Cost:	($41,125)
Operating and Maintenance Cost:	($1,900) per year
Payback Period:	6 months

Additional Carbon Market Value:	$210,000 ($30 per tonne of CO_2e)

Discussion Questions

- To what extent are you implementing this technology?
- How can this technology be improved upon or altered for use in your operation(s)?
- What is stopping you from implementing this technology (technological, economic, lack of information, manpower, etc.)?

Reference: Unit Conversions

1 cubic foot =	0.02832 cubic meters
Degrees Fahrenheit =	(°F – 32) * 5/9 degrees Celsius
1 inch =	2.54 centimeters
1 mile =	1.6 kilometers
14.7 pounds per square foot =	1 atmosphere