Methane to Markets

Reducing Methane Emissions with Vapor Recovery on Storage Tanks

Oil & Gas Subcommittee Technology Transfer Workshop

January 28, 2009
Monterrey, Mexico

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Vapor Recovery Units: Agenda

- Methane Losses
- Methane Savings
- Is Recovery Profitable?
- Industry Experience
- Discussion Questions

Sources of Methane Losses from Tanks

- A storage tank battery can vent 5 to 500 MMcf of natural gas and light hydrocarbon vapors to the atmosphere each year
  - Vapor losses are primarily a function of oil or condensate throughput, gravity, and gas-oil separator pressure
- 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
- Standing losses
  - Occur with daily and seasonal temperature and barometric pressure changes

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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

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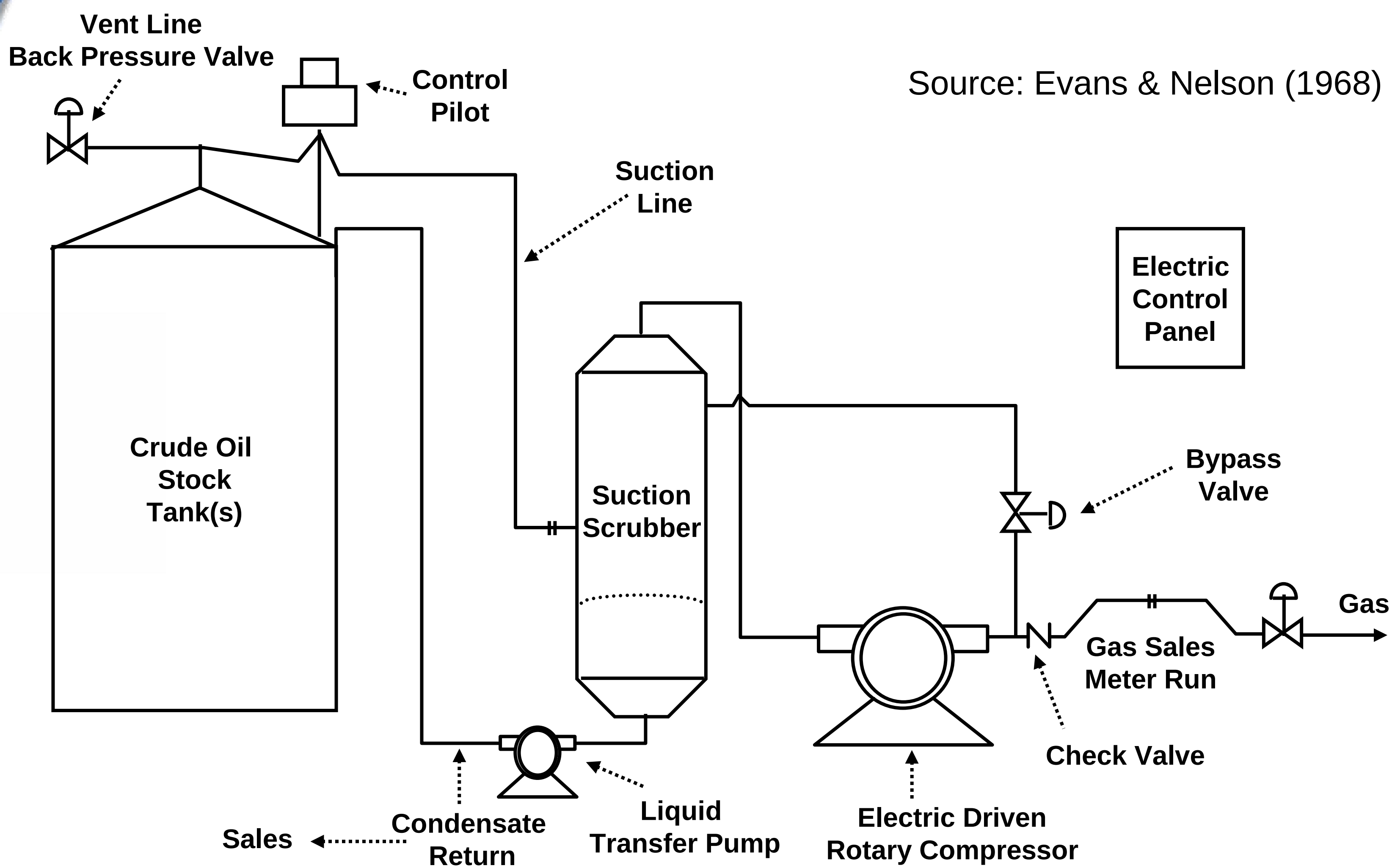
Types of Vapor Recovery Units

- Conventional vapor recovery units (VRUs)
  - Use screw or vane compressor to suck vapors out of atmospheric pressure storage tanks
  - Scroll compressors are new to this market
  - Require electrical power or engine driver
- Venturi ejector vapor recovery units (EVRU^{TM}) or Vapor Jet
  - Use Venturi jet ejectors in place of rotary compressors
  - Contain no moving parts
  - EVRU^{TM} requires a source of high pressure motive gas and intermediate pressure discharge system
  - Vapor Jet requires high pressure motive water

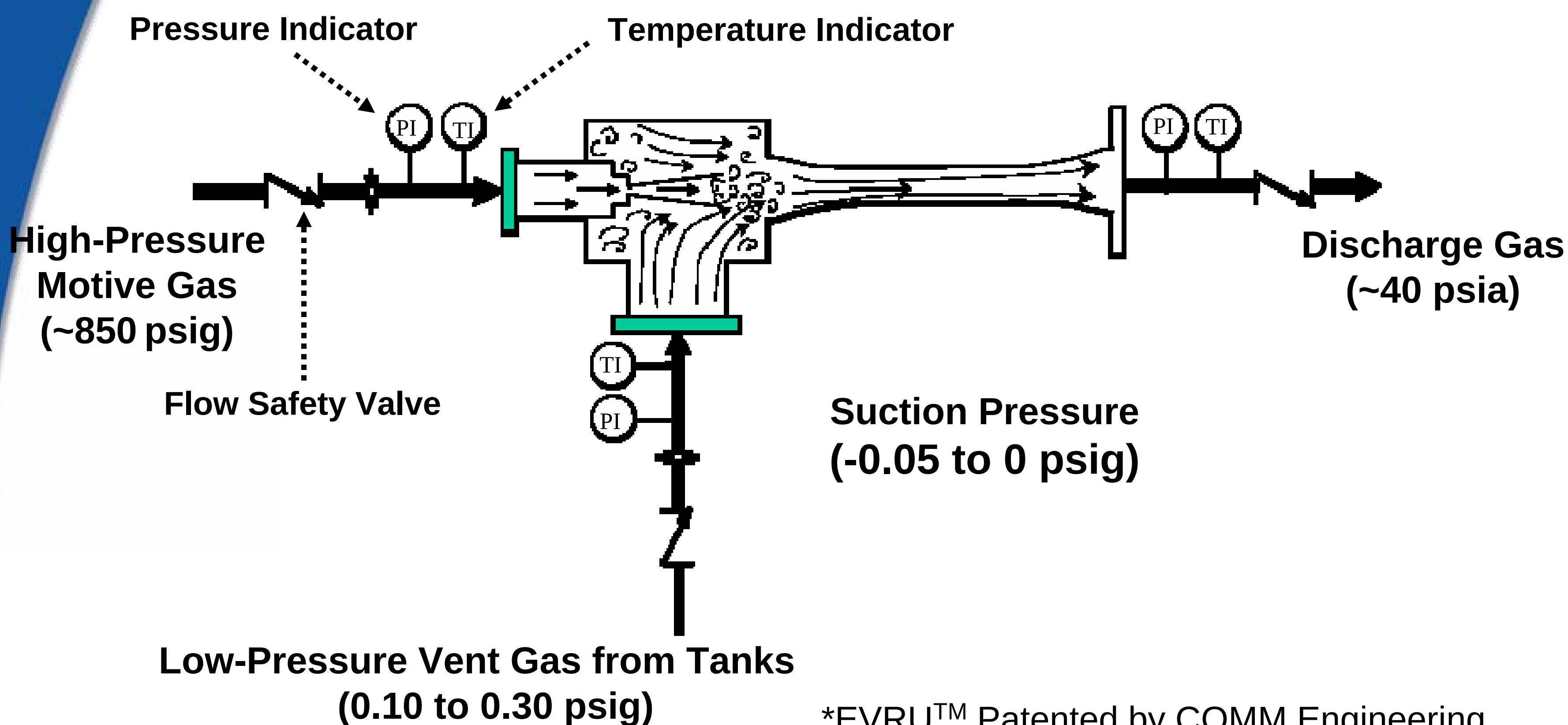
Conventional Vapor Recovery Unit

Source: Evans & Nelson (1968)



Vapor Recovery Installations

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

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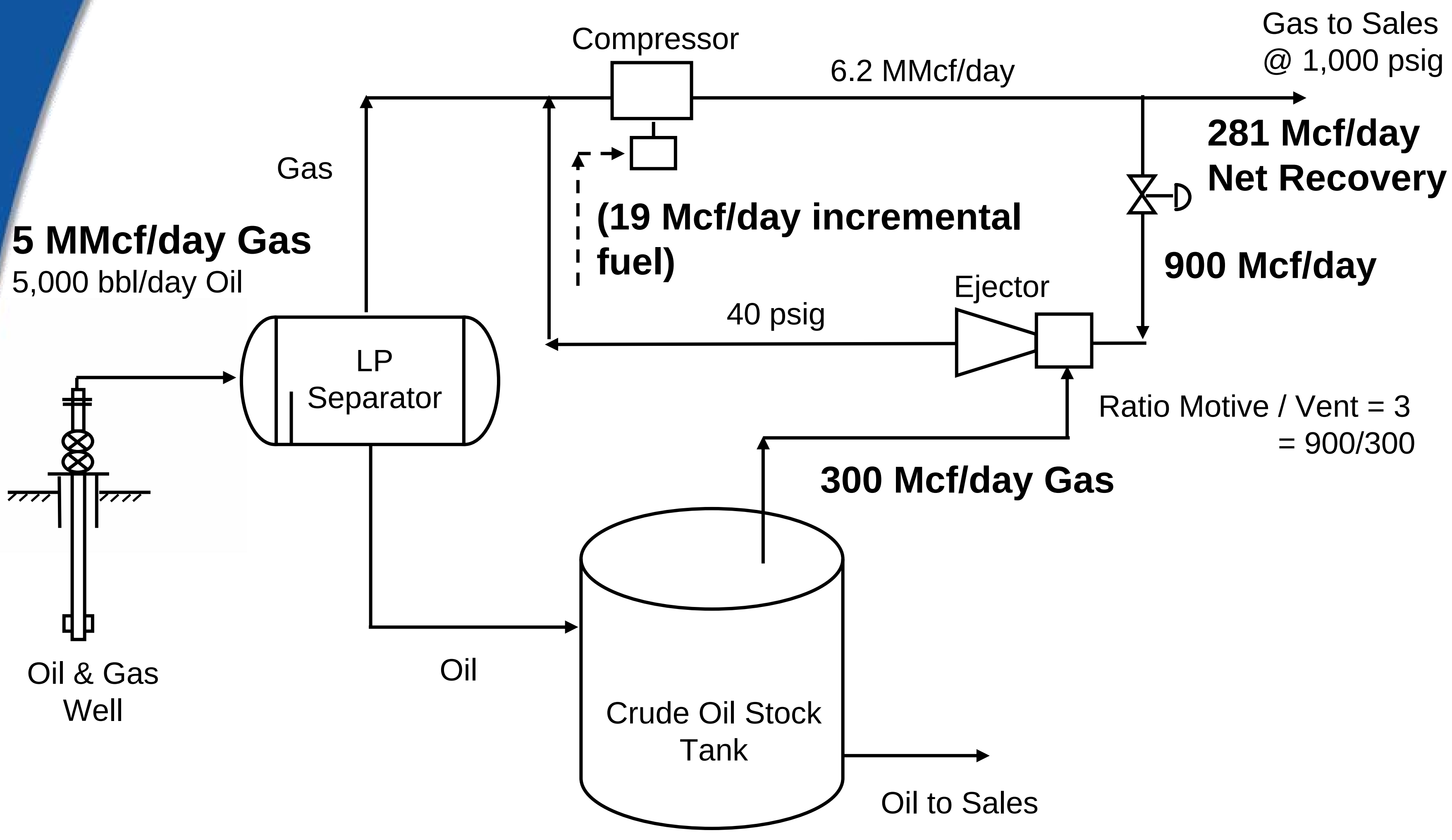
Vapor Recovery with Ejector



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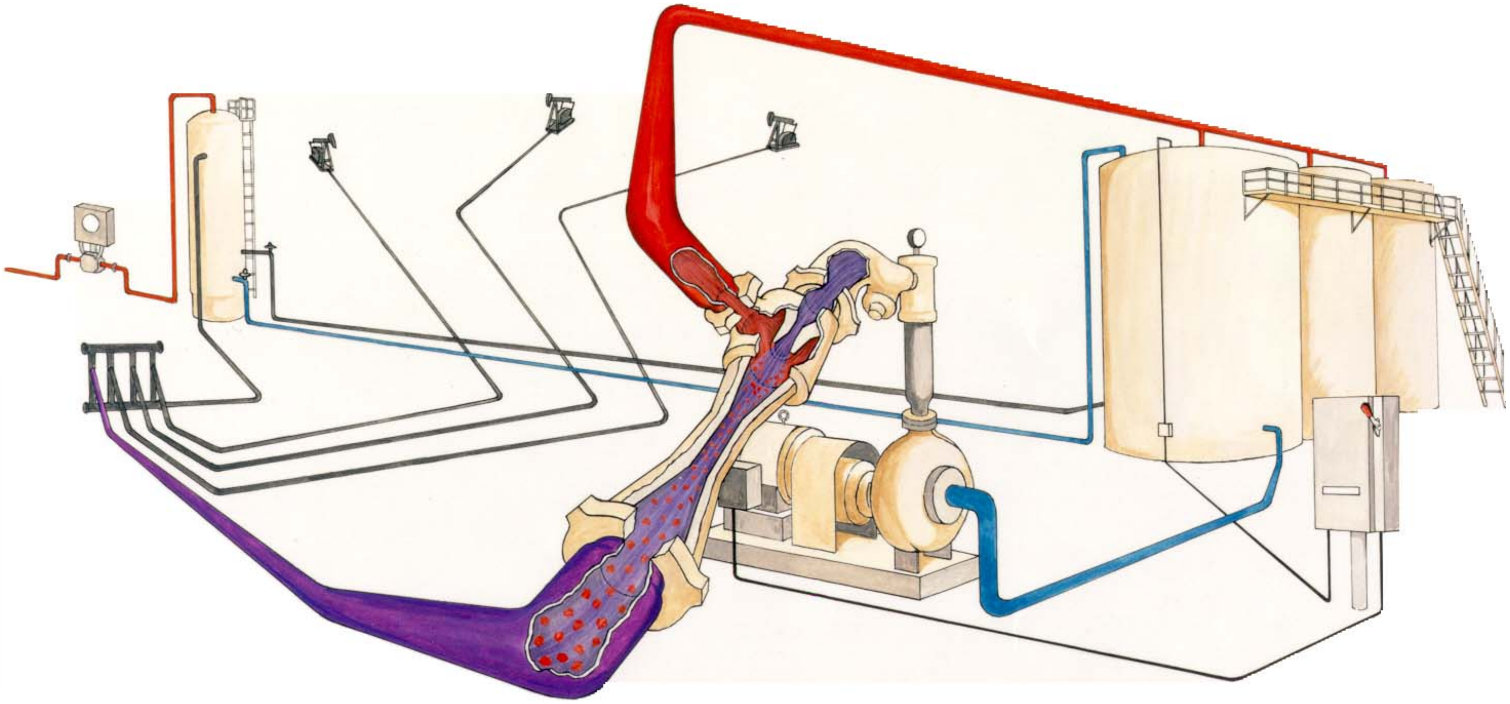
Vapor Jet System*



- 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

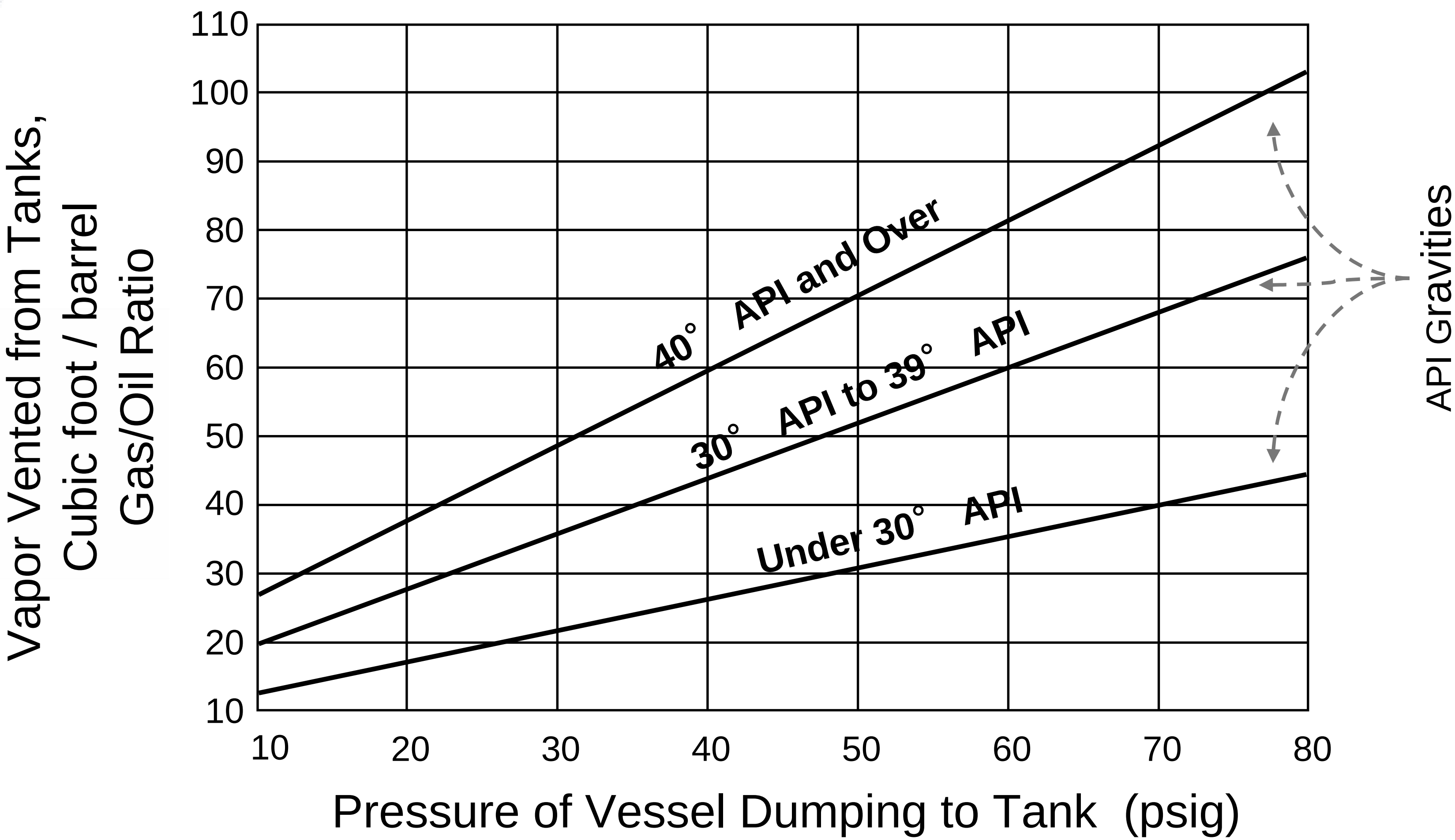
Criteria for Vapor Recovery Unit Locations

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

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

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
- Gross revenue per year = (Q x P x 365) + NGL
  - Q = Rate of vapor recovery (MMBtu per day)
  - P = Price of natural gas (US$/MMBtu)
  - NGL = Value of natural gas liquids

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Value of Natural Gas Liquids

NGL Components	1 Btu/gal	2 MMBtu/gal	3 US$/gal	4 US$/MMBtu[1,2] (=3/2)
Methane	59,755	0.060	0.30	5.00
Ethane	74,010	0.074	0.26	3.45
Propane	91,740	0.092	045	5.09
n Butane	103,787	0.104	0.49	4.91
iso Butane	100,176	0.100	0.53	5.44
Pentanes+	105,000	0.105	0.57	5.27

	5 Btu/cf	6 MMBtu/Mcf	7 US$/Mcf (=4*6)	8 US$/MMBtu	9 Vapor Composition	10 Mixture (MMBtu/Mcf)	11 Value (US$/Mcf) (=8*10)
Methane	1,000	1.000	$5.00	$5.00	82%	0.82	$4.10
Ethane	1,773	1.773	$6.12	$3.45	8%	0.14	$0.49
Propane	2,524	2.524	$12.86	$5.,09	4%	0.10	$0.51
n Butane	3,271	3.271	$16.05	$4.91	3%	0.10	$0.48
iso Butane	3,261	3.261	$17.74	$5.44	1%	0.03	$0.18
Pentanes+	4,380	4.380	$23.06	$5.27	2%	0.09	$0.46
Total						1.28	6.22

1 – Natural Gas price assumed at Mexico’s cost US$5/MMBtu
2 – Prices of Individual NGL components estimated based on natural gas price in Mexico.

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Cost of a Conventional VRU

Vapor Recovery Unit Sizes and Costs				
Capacity (Mcf/day)	Compressor Horsepower	Capital Costs (US$)	Installation Costs (US$)	O&M Costs (US$/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.				

Is Recovery Profitable?

Financial Analysis for a Conventional VRU Project						
Peak Capacity (Mcf/day)	Installation & Capital Costs[1] (US$)	O&M Costs (US$/year)	Value of Gas[2] (US$/year)	Annual Savings (US$)	Simple Payback (months)	Internal Rate of Return %
25	35,738	7,367	28,398	21,031	20	51
50	46,073	8,419	56,795	48,376	11	102
100	55,524	10,103	113,590	103,487	6	185
200	74,425	11,787	227,181	215,394	4	289
500	103,959	16,839	567,952	551,113	2	530

1 - Unit cost plus estimated installation of 75% of unit cost

2 - US$6.22 x ½ peak capacity x 365, Assumed price includes enriched gas

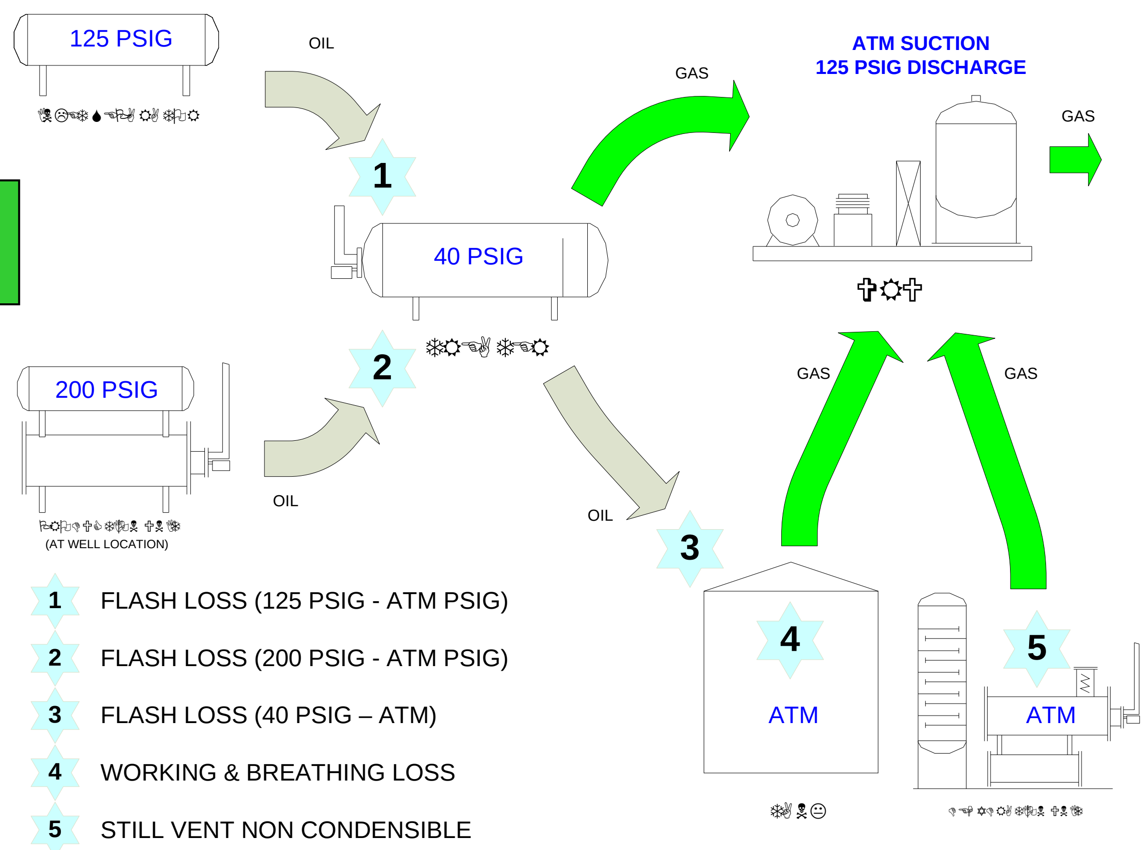
Industry Experience: EnCana Oil & Gas

- Vapor recovery unit installed in Frenchie Draw, WY, U.S.
- 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

Industry Experience: EnCana Oil & Gas

- Quantify the volume of vapor emissions

Total Emissions- 284 MSCFD



Source: EnCana Oil & Gas (USA) Inc.

EnCana Oil & Gas: Project Costs

- Determine the cost of VRU project

Installation (US$)

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

O & M (US$)

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

EnCana Oil & Gas: Project Economics

- Evaluate VRU economics

Capacity–	500 Mcfd
Installation Cost -	US$400,000
O&M-	US$106,000/year
Value of Gas*-	US$515,594/year

Gas Price (US$/MMBtu)	3	5	7
Payback (months)	24	12	8
NPV (US$)	281,682	973,023	1,664,364

*Conservatively based on Mexico natural gas price assumed to be US$5/MMBtu and 1 Mcf = 1 MMBtu

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: 1–5 psig
  - 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

VRT/VRU Photos

Courtesy of Anadarko

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Industry Experience: Anadarko

- VRT reduces pressure drop from approximately 50 psi to 1–5 psi
  - Reduces flashing losses
  - Captures more product for sales
  - Anadarko netted between US$7 to US$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
  - 20” x 35’
  - 48” x 35’
- Anadarko has installed over 300 VRT/VRUs since 1993 and continues on an as needed basis

Servipetrol/ Petrobras Bolivia

- Installing vapor recovery units in Caranda, Bolivia field later this year.
- 2,000 bopd; 40 API gravity crude; 50 psig separator pressure
- Anticipate average of 141 Mcf/day gas capture
- US$257,800 incremental revenue per year, plus value of condensate produced

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 (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™ 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