Installing Vapor Recovery Units to Reduce Methane Losses

Lessons Learned from Natural Gas STAR

Producers Technology Transfer Workshop

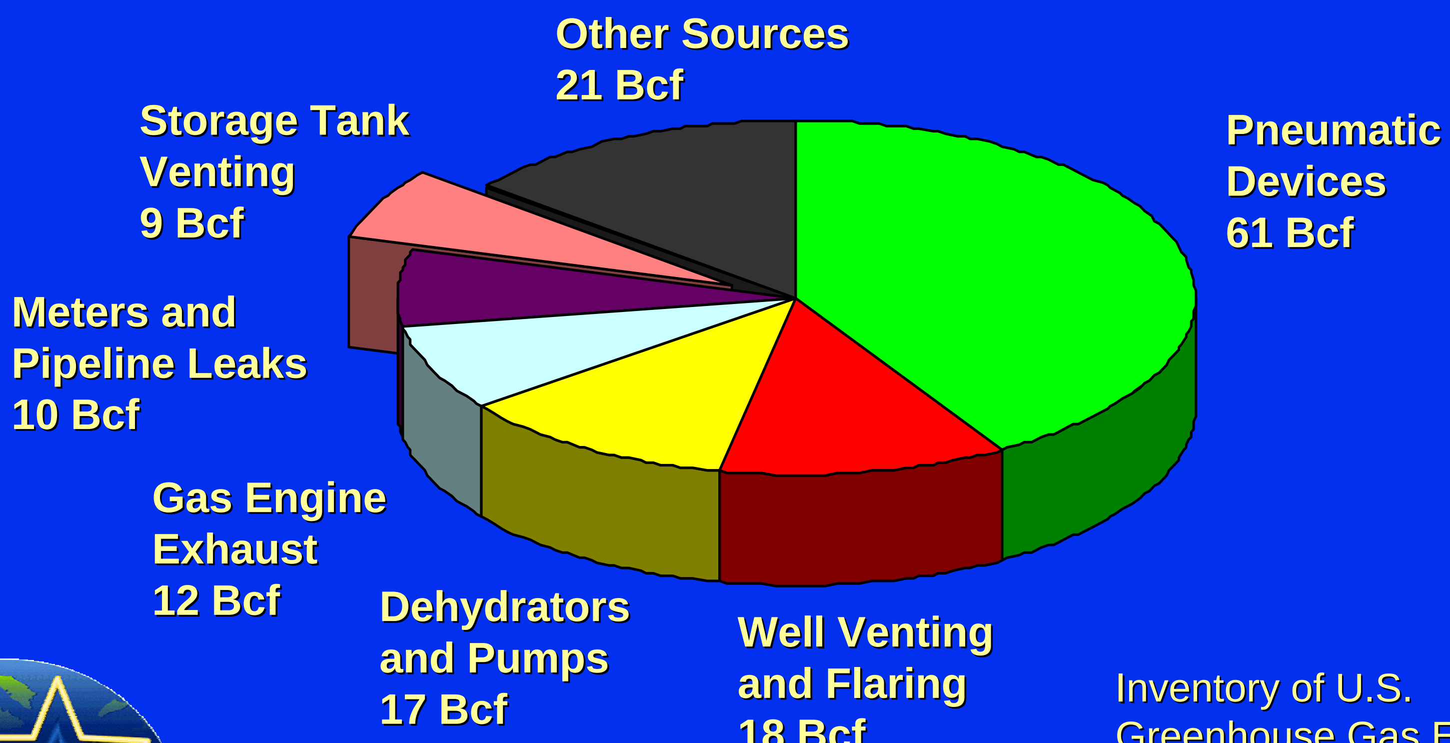
Marathon Oil and
EPA's Natural Gas STAR Program
Houston, TX
October 26, 2005

Vapor Recovery Units: Agenda

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

Methane Losses from Storage Tanks

- Storage tanks are responsible for 6% of methane emissions in natural gas and oil production sector
  - **96% of tank losses occur from tanks without vapor recovery**



Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2003

Sources of Methane Losses

- 9 Bcf methane lost from storage tanks each year from producers*
- Flash losses - occur when crude is transferred from a gas-oil separator at higher pressure to an atmospheric pressure storage tank
- Working losses - occur when crude levels change and when crude in tank is agitated
- Standing losses - occur with daily and seasonal temperature and pressure changes

* Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2003

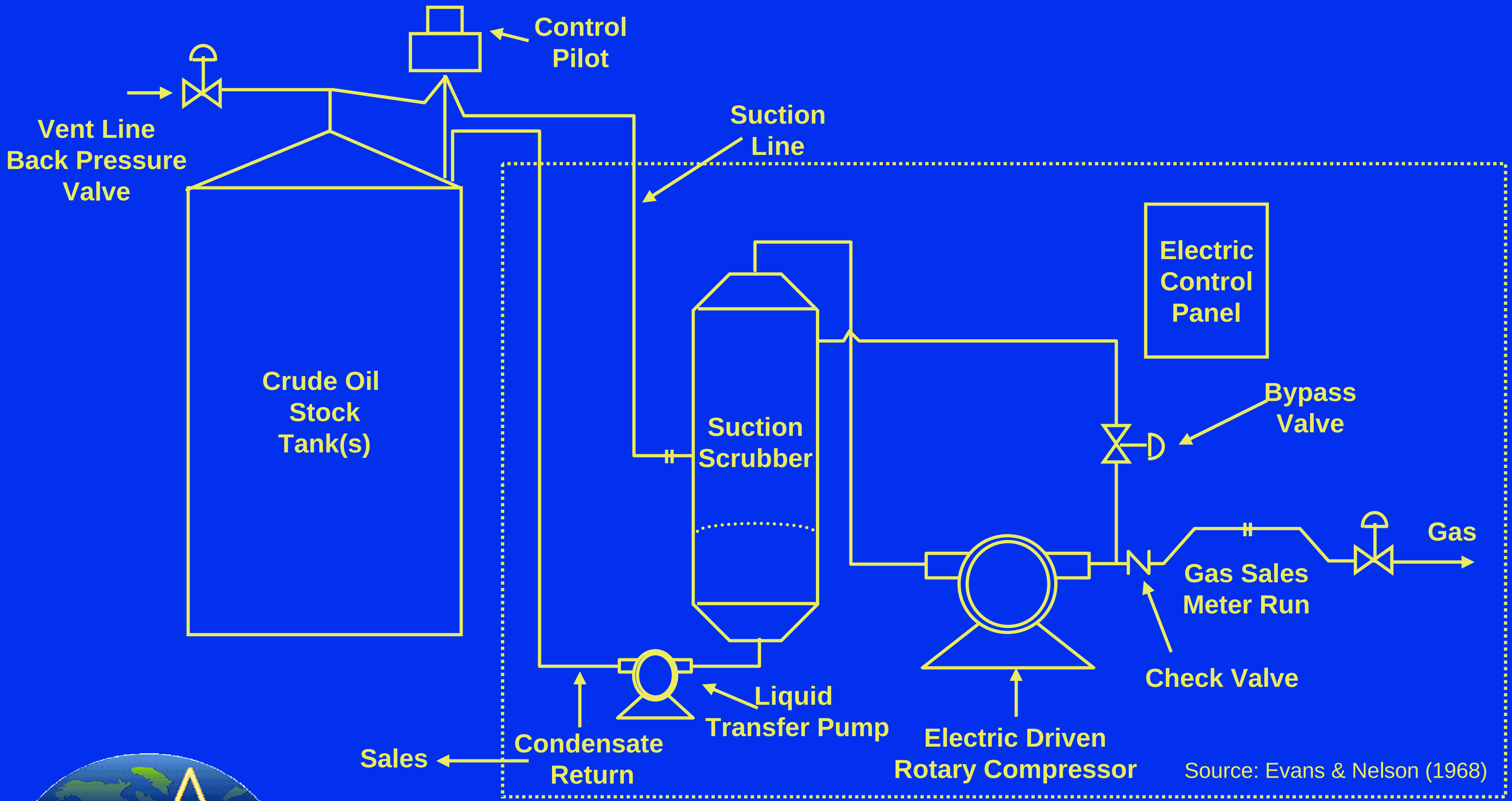
Methane Savings: Vapor Recovery Units

- Capture up to 95% of hydrocarbon vapors vented from tanks
- Recovered vapors have higher Btu 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 NGLs**

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**
- Venturi ejector vapor recovery units (EVRU™) or Vapor Jet
  - **Use Venturi jet ejectors in place of rotary compressors**
  - **Do not contain any moving parts**
  - **EVRU™ requires source of high pressure gas and intermediate pressure system**
  - **Vapor Jet requires high pressure water motive**

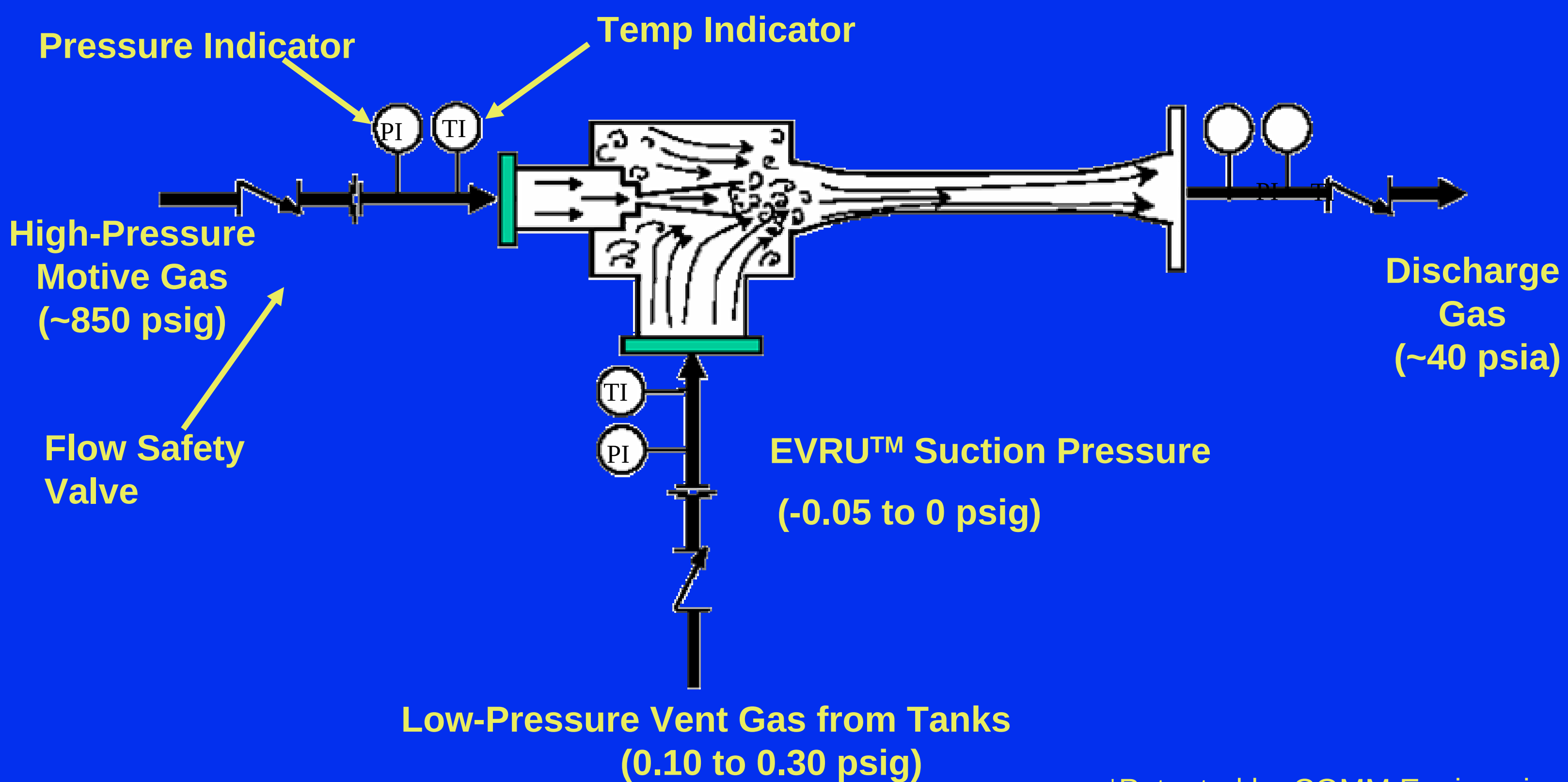
Standard Vapor Recovery Unit



Source: Evans & Nelson (1968)

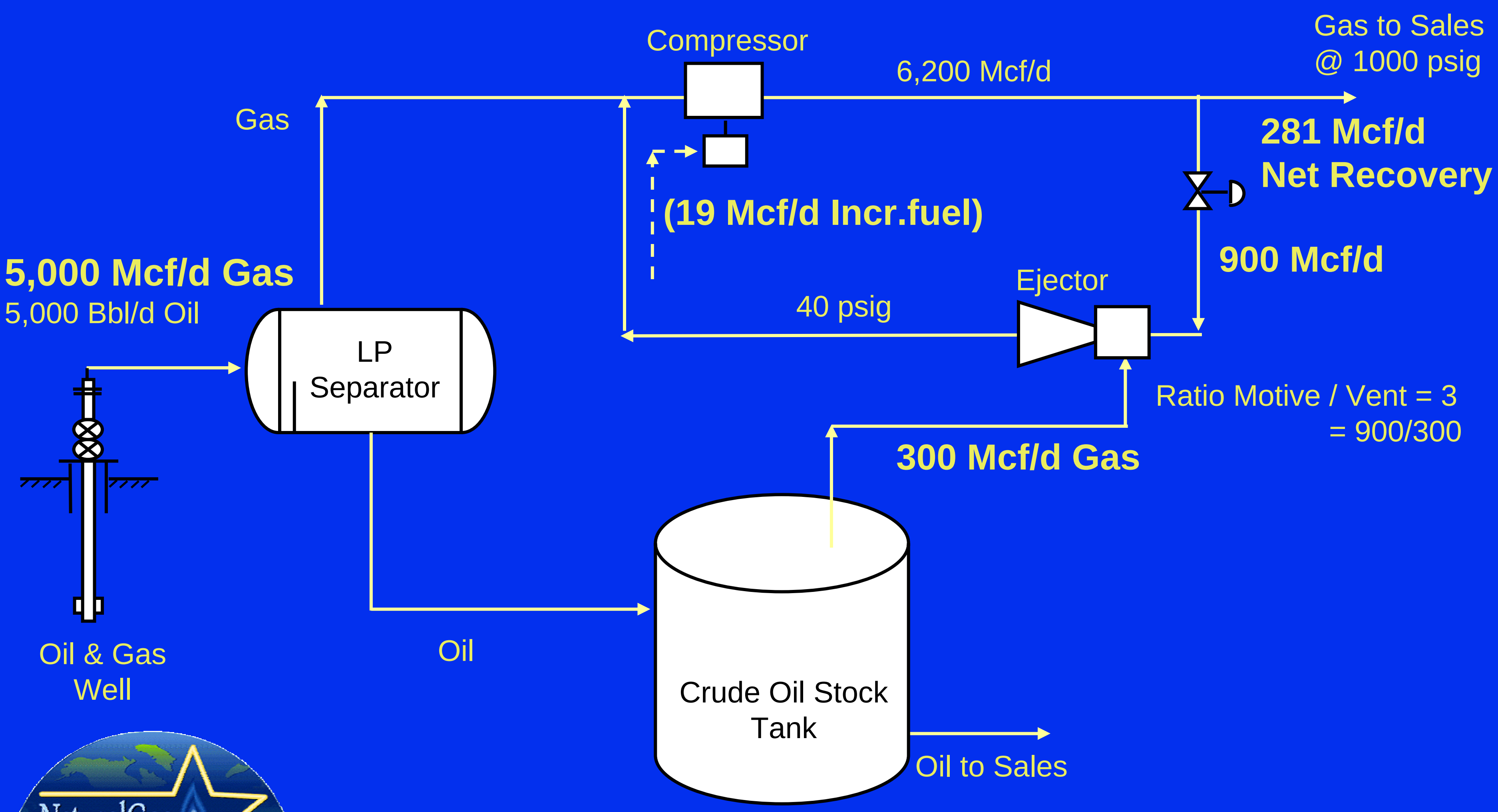
Vapor Recovery Installations

Venturi Jet Ejector*

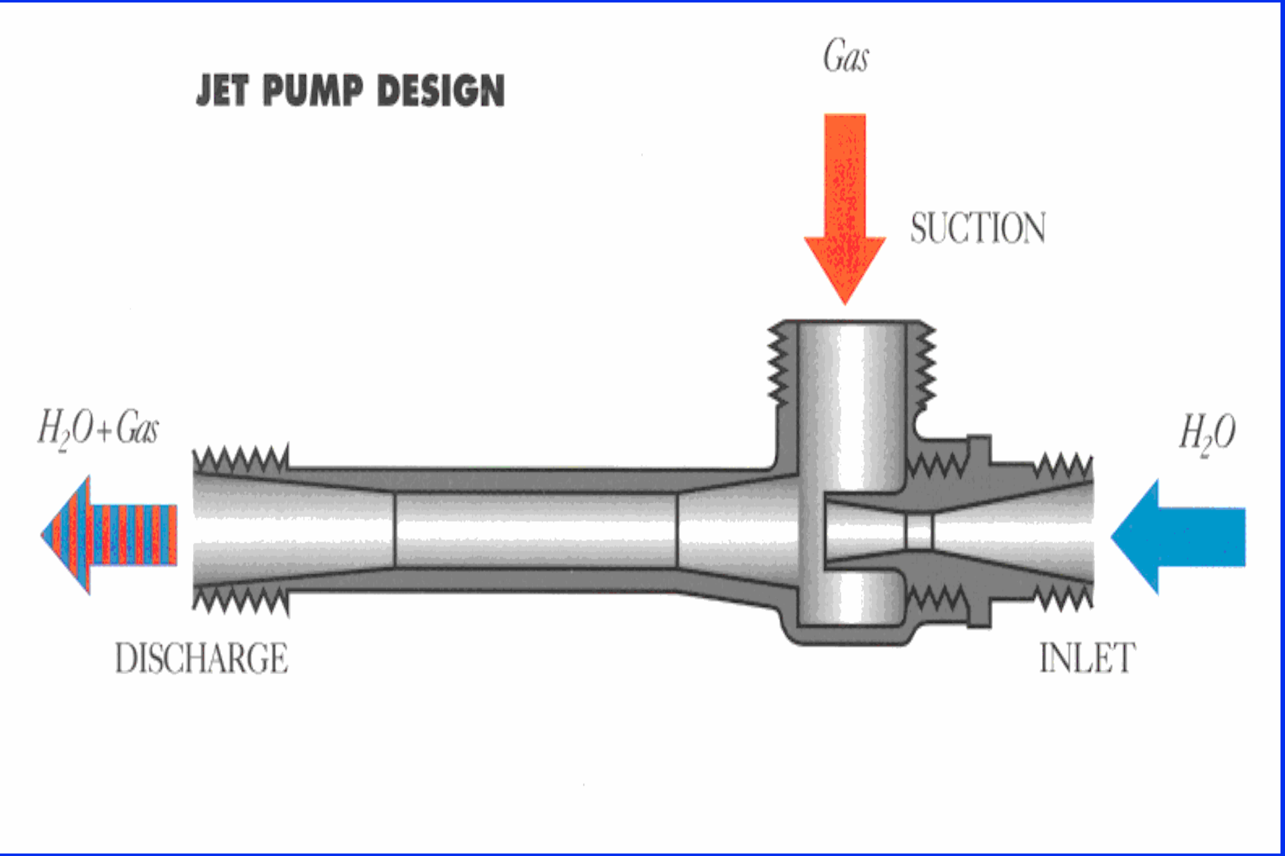


*Patented by COMM Engineering

Vapor Recovery with Ejector

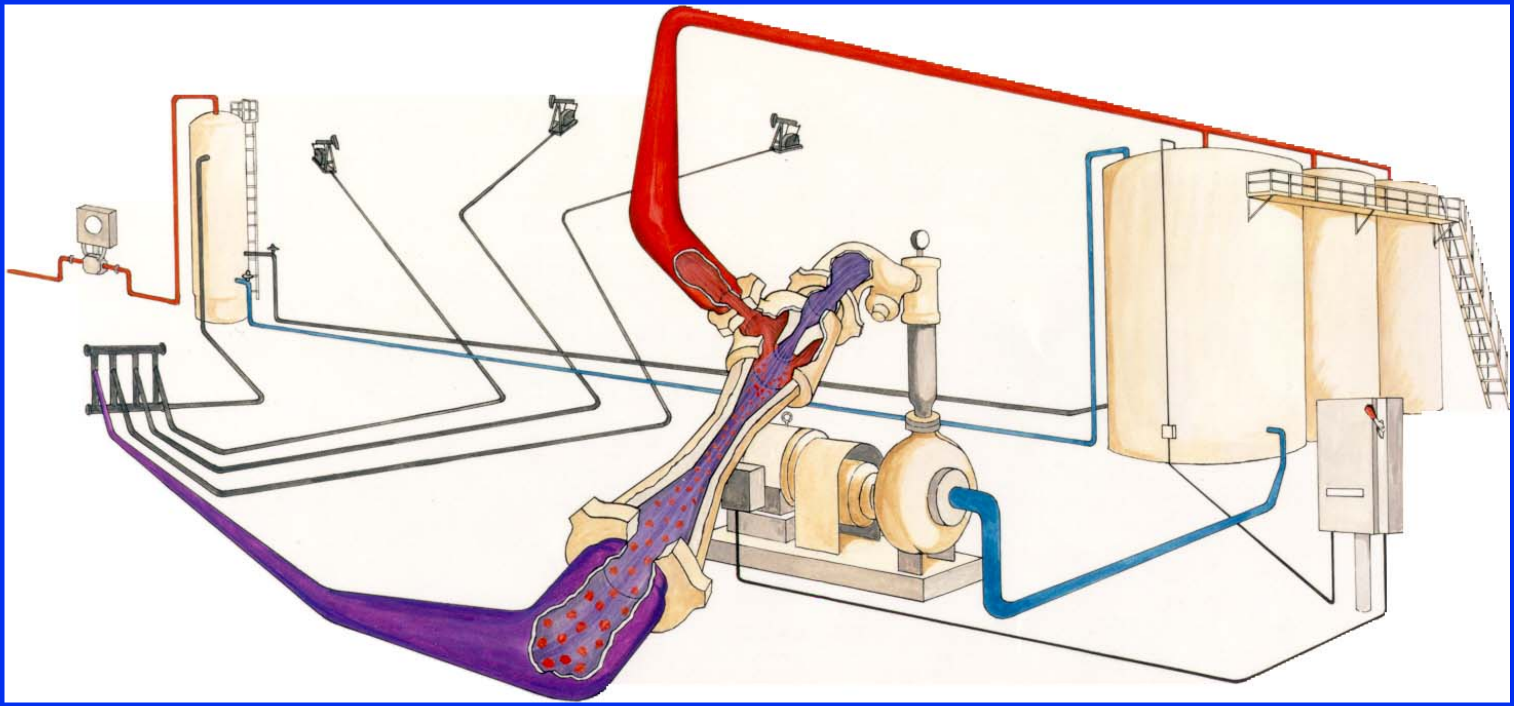


Vapor Jet System*



*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 Mcfd and discharge pressure of 40 psig

*Patented by Hy-Bon Engineering

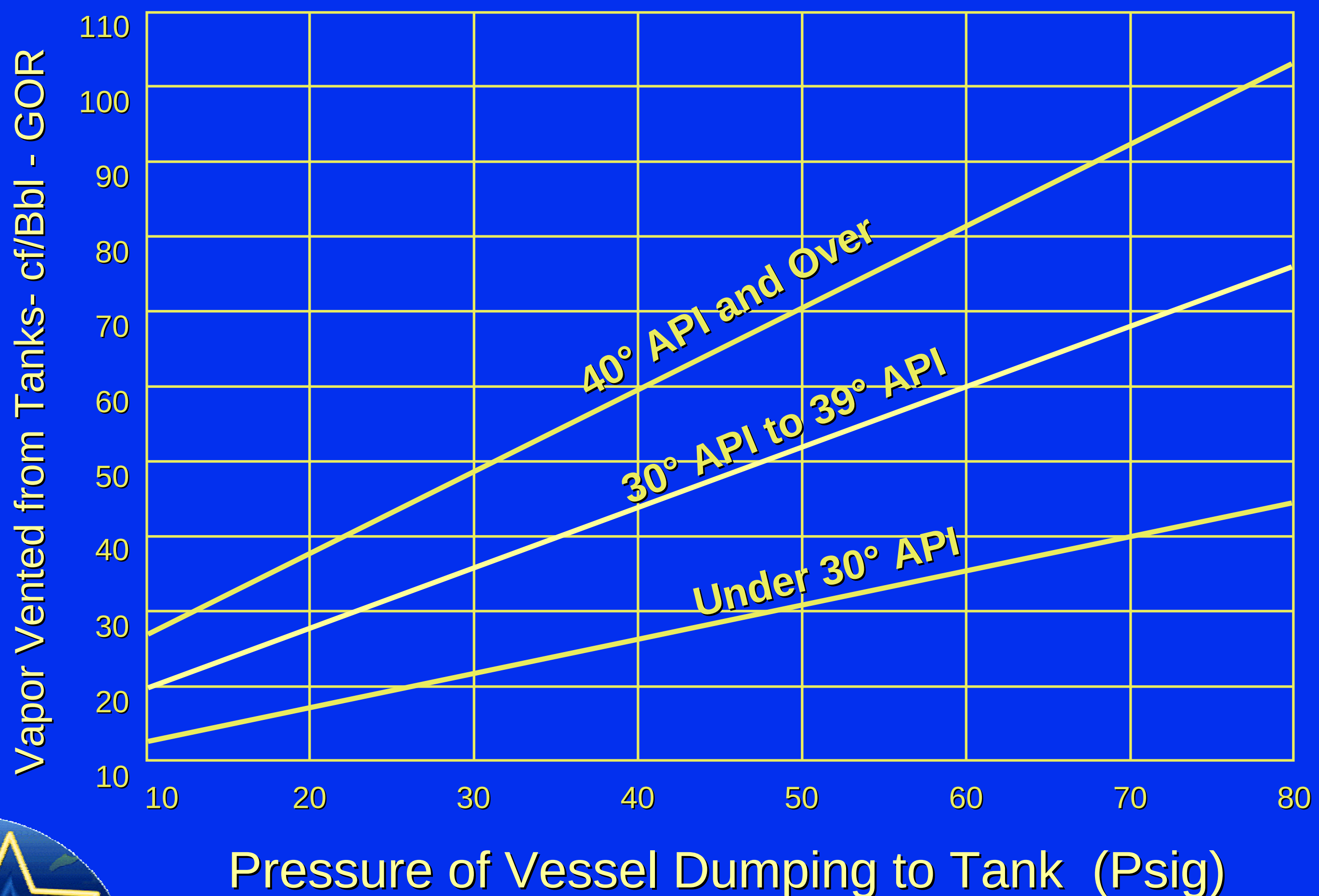
Criteria for Vapor Recovery Unit Locations

- 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



What is the Recovered Gas Worth?

- Value depends on Btu 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 Btu) gas**
  - **Gas processing plant - measured by value of NGLs 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 (Mcfd)

P = Price of natural gas

NGL = Value of natural gas liquids

Value of NGLs

	1 Btu/gal	2 MMBtu/gal	3 $/gal	4 $/MMBtu[1,2] (=3/2)
Methane	59,755	0.06	0.32	5.32
Ethane	74,010	0.07	0.42	5.64
Propane	91,740	0.09	0.59	6.43
n Butane	103,787	0.10	0.73	7.06
iso Butane	100,176	0.10	0.78	7.81
Pentanes+	105,000	0.11	0.85	8.05

	5 Btu/cf	6 MMBtu/Mcf	7 $/Mcf (=4*6)	8 $/MMBtu	9 Vapor Composition	10 Mixture (MMbtu/Mcf)	11 Value ($/Mcf) (=(8*10)/1000)
Methane	1,012	1.01	$ 5.37	5.32	82%	0.83	$ 4.41
Ethane	1,773	1.77	$ 9.98	5.64	8%	0.14	$ 0.80
Propane	2,524	2.52	$ 16.21	6.43	4%	0.10	$ 0.65
n Butane	3,271	3.27	$ 23.08	7.06	3%	0.10	$ 0.69
iso Butane	3,261	3.26	$ 25.46	7.81	1%	0.03	$ 0.25
Pentanes+	4,380	4.38	$ 35.25	8.05	2%	0.09	$ 0.70
Total						1.289	$ 7.51

1 Natural Gas Price assumed at $5.32/MMBtu as on mar 5 at Henry Hub

2 Prices of Individual NGL components are from Platts Oilgram for Mont Belvieu, TX, March 05,2004

3 Other NGL information obtained from Oil and Gas Journal, Refining Report, March 19, 2001, p-83

Cost of a Conventional VRU

Vapor Recovery Unit Sizes and Costs

Capacity (Mcfd)	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

Note: Cost information provided by Partners and VRU manufacturers.

Is Recovery Profitable?

Financial Analysis for a conventional VRU Project						
Peak Capacity (Mcfd)	Installation & Capital Costs[1]	O & M Costs ($/year)	Value of Gas[2] ($/year)	Annual Savings	Payback period[3] (months)	Return on Investment[4]
25	26,470	5,250	$ 34,242	$ 28,992	11	107%
50	34,125	6,000	$ 68,484	$ 62,484	7	182%
100	41,125	7,200	$ 136,967	$ 129,767	4	315%
200	55,125	8,400	$ 273,935	$ 265,535	2	482%
500	77,000	12,000	$ 684,836	$ 672,836	1	874%

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

2 $7.51 x 1/2 capacity x 365, Assumed price includes Btu enriched gas (1.289 MMBtu/Mcf)

3 Based on 10% Discount rate for future savings. Excludes value of recovered NGLs

4 Calculated for 5 years

Top Gas STAR Partners for VRUs

Top five companies for emissions reductions using VRUs in 2004

Company	2004 Annual Reductions (Mcf)
Partner 1	1,273,059
Partner 2	614,977
Partner 3	468,354
Partner 4	412,049
Partner 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/yr)	Approximate Savings per Unit[1]	Total Savings	Total Capital and Installation Costs	Payback
21,900	$43,800	$525,600	$240,000	<1 yr
[1] Assumes a $3 per Mcf gas price; excludes value of recovered NGLs. Refer to the *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 ~ 20 Mcfd
- Installed a system with maximum capacity of 77 Mcfd anticipating production increases
- Revenue was about $91,000 with capital cost of $25,000 and operating expenses less than $0.40/Mcf of gas recovered
  - **This paid back investment in five months**

Industry Experience: EVRU™

✯ Oil production:	5,000 Bbl/d, 30 Deg API
✯ Gas production:	5,000 Mcf/d, 1060 Btu/cf
✯ Separator:	50 psig, 100ºF
✯ Storage tanks:	4 - 1500 Bbls @1.5oz relief
✯ Gas compressor:	Wauk7042GSI/3stgAriel
✯ Suction pressure:	40 psig
✯ Discharge pressure:	1000 psig
✯ Measured tank vent:	300 Mcf/d @ 1,850 Btu/cf

Emissions After EVRU™ CO_2 Equivalents

✭ Motive gas required:	900 Mcf/d
✭ Fuel consumption before EVRU™:	171 MMBtu/d @ 9000 Btu/Hp-hr
✭ Fuel consumption after EVRU™:	190 MMBtu/d @ 9000Btu/Hp-hr
✭ Emission Reductions:	13,596 Tons CO_2 Eq/yr (73.5%)
✭ Gas Saved:	514 MMBtu/d
✭ Gas Value:	$2,570/d = $77,100/mo
✭ EVRU™ cost installed:	$75,000
✭ Payback Period:	<1 month

Lessons Learned

- Vapor recovery can yield generous returns when there are market outlets for recovered gas
  - **Recovered high Btu gas has extra value**
  - **VRU technology can be highly cost-effective in most general applications**
  - **Venturi jet models work well in certain niche applications, with reduced O&M 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^{TM} recommended where there is gas compressor with excess capacity
- Vapor Jet recommended where less than 75 Mcfd and discharge pressures below 40 psig

Discussion Questions

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