Directed Inspection and Maintenance and Infrared Leak Detection

Lessons Learned from the
Natural Gas STAR Program

SGA Environmental Round Table
Charlotte, North Carolina
June 25 - 27, 2008

epa.gov/gasstar

Directed Inspection and Maintenance and Infrared Leak Detection Agenda

- Methane Losses
  - What are the sources of emissions?
  - How much methane is emitted?
- Methane Recovery
  - Directed Inspection and Maintenance (DI&M)
  - DI&M by Infrared Leak Detection
- Is Recovery Profitable?
- Partner Experience
- Discussion

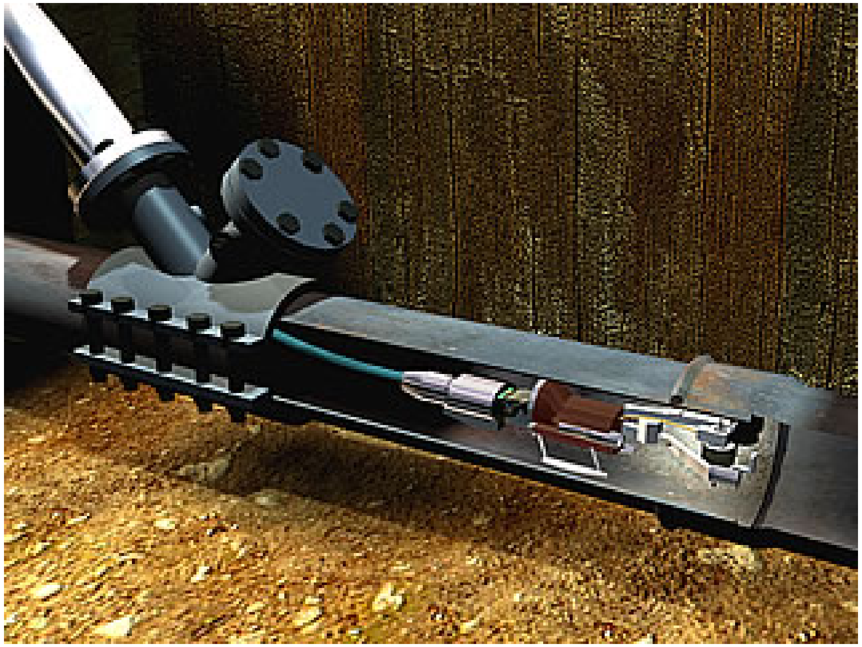
Methane Losses – Natural Gas Transmission

- Fugitive emissions from gas transmission and storage facilities are estimated to be 58 billion cubic feet per year (Bcf/year)
- Estimated 26 million cubic feet per year (MMcf/year) per compressor station in fugitive emissions

Source: TransCanada

Methane Losses – Natural Gas Distribution

- Fugitive emissions from natural gas distribution systems are estimated to be 59 billion cubic feet per year (Bcf/year)
- Estimated 270 thousand cubic feet per year (Mcf/year) per surface facility in fugitive emissions



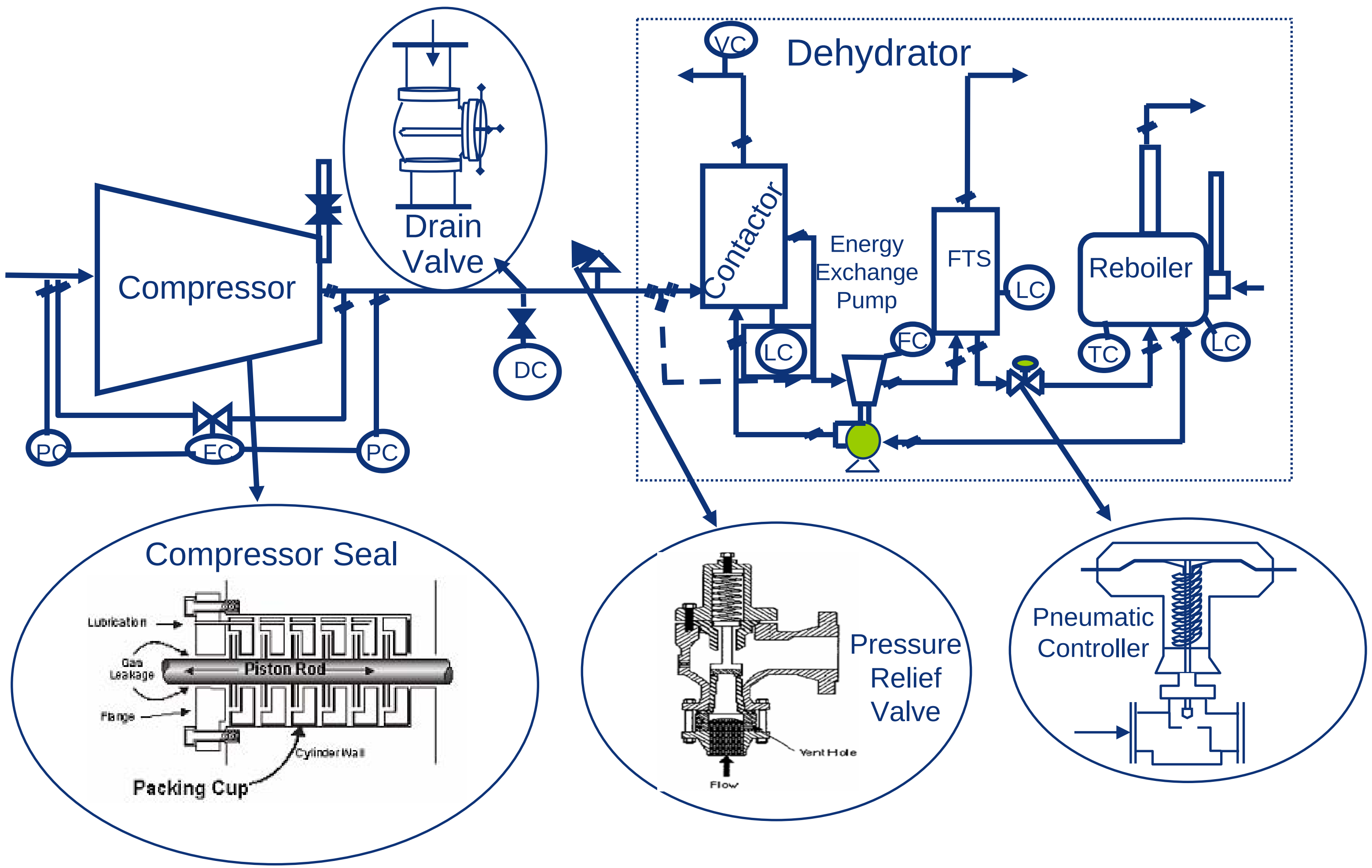
Source: ULC Robotics

What is the Problem?

- Methane gas leaks are invisible, unregulated, and go unnoticed

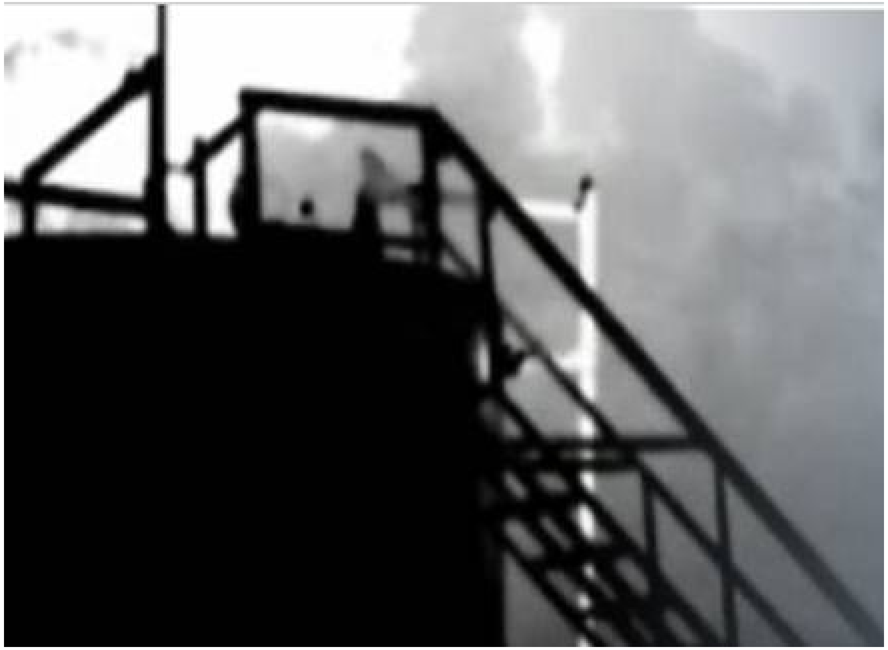
- Natural Gas STAR Partners find that valves, connectors, compressor seals, and open-ended lines (OELs) are major methane fugitive emission sources
  - Transmission and distribution fugitive methane emissions depend on operating practices, equipment age, and maintenance

Sources of Methane Emissions



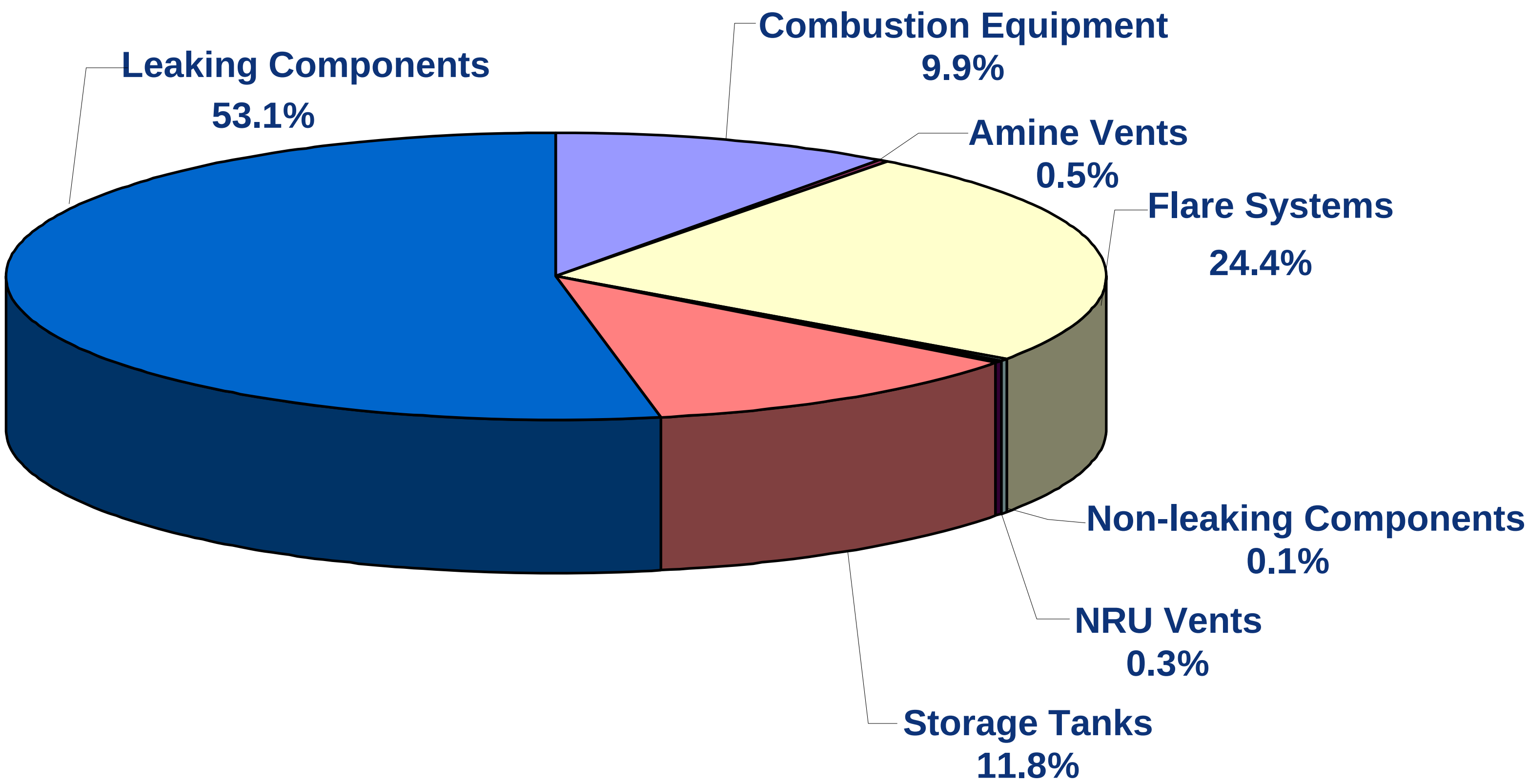
Fugitive Emissions Study - Clearstone

- Clearstone studied 4 gas processing plants
  - Screened for all leaks
  - Measured larger leak rates
  - Analyzed data
- Principles are relevant to all sectors
  - Fugitive leaks from valves, connectors, compressor seals, and lines still a problem in transmission
  - Solution is the same



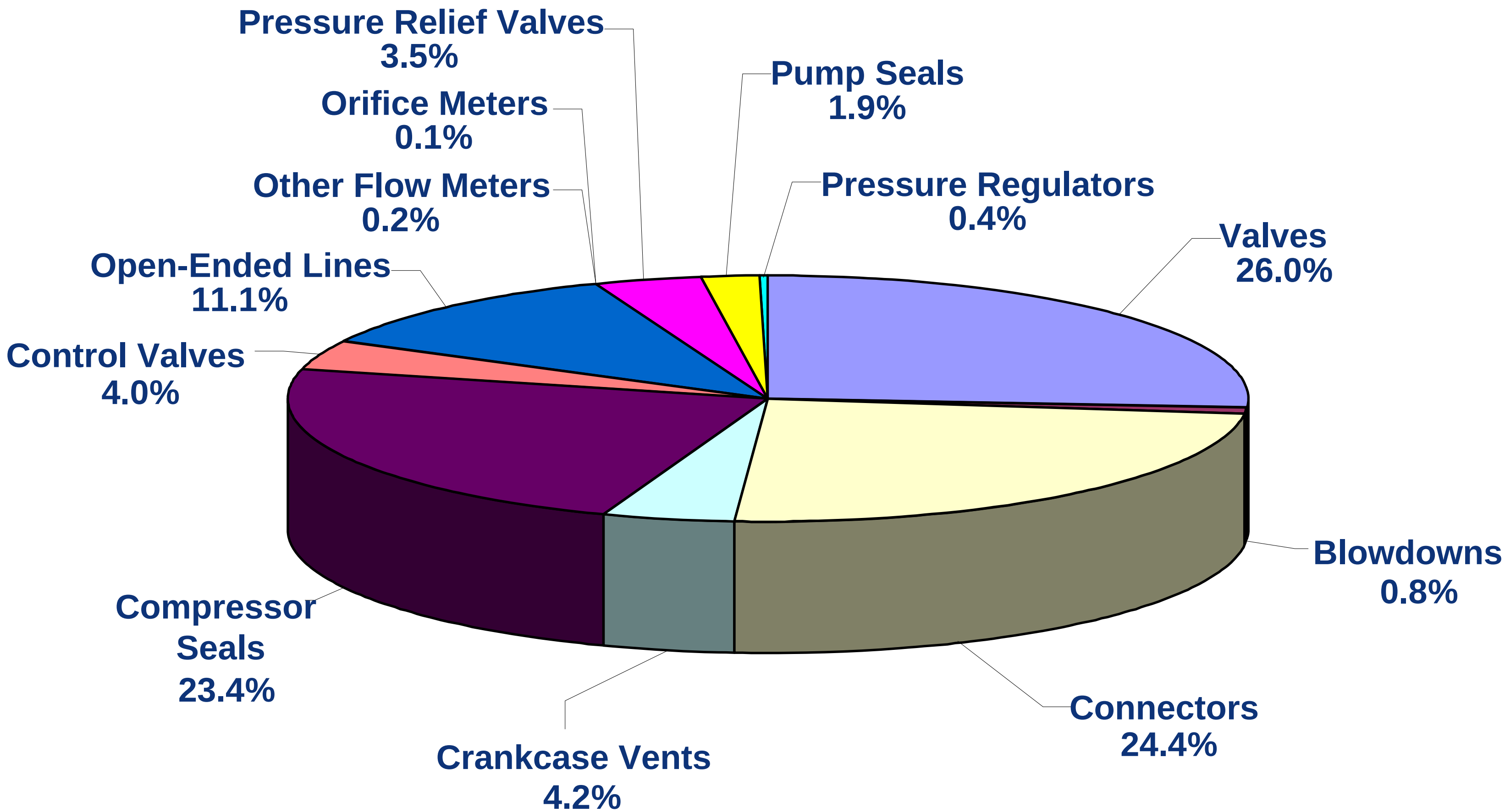
Source: Hy-bon Engineering

Clearstone - Distribution of Losses by Source Category



Source: Clearstone Engineering, 2002

Clearstone - Distribution of Losses from Equipment Leaks by Type of Component



Source: Clearstone Engineering, 2002

Clearstone - How Much Methane is Emitted?

Methane Emissions from Leaking Components at Gas Processing Plants			
Component Type	**% of Total Methane Emissions**	**% Leak Sources**	**Estimated Average Methane Emissions per Leaking Component (Mcf/year)**
Valves (Block & Control)	26.0%	7.4%	66
Connectors	24.4%	1.2%	80
Compressor Seals	23.4%	81.1%	372
Open-ended Lines	11.1%	10.0%	186
Pressure Relief Valves	3.5%	2.9%	844
Source: Clearstone Engineering, 2002, *Identification and Evaluation of Opportunities to Reduce Methane Losses at Four Gas Processing Plants*. Report of results from field study of four gas processing plants in Wyoming and Texas to evaluate opportunities to economically reduce methane emissions.			

Mcf = Thousand cubic feet

Clearstone - How Much Methane is Emitted?

Summary of Natural Gas Losses from the Top Ten Leak Sources[1]				
Plant Number	**Gas Losses From Top 10 Leak Sources (Mcf/day)[2]**	**Gas Losses From All Leak Sources (Mcf/day)**	**Contribution By Top 10 Leak Sources (%)**	**Contribution By Total Leak Sources (%)**
1	43.8	122.5	35.7	1.78
2	133.4	206.5	64.6	2.32
3	224.1	352.5	63.6	1.66
4	76.5	211.3	36.2	1.75
Combined	477.8	892.8	53.5	1.85

1 – Excluding leakage into flare system
2 – Approximately 10,000 components surveyed per plant

Distribution Emissions - EPA/GRI/PRCI Study

- Sixteen M&R facilities in the U.S. and Western Canada were selected for joint EPA and GRI (GTI) study of DI&M using high volume sampler
- Average gas lost from leaks at each site was estimated at 409 Mcf per year
- Final component count - 2,261
  - South East U.S. Plants - 171 components
  - North East U.S. Plants - 1,102 components
  - Midwest U.S. Plants - 859 components
  - Western Canada Plant - 129 components

Distribution Emission Factors

Average Emissions Factors for Equipment Leaks at Sixteen Metering and Regulating Facilities				
Component	**Emissions Factor (Mcf/yr/component)**	**Total Number of Components Screened**	**Average Number Components per Site**	**% Contribution to Total**
Ball/Plug Valve	0.21	248	18	0.002%
Control Valve	0.46	17	1	0.33%
Flange	0.13	525	38	0.09%
Gate Valve	0.79	146	10	0.6%
Pneumatic Vent	134.3	40	1	95.5%
Pressure Relief Valve	4.84	5	1	3.4%
Connectors	0.11	1,280	91	0.08%
Total		**2,261**	**160**	
Source: Indaco Air Quality Services, 1998.				

Methane Recovery

- Fugitive losses can be dramatically reduced by implementing a directed inspection and maintenance program
  - Voluntary program to identify and fix leaks that are cost-effective to repair
  - Survey cost will pay out in the first year
  - Provides valuable data on leak sources with information on where to look “next time”

What is Directed Inspection and Maintenance?

- Directed Inspection and Maintenance (DI&M)
  - Cost-effective practice, by definition
  - Find and fix significant leaks
  - Choice of leak detection technologies
  - Strictly tailored to company's needs
- DI&M is NOT the regulated volatile organic compound leak detection and repair (VOC LDAR) program

Source: TransCanada

How Do You Implement DI&M?

CONDUCT baseline survey

↓

SCREEN and MEASURE leaks

↓

FIX on the spot leaks

↓

ESTIMATE repair cost, fix to a payback criteria

↓

DEVELOP a plan for future DI&M

↓

RECORD savings/REPORT to Natural Gas STAR

How Do You Implement DI&M?

- Screening - find the leaks
  - Soap bubble screening
  - Electronic screening (“sniffer”)
  - Toxic vapor analyzer (TVA)
  - Organic vapor analyzer (OVA)
  - Ultrasound leak detection
  - Acoustic leak detection
  - Infrared leak detection

Toxic Vapor Analyzer

Acoustic Leak Detection

How Do You Implement DI&M?

- Evaluate the leaks detected - measure results
  - High volume sampler
  - Toxic vapor analyzer (correlation factors)
  - Rotameters
  - Calibrated bagging

Leak Measurement Using High Volume Sampler

How Do You Implement DI&M?

Summary of Screening and Measurement Techniques		
Instrument/ Technique	**Effectiveness**	**Approximate Capital Cost**
Soap Solution	★★	$
Electronic Gas Detector	★	$$
Acoustic Detector/ Ultrasound Detector	★★	$$$
TVA (Flame Ionization Detector)	★	$$$
Calibrated Bagging	★	$$
High Volume Sampler	★★★	$$$
Rotameter	★★	$$
Infrared Leak Detection	★★★	$$$
Source: EPA's Lessons Learned		

* - Least effective at screening/measurement

*** - Most effective at screening/measurement

$ - Smallest capital cost

$$$ - Largest capital cost

Estimating Comprehensive Survey Cost

- Cost of complete screening survey using high volume sampler (processing plant)
  - Ranges $15,000 to $20,000 per medium size plant
  - Rule of Thumb: $1 per component for an average processing plant
  - Cost per component for compressor stations would be higher than $1
- 25 to 40% cost reduction for follow-up survey
  - Focus on higher probability leak sources

    (e.g. compressors)

DI&M by Infrared Leak Detection

- Real-time detection of methane leaks
  - Quicker identification & repair of leaks
  - Screen hundreds of components an hour
  - Screen inaccessible areas simply by viewing them

Infrared Leak Detection

Source: Leak Surveys Inc.

Remote Methane Leak Detector

Source: Heath Consultants

Infrared Methane Leak Detection

- Video recording of fugitive leaks detected by various infrared devices

Is Recovery Profitable? – Compressor Stations

Repair the Cost-Effective Components			
Component	**Value of lost gas[1] ($)**	**Estimated repair cost ($)**	**Payback (months)**
Plug Valve: Valve Body	29,498	200	0.1
Union: Fuel Gas Line	28,364	100	0.1
Threaded Connection	24,374	10	0.0
Distance Piece: Rod Packing	17,850	2,000	1.4
Open-Ended Line	16,240	60	0.1
Compressor Seals	13,496	2,000	1.8
Gate Valve	11,032	60	0.1
Source: Hydrocarbon Processing, May 2002 1 – Based on $7/Mcf gas price			

Is Recovery Profitable? – Surface Facilities

Example of Repair Costs and Net Savings for Selected Equipment Components						
Component Description	**Type of Repair**	**Repair Cost[1]**	**Total Number of Components Fixed at Two Sites**	**Total Gas Savings (Mcf/year)**	**Estimated Net Savings[2] ($/yr)**	**Repair Payback Period (Months)**
Ball Valve	Re-grease	$18	5	60	$330	3
Gate Valve	Replace valve stem packing	$4	5	67	$449	<1
Gate Valve	Replace valve stem packing	$4	1	92	$640	<1
Connector	Tighten threaded fittings	$4	4	11	$61	3
Sr. Daniel Orifice Meter	Tighten fittings	$44	1	68	$432	2
Flange[3]	Tighten (estimated)	$54	5	99	$423	5

1 – Average repair costs include labor and materials, 2006 dollars
2 – Assumes gas price of $7/Mcf
3 – Repair cost not reported in original study.
Source: Indaco Air Quality Services, 1998.

DI&M - Lessons Learned

- A successful, cost-effective DI&M program requires measurement of the leaks
- A high volume sampler is an effective tool for quantifying leaks and identifying cost-effective repairs
- Open-ended lines, compressor seals, blowdown valves, engine-starters, and pressure relief valves represent <3% of components but >60% of methane emissions
- The business of leak detection has changed dramatically with new technology

Source: Chevron

Partner Experience - Northern Natural Gas

- Screened 659 rod packings with IR camera to identify leaks
- High volume sampler, Rotameter, and Mueller utilized to measure leaks
- Leak rates varied from default (newly installed) to 3,155 Mcf/yr
- Regular monitoring and correction keeps rod packing emissions low
- Annual savings of 71MMcf in 2006 by replacing compressor rod packing

Source: Northern Natural Gas

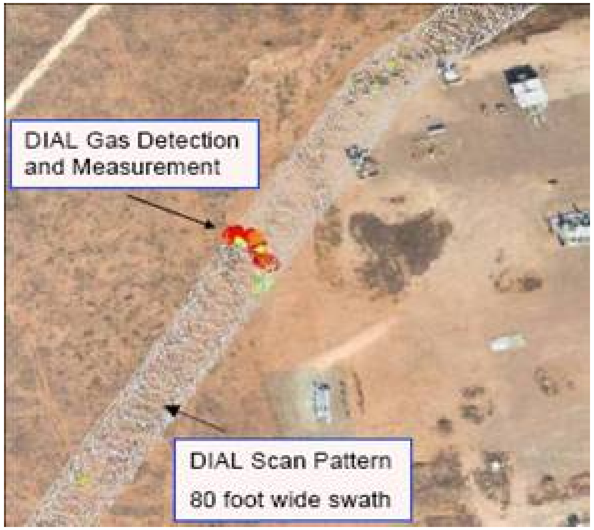
DI&M - Aerial Leak Surveys

- Aerial leak surveys with infrared leak detection devices can aid in leak identification over large sections of pipelines
- Aerial surveys can be conducted in helicopters or fixed wing aircrafts using both active and passive IR detection devices

Source: LaSen Inc.

Partner Experience - Northern Natural Gas

- 1,183 miles of pipeline surveyed using ITT ANGEL Service (Airborne Natural Gas Emission Lidar) with
- Data collection time: 13.4 hours
- Differential Absorption LIDAR (DIAL) laser technology provides accurate leak detection and measurement
- Color digital geospatial video of rights-of-way and surrounding areas
- Datasets show complete pipeline leak survey coverage
- Leaks found and verified in 27 locations



Source: Northern Natural Gas

Partner Experience - Northern Natural Gas

- Facility leak detection by DIAL, Kansas

Source: Northern Natural Gas

Partner Experience - Northern Natural Gas

- Underground leak detected by DIAL, Kansas

Source: Northern Natural Gas

Discussion

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