# Methane to Markets

Natural Gas STAR Recommended Technologies and Practices for Reducing Methane Emissions from Transmission Pipelines

## Gazprom – EPA Technical Seminar on Methane Emission Mitigation

28 – 30 October, 2008

Methane to Markets

NaturalGas
EPA POLLUTION PREVENTER

# Methane Savings from Transmission Pipelines: Agenda

- Transmission Pipeline Opportunities for Methane Recovery:
  - **Pipeline pumpdowns**
  - Composite wrap
  - Hot taps
  - Pipeline pigging
  - Aerial leak detection
- Discussion

Methane to Markets

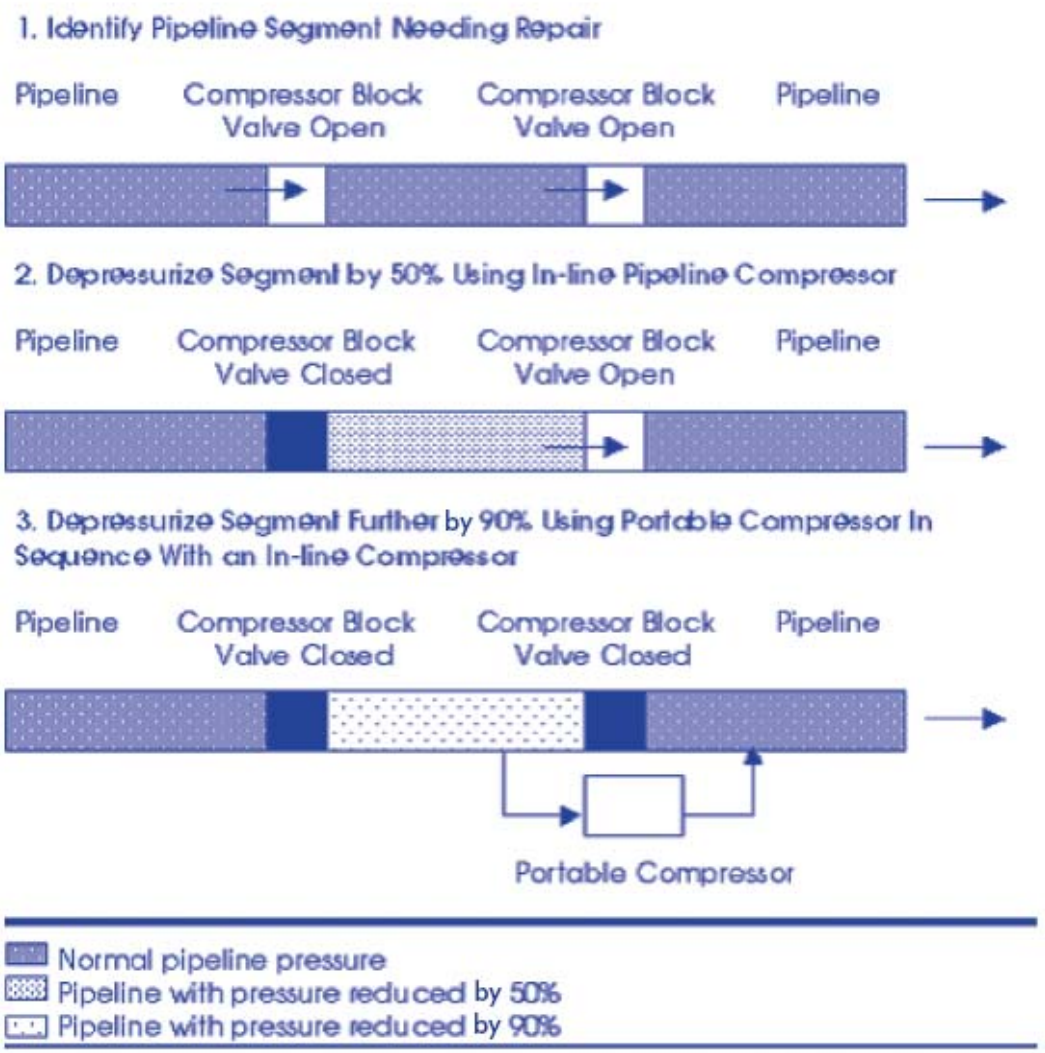
# Reducing Methane Emissions from Pipelines: Economics

- All technologies and practices promoted by Methane to Markets and Natural Gas STAR are proven based on successful field implementation by Partner companies
- Examples represented in the following presentation are based on company specific data collected from actual projects in the U.S. and other countries; economic information is presented according to U.S. costs and gas prices
- One example estimates the economics for Russia using a range of natural gas prices and a factor to adjust for Russian capital and labor costs (slides 16 to 18) using data from the Oil and Gas Journal

# Overview: Pipeline Pumpdown

- Most applicable to large pipelines operating at high pressures
- Use in-line compressors to “pull down” the pressure to minimum suction pressure
- Use portable compressor to “pull down” pressure even further
- Cost is justified by immediate payback in gas savings
- About 90% of gas usually vented is recoverable

# Pipeline Pumpdown Sequence of Depressurization Events



# Economics of Pipeline Pumpdowns

- Calculate total gas that would be vented by depressurizing pipeline to atmosphere
- Calculate gas savings from pumpdown with in-line compressors
- Calculate costs and savings from pumpdown with portable compressor
- Calculate annual savings

# Pipeline Pumpdown: Calculate Gas Savings

- Estimate the quantity and value of gas that in-line and portable compressors can recover:
  - Total gas in pipeline segment:
    $M = L*(1{,}000\ m/km) * (\pi * I^2/4) * (P/101.3\ kPa) * (1\ Mcm/1{,}000\ m^3)$
  - Gas saved by in-line compressor:
    $Ni = M - (M/Ri)$
  - Gas saved by portable compressor:
    $Np = Ni - (Ni / Rp)$

# Pipeline Pumpdown: Calculate Gas Savings

- Example Calculation
  - Given:
    - Pipeline isolated length (L) = 16.1 kilometer (km)
    - Pipeline interior diameter (I) = 0.724 meter (m)
    - Pipeline operating pressure (P) = 4,134 kilopascals (kPa)
    - In-line compressor compression ratio (Ri) = 2
    - Portable compression ratio (Rp) = 8

| | Volume of Gas (Mcm) | Value of Gas Saved ($) |
|---|---|---|
| Total Gas in Pipeline Segment | 270 | |
| Gas Saved by In-Line Compressor | 135 | $34,000 |
| Gas Saved by Portable Compressor | 118 | $30,000 |
| Total Gas Saved by Pumpdown | 253 | $64,000 |

Source: EPA Natural Gas STAR Lessons Learned Document "Using Pipeline Pumpdown Techniques to Lower Gas Line Pressure Before Maintenance"

# Pipeline Pumpdown: Calculate Portable Compressor Costs

- Estimate the costs associated with using a portable compressor
  - Capital or compressor leasing costs
  - Fuel costs (mostly natural gas) ~ 7.38 – 8.86 MJ per brake horse power per hour
  - Maintenance costs ~ $5 – $12 per horsepower per month
  - Labor costs
  - Taxes and administrative costs
  - Installation costs
  - Freight costs

# Calculate Portable Compressor Capital Costs

| Portable Compressor Purchase and Lease Cost Range* | | | | | |
|---|---|---|---|---|---|
| 68 atm – High Flow | | 41 atm – Medium Flow | | 20 atm – Low Flow | |
| Purchase | Lease | Purchase | Lease | Purchase | Lease |
| $3 - $6 million | $77,000 - $194,000 per month | $1.0 - $1.6 million | $31,000 - $46,000 per month | $518,131 - $777,197 | $15,000 - $23,000 per month |

*Based on assumptions that purchase cost does not include cost of freight or installation and that lease cost is 3 percent of purchase cost

Source: EPA Natural Gas STAR Lessons Learned Document "Using Pipeline Pumpdown Techniques to Lower Gas Line Pressure Before Maintenance"

- **Example: Total cost of using the portable compressor during a 12 month period**

  = fuel costs + lease and maintenance costs + freight costs

  = 12 * ($500 + $31,000) + $19,000

  = $397,000

Methane to Markets

# Pipeline Pumpdown: Calculate Annual Savings

Based on this example:

- Gross value of gas recoverable during a 12- month period, **In-line Compressor**[1]

  = $34,000 * 4 * 12

  = $1,632,000

- Gross value of gas recoverable during a 12-month period, **Portable Compressor**[1]

  = $30,000 * 4 * 12

  = $1,440,000

- **Net Savings** associated with using **both In-line and Portable Compressor**

  = $1,632,000 + ($1,440,000 – $397,000)

  = $2,675,000

[1]Gross value of the recoverable gas during a 12-month period, assuming an average of 4 pump-downs per month

# Methane Savings from Transmission Pipelines: Agenda

- Transmission Pipeline Opportunities for Methane Recovery:
  - Pipeline pumpdowns
  - **Composite wrap**
  - Hot taps
  - Pipeline pigging
  - Aerial leak detection
- Discussion

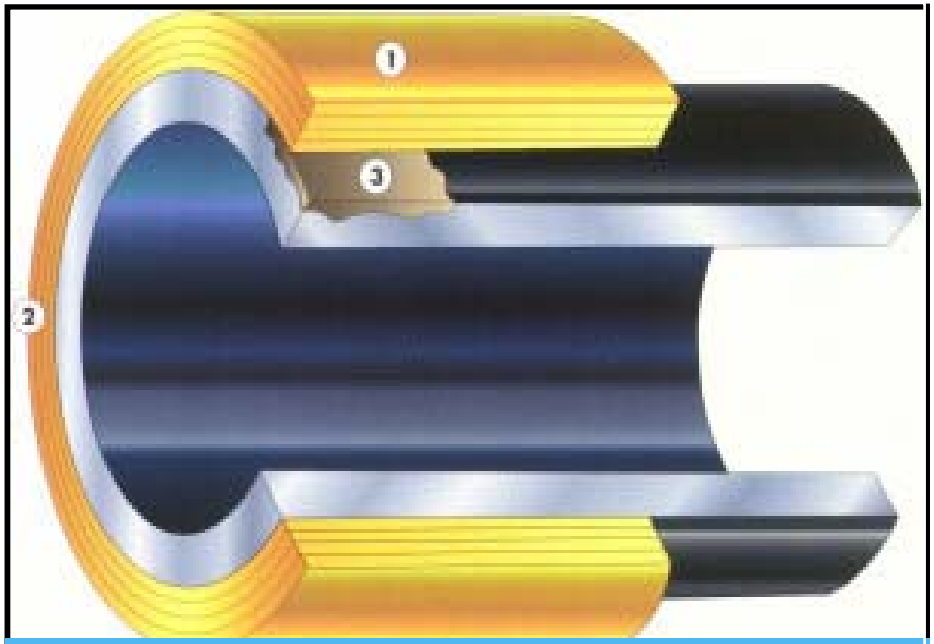
Source: Armor Plate

# What is Composite Wrap?

- Non-leaking pipeline defects can only be fixed in one of three ways:
  - Cut out damaged segment and replace with new pipes
  - Install a full-encirclement steel split sleeve over the damaged area
  - Install a composite sleeve over the damaged area
- Composite wrap advantages:
  - Can be performed without taking pipeline out of service
  - Repair is quick and less costly than replacement or sleeve options
  - Eliminates venting associated with replacement

# Composite Wrap Overview

1) A high-strength glass fiber composite or laminate
2) An adhesive or resin bonding system
3) A high-compressive-strength load transfer filler compound
4) Replaces lost hoop strength




Source: Clock Spring® Company L. P.

# Composite Wrap Installation

- After excavation and pipe preparation
  - External defects filled with filler
  - Composite wrap wound around pipe with adhesive or laminating agents
  - Typically 5 cm of wrap must extend beyond damage
  - Excavation site refilled after mandated curing time
- Reducing pressure improves quality of repair

Source: Armor Plate

# Economics of Composite Wrap

- Calculate associated costs
  - State assumptions (pipeline diameter, distance between shut-off valves, value of gas, etc.)
  - Calculate labor cost
  - Calculate capital and equipment costs
  - Calculate indirect costs
- Calculate natural gas savings
- Compare options

# Example Economic Analysis: Adjusted Russian Cost Scenario

- The chart on the next slide shows a comparison of economics for pipeline replacement vs. composite wrap

- Economics are estimated for Russia using a range of natural gas prices and factors from the Oil and Gas Journal[1] to adjust for Russian capital and labor costs

[1] Gillis, Brian, et. al. *Technology drives methane emissions down, profits up*. Oil & Gas Journal. August 13, 2007.

# Comparison of Options: Pipeline Replacement vs. Composite Wrap[1]

| Cost Factors | At 971 RUB/Mcm ($40/Mcm) | | | | At 9,712 RUB/Mcm ($400/Mcm) | | | |
|---|---|---|---|---|---|---|---|---|
| | 15 cm Defect | | 595 cm Defect | | 15 cm Defect | | 595 cm Defect | |
| | Composite Wrap | Pipeline Replace. | Composite Wrap | Pipeline Replace. | Composite Wrap | Pipeline Replace. | Composite Wrap | Pipeline Replace. |
| Natural Gas Lost (Mcm) | 0 | 112 | 0 | 112 | 0 | 112 | 0 | 112 |
| Purge Gas (Mcm) | 0 | 5.64 | 0 | 5.64 | 0 | 5.64 | 0 | 5.64 |
| Number of Wrap Kits | 1 | 0 | 20 | 0 | 1 | 0 | 20 | 0 |
| Cost of Natural Gas Lost | 0 | 108,780 | 0 | 108,780 | 0 | 1,087,800 | 0 | 1,087,800 |
| Cost of Purge Gas | 0 | 1,580 | 0 | 1,580 | 0 | 1,580 | 0 | 1,580 |
| Labor | 11,000 | 39,500 | 22,000 | 59,250 | 11,000 | 39,500 | 22,000 | 59,250 |
| Equipment and Materials | 45,530 | 118,840 | 910,600 | 214,920 | 45,530 | 118,840 | 910,600 | 214,920 |
| Indirect Costs | 28,265 | 50,700 | 466,300 | 109,670 | 28,265 | 50,700 | 466,300 | 109,670 |
| Total Cost of Repair | 84,795 | 319,400 | 1,398,900 | 494,200 | 84,795 | 1,298,420 | 1,398,900 | 1,473,220 |
| Most Economical Option | X | | | X | X | | X | |

[1] Based on repair of a small versus large defect on a 61 cm diameter pipeline operated at 24 atm, with 16.1 km between shut-off valves

# Composite Wrap versus Pipeline Replacement

- Based on this example and Natural Gas Star Partner company experiences, composite wrap is the most cost-effective repair option for small defects
- Larger defects may be repaired using composite wrap or pipeline replacement depending on value of gas, labor costs, and equipment costs
  - Note: using higher Russian cost estimates, our economic analysis showed pipeline replacement may be more economic for larger defects
  - Companies should calculate break even point for defect size based on your specific capital and labor costs

# Summary: Composite Wrap Lessons Learned

- Reduced gas venting as opposed to pipeline replacement
- Proven permanent repair for external defects
- Temporary repair for internal faults
- In-service pipeline repair methodology
- Ideal for urgent and quick repair
- Avoid service disruptions
- Cost-effective
- Trained but not skilled crafts persons required
- Specialized welding and lifting equipment not required
- No delays awaiting metal sleeve
- Cathodic protection remains functional

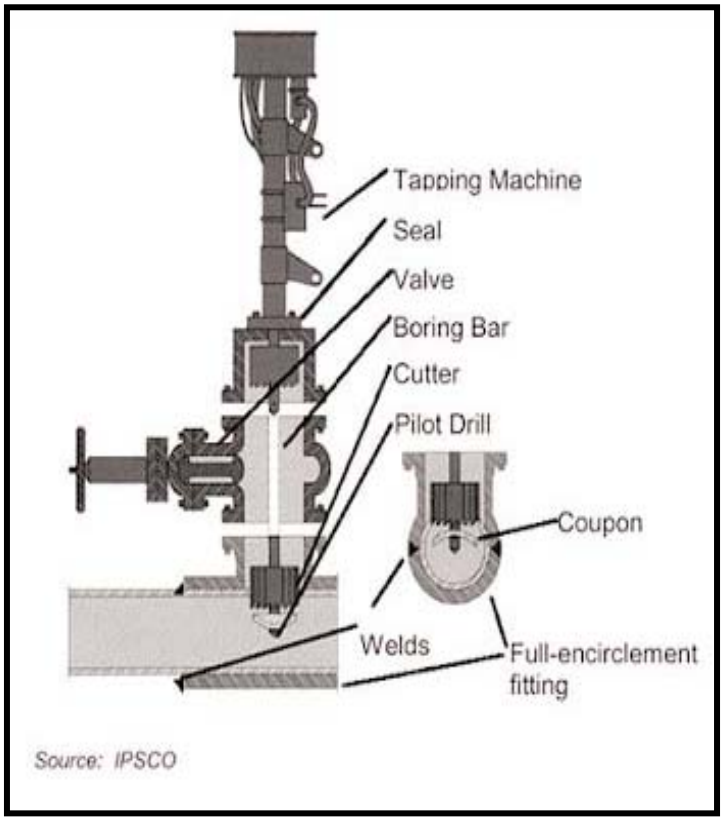
# Methane Savings from Transmission Pipelines: Agenda

- Transmission Pipeline Opportunities for Methane Recovery:
  - Pipeline pumpdowns
  - Composite wrap
  - **Hot taps**
  - Pipeline pigging
  - Aerial leak detection
- Discussion

Source: Williamson Industries Inc.

# What are Hot Taps?

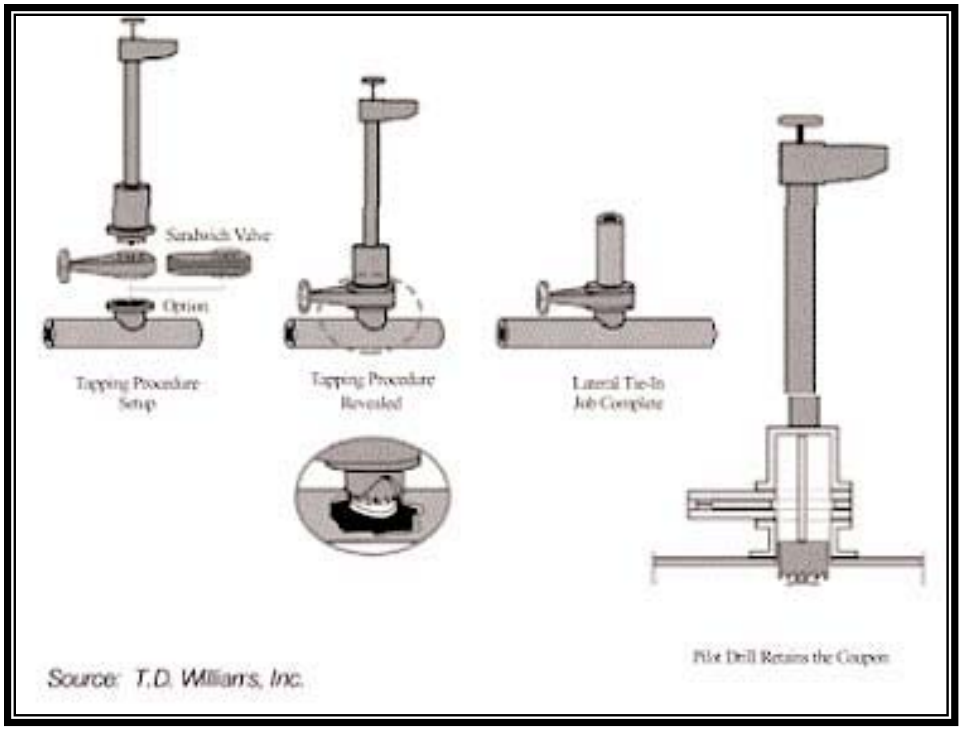
- New branch connection while the pipeline remains in service
  - Attach a branch connection and valve to the main pipeline
  - Cut-out a section of the main pipeline wall through the valve to connect the branch to the main pipeline
- Current technology has improved reliability and reduced complications
- Hot tapping can be used to add connections to a wide range of pipelines
  - Transmission pipelines
  - Distribution mains




Schematic of Hot Tapping Machine

# Hot Tapping Procedure

- Connect fitting and permanent valve on the existing pipeline
- Install hot tapping machine on the valve
- Perform hot tap and extract coupon through the valve
- Close valve and remove hot tapping machine
- Connect branch line



# Hot Tap Benefits

- Continuous system operation – shutdown and service interruptions are avoided
- No gas released to the atmosphere
- Avoided cutting, realignment and re-welding of pipeline sections
- Reduced planning and coordination costs
- Increased worker safety
- No gas outages for customers

# Hot Tap Economics

- Determine physical conditions of existing line
- Calculate the cost of a shutdown interconnect
- Calculate the cost of a hot tap procedure
- Estimate annual hot tap program costs
- Estimate annual hot tap program savings
- Economic analysis of hot tap vs. shutdown

# Hot Taps: Determine physical conditions of existing line

- Maximum operating pressure (during hot tap)
- Type of pipe material
- Condition of parent pipeline (internal/external corrosion and wall thickness)
- Emergency valve location for isolation in case of accidents
- Working space evaluation (desired tap diameter, location of other welds, obstructions, etc.)
- Check if the line is looped

# Estimated Annual Hot Tap Savings

| Estimated Annual Gas Savings for the Example Scenario[1] | | | | | | |
|---|---|---|---|---|---|---|
| Tap Scenario | Annual Tap Number | Natural Gas Savings | | Nitrogen Purge Gas Savings | | Total Gas Savings |
| Pipeline | | Per tap Mcm | Annual Mcm | Per tap Mcm | Annual Mcm | $ |
| 10.2 cm pipeline, 24.8 atm, 3.2 km | 250 | 0.6 | 155.7 | 0.05 | 14.1 | 42,500 |
| 20.3 cm pipeline, 7.8 atm, 1.6 km | 30 | 0.4 | 11 | 0.1 | 3.4 | 3,690 |
| 25.4 cm pipeline, 69.0 atm, 4.8 km | 25 | 16.7 | 417 | 0.5 | 13.4 | 106,875 |
| 45.7 cm pipeline, 14.6 atm, 3.2 km | 15 | 7.2 | 108.3 | 1.2 | 17.4 | 31,695 |
| Total Annual | 320 | | 692.1 | | 48.4 | 184,760 |

[1] Source: EPA Natural Gas STAR Lessons Learned Document "Using Hot Taps for In Service Pipeline Connections

# Economic Analysis of Hot Tap vs. Shutdown

| Economic Analysis for Five Year Hot Tap Program (320 taps/yr)[1] | | | | | | |
|---|---|---|---|---|---|---|
| | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
| Capital Cost, $ | (47,409) | 0 | 0 | 0 | 0 | 0 |
| Contract Service Cost, $ | 0 | (54,263) | (54,263) | (54,263) | (54,263) | (54,263) |
| O&M Cost, $ | 0 | (7,959) | (7,959) | (7,959) | (7,959) | (7,959) |
| Total Cost, $ | (47,409) | (62,222) | (62,222) | (62,222) | (62,222) | (62,222) |
| Natural Gas Savings, $ | | 171,080 | 171,080 | 171,080 | 171,080 | 171,080 |
| Inert Gas Savings, $ | | 13,680 | 13,680 | 13,680 | 13,680 | 13,680 |
| Net Benefit, $ | (47,409) | 122,538 | 122,538 | 122,538 | 122,538 | 122,538 |
| Payback (months) | | | | | | 5 |
| IRR | | | | | | 258 % |
| NPV[2] | | | | | | $417,107 |

[1] Source: EPA Natural Gas STAR Lessons Learned Document "Using Hot Taps for In Service Pipeline Connections

[2] Net Present Value (NPV) based on 10% discount rate for 5 years.

# Methane Savings from Transmission Pipelines: Agenda

- Transmission Pipeline Opportunities for Methane Recovery
  - Pipeline pumpdowns
  - Composite wrap
  - Hot taps
  - **Pipeline pigging**
  - Aerial leak detection
- Discussion

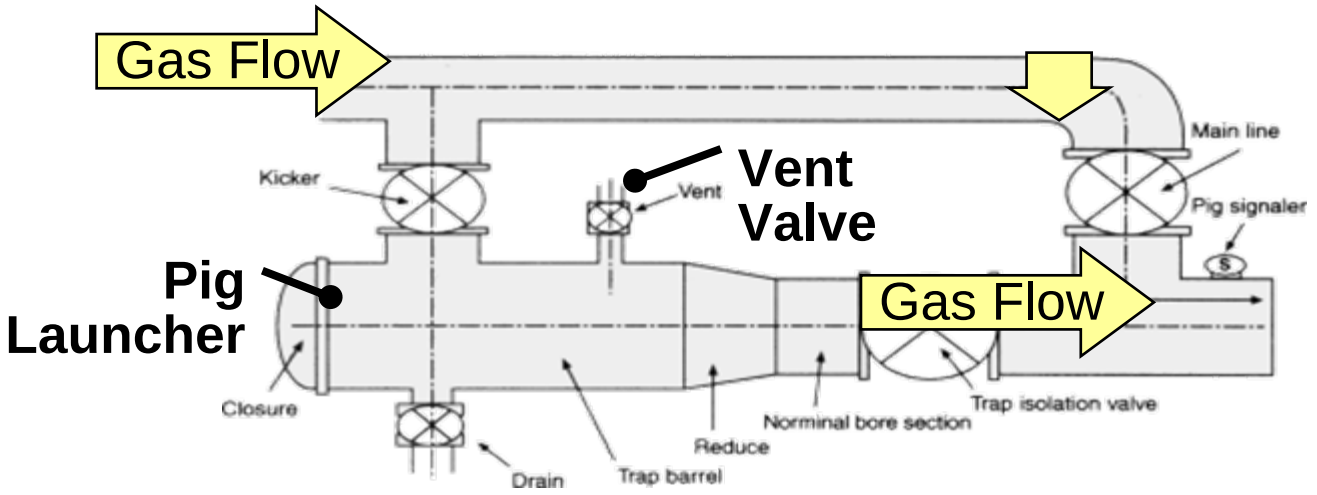
Source: www.girardind.com/

# Overview: Pigging Pipelines

- Hydrocarbons and water condense inside pipelines, causing pressure drop and reducing gas flow
- Periodic line pigging removes liquids and debris to improve gas flow
  - Also inspect pipeline integrity
- Efficient pigging:
  - Keeps pipeline running continuously
  - Keeps pipeline near maximum throughput by removing debris
  - Minimizes product losses during launch/capture

# How Does Pigging Vent Methane?

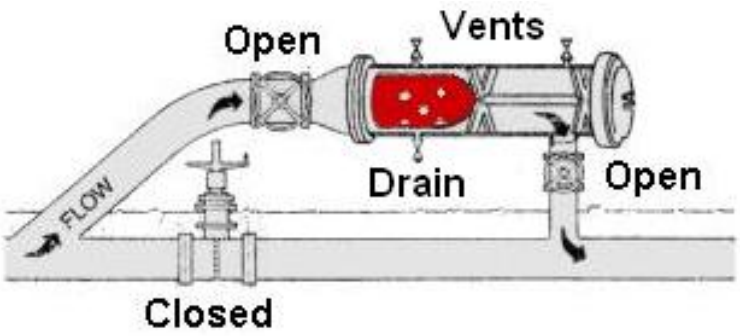
- Pig launchers have isolation valves for loading pigs, pressurizing pigs, and launching pigs with gas bypassed from the pipeline
- Launcher pressuring/depressuring loses methane out the vent valve




Source: www.girardind.com/

# Pigging Vents Methane Twice

- Methane lost through vent valve on the launcher and again through vent valve on the receiver
  - Once receiver is isolated from the line, it must be depressured to remove the pig
  - Liquids ahead of the pig drain to a vessel or tank
- *MORE than twice:* isolation valve leaks may cause excessive venting to depressure




Source: www.girardind.com/

# Pipeline Pigging: Methane Recovery

- Pipeline maintenance requires pipe section blowdown before work can begin
- Gas in pipeline is usually vented to the atmosphere
- Route vent to vapor recovery system or fuel gas
  - One processing company reported connecting pig receiver vent to fuel gas to recover gas while working a tight isolation

# Pipeline Pigging: Is Recovery Profitable?

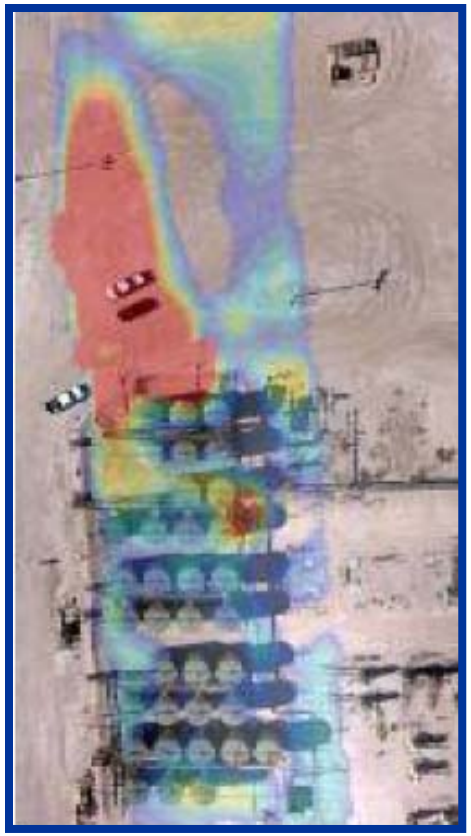
- One U.S. processing company pigged gathering lines 30 to 40 times per year, collecting several thousand barrels of condensate per application
- Reported saving 606 Mcm/year from recovering flash gases
- Dedicated vapor recovery unit (VRU) was installed with an electric compressor at an installation cost of $24,000 and an annual operating cost of $40,000 mostly for electricity Large gas savings and increasing gas prices will offset costs

| | |
|---|---|
| Gas Price ($/Mcm) | $250 |
| Gas Saved (Mcm/year) | 606 |
| Annual Savings ($/year) | $149,800 |
| Installed Cost | $24,000 |
| Operating Cost | $40,000 |
| Payback Period (years) | 0.3 |

Source: EPA Natural Gas STAR Partner Reported Opportunity “Recover Gas from Pipeline Pigging Operations” Fact Sheet

# Methane Savings from Pipelines: Agenda

- Pipeline Opportunities
  - Pipeline pumpdowns
  - Composite wrap
  - Hot taps
  - Pipeline pigging
  - **Aerial leak detection**
- Discussion



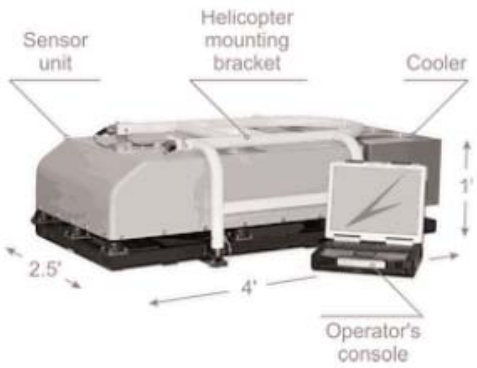
# Aerial Leak Detection

- Aerial surveys can quickly detect leaks over long distance transmission pipelines
- U.S. pipeline companies report performing aerial surveys from different platforms using infrared leak detection technologies
  - Fixed wing aircraft or helicopter
  - Passive IR imaging or Light Detection and Ranging (LIDAR) sensors


Source: LaSen, Inc.

# DCP Midstream (U.S. Gathering and Processing Company) Aerial Leak Detection

- DCP operates nearly 100,000 km of gathering pipelines
  - No straight sections longer than 8 km
- Decided on helicopter surveys using the Airborne LIDAR Pipeline Inspection System (ALPIS)
- DCP prioritizes survey activities by using system balance measurements to determine which pipeline segments may be leaking

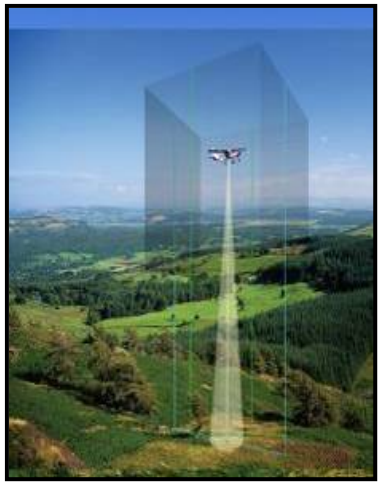


# DCP Midstream (U.S. Gathering and Processing Company) Aerial Leak Detection

- Using the ALPIS system, DCP was able to locate 70 – 80% of pipeline leaks
- DCP has combined aerial surveys with on the ground screening using the RMLD to help pinpoint leaks
  - DCP is able to locate 97% of leaks by combining ALPIS aerial surveys with ground-based RMLD follow-up surveys
- Since beginning these surveys, DCP has reduced lost and unaccounted for gas up to 50%

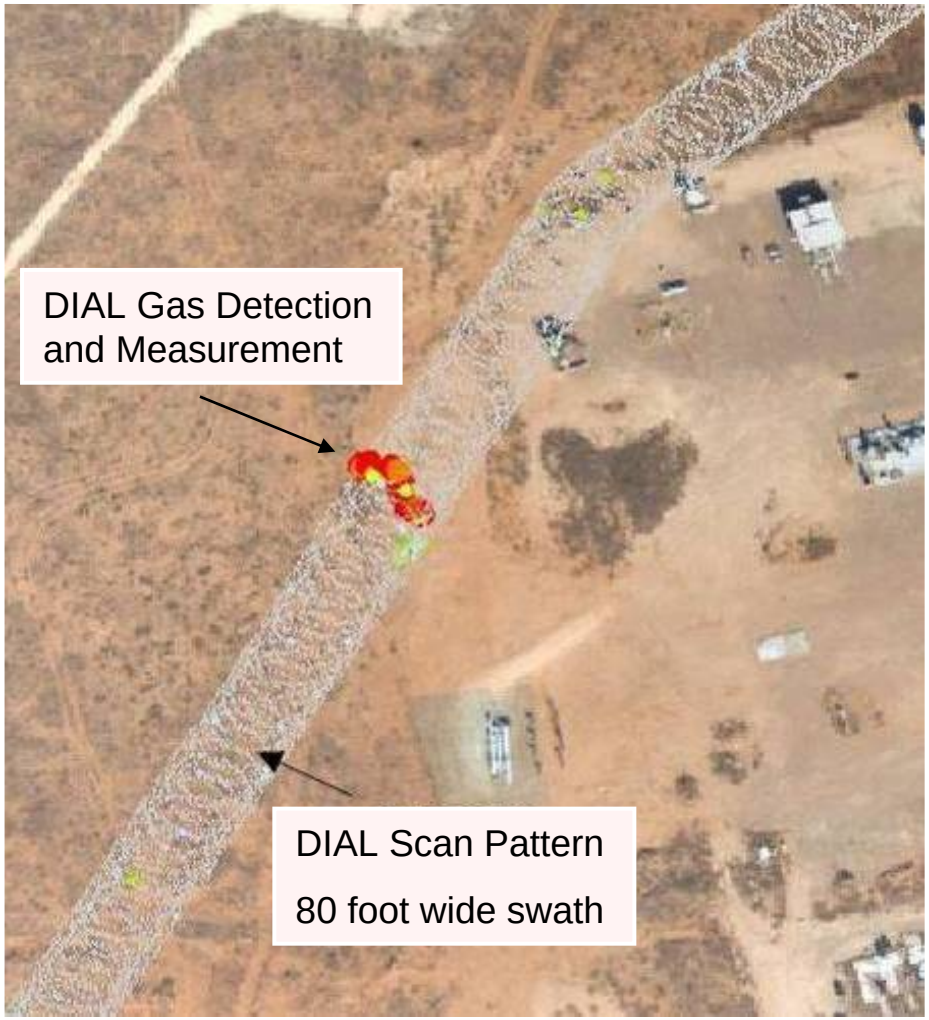
# Northern Natural Gas (U.S. Transmission Company): Pipelines Inspected with ANGEL Service

- Airborne Natural Gas Emission LIDAR (ANGEL) Service
  - ANGEL system can detect, image and map emissions of natural gas
- Miles of Pipeline Surveyed: 1,183 Miles
- Total Collection Time (DIAL): 13.5 Hours
- Leaks Found and Verified: 27 Locations

ANGEL Collection Aircraft and Sensors

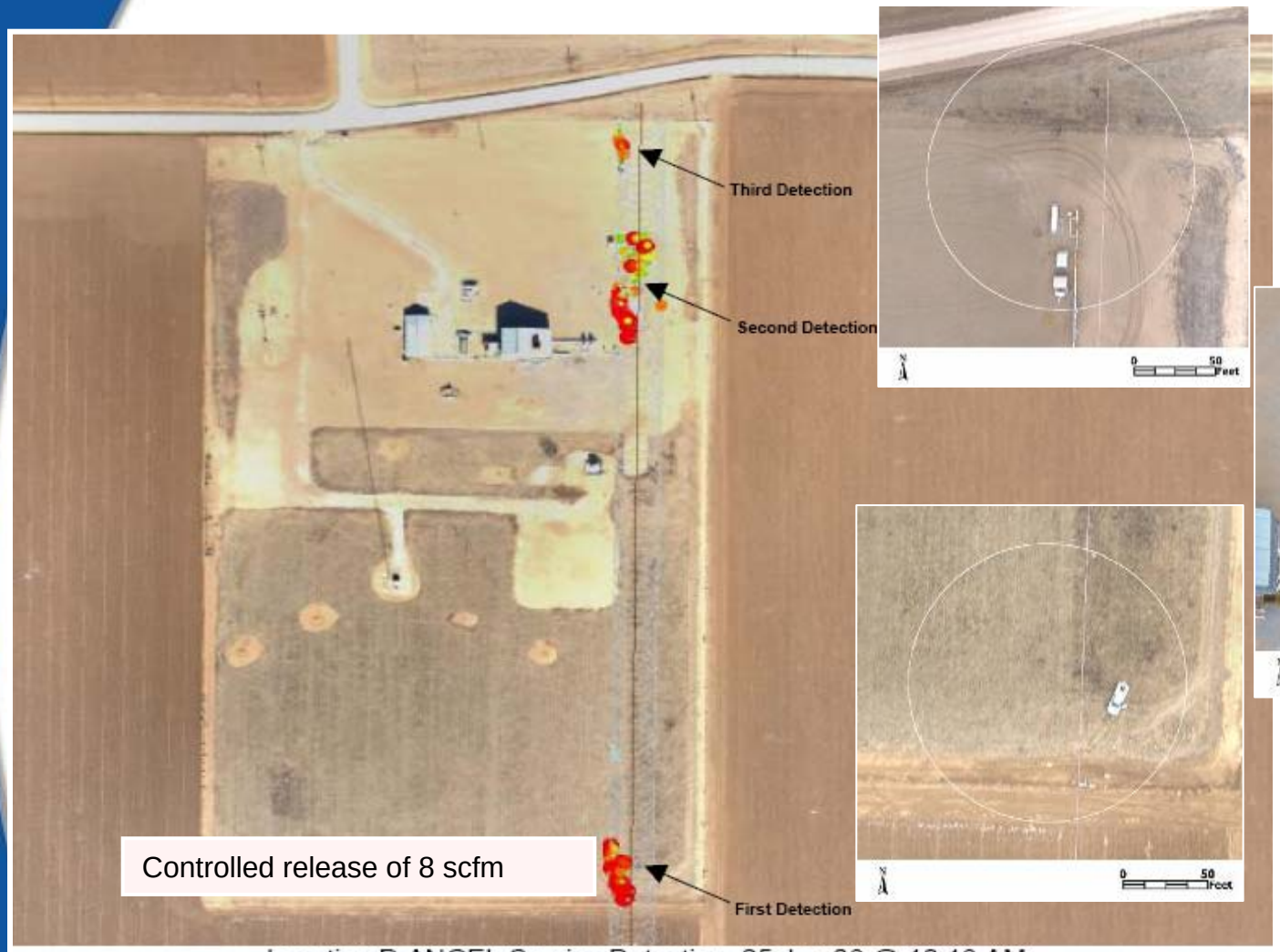
# Northern Natural Gas: Underground Pipeline Leak - Texas - 2006





Source: Northern Natural Gas

# Northern Natural Gas: Facility Emissions - Texas - 2006








Source: Northern Natural Gas

# Discussion

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