Methane to Markets

Natural Gas STAR Recommended Technologies and Practices for Reducing Methane Emissions from Natural Gas Distribution Systems

Gazprom – EPA Technical Seminar on Methane Emission Mitigation

28 – 30 October, 2008

Reducing Methane Emissions from Distribution Systems: Agenda

- Pipeline Rehabilitation Opportunities
  - Cast Iron Joint Sealing Robot (CISBOT)
  - Flexible Plastic Pipeline Inserts
- Recover Blowdown Gas by Injection Into Low Pressure Mains
- Leak Detection and Repair at Metering and Regulator Stations
- Discussion

Methane to Markets

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Reducing Methane Emissions from Distribution Systems: 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.

Methane to Markets

Underground Pipelines: Methane Losses

- Fugitive emissions from underground pipelines make up over 50% of methane emissions in the U.S. distribution sector[1]
- Frequency and size of leaks vary depending on:
  - Pipeline operating pressure (mains vs. services)
  - Pipeline material (cast iron, steel, plastic)
  - Pipeline age
- Cast iron was the material of choice for low pressure distribution mains in the U.S. up until the 1950s

1 - EPA. *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 – 2006.* April, 2008

Cast Iron Mains: Methane Losses

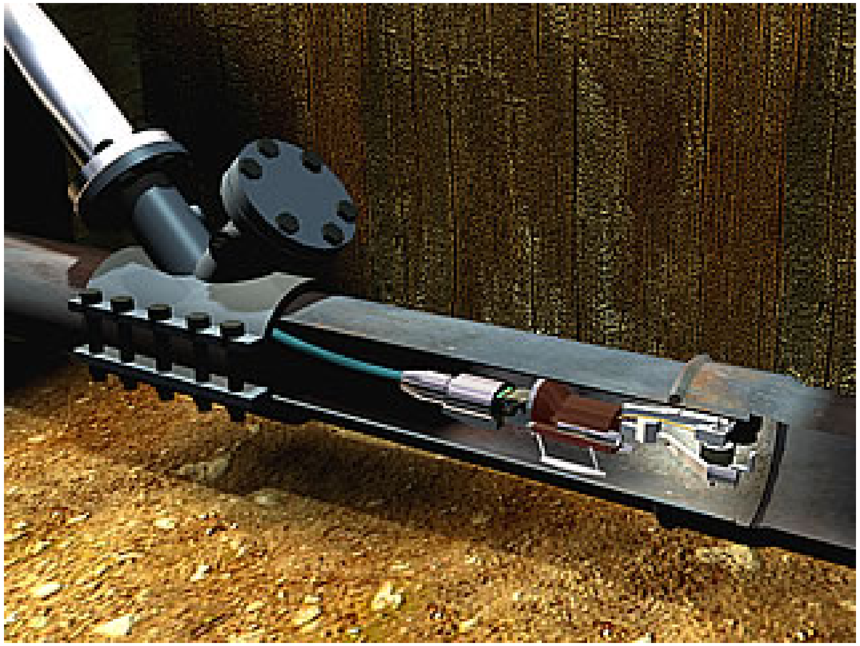
- 3.65 meter sections connected by bell and spigot joints
  - Joint sealed by jute packing plus cement or molten lead
- Leaks may develop in joints over time due to:
  - Heavy overhead traffic
  - Freeze-thaw cycles
  - Pipe movement in the soil
- Leaks can also increase if there is a shift towards lower moisture content (i.e., dryer) natural gas
- In the U.S., cast iron mains are a significant source of methane in the distribution sector, with an estimated national average leak rate of approximately 4.2 Mcm/kilometer/year[1]

1 - EPA. *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 – 2006.* April, 2008

Pipeline Rehabilitation Opportunities

Focus of this presentation:

- **Cast Iron Joint Sealing Robot (CISBOT)**
  - Developed with support from Con Ed (US) and Enbridge (Canada), and licensed to ULC Robotics
  - Live main sealing technology
- **Gas main flexible liners**
  - Insert plastic liner inside existing cast iron pipe



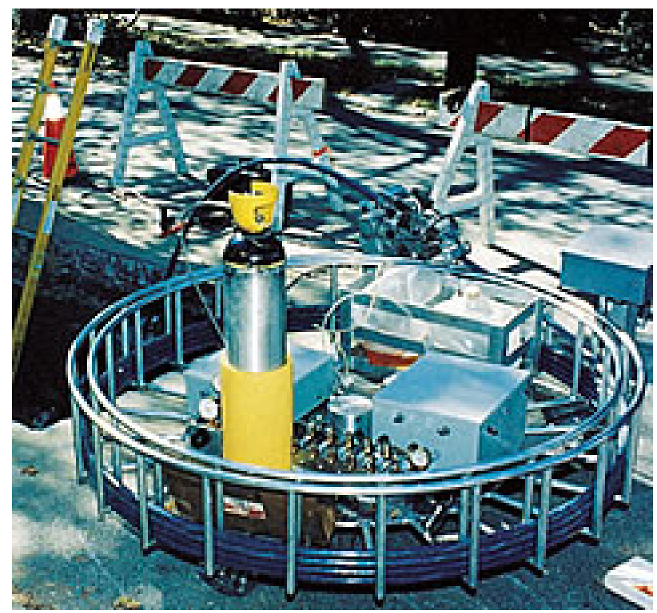
Source: ULC Robotics

Other Rehabilitation Options:

- Joint encapsulation
- Pipeline replacement
  - Excavate and replace cast iron main with steel or plastic pipe

CISBOT

- Can be used to seal joints in live cast iron mains between 15 – 30 centimeters in diameter
- CISBOT can seal joints in up to 90 meters of pipeline through a single excavation (45 meters in each direction from launching pit)
- Equipped with:
  - Video camera
  - Pointer lights
  - Support arms
  - Drill head
  - Sealant injector
- Uses anaerobic sealant for long term repairs



Source: ULC Robotics

CISBOT Procedure

- Excavate pipe and install bidirectional fitting and CISBOT launch tube
- Launch CISBOT, and drive to the farthest joint (45 m) from the excavation
- Operator works CISBOT back, sealing joints by drilling into joint space and injecting sealant into the jute
- CISBOT is removed and launched in the opposite direction to seal additional joints

Source: ULC Robotics

Partner Experience: Consolidated Edison (U.S. Distribution Company)

- Use CISBOT for preventive maintenance
  - Have sealed over 3,000 cast iron joints
  - Benefits
    - Minimize excavation and repaving costs
    - Reduce disruption to residents and traffic
- Estimate that one CISBOT system could rehabilitate 5.8 km (1,600 joints) of cast iron per year
  - 32 weeks per year (generally not operated in freezing conditions)
  - 2 sites per week
  - 90 meters (25 joints) per site

Partner Experience: Consolidated Edison (U.S. Distribution Company)

- CISBOT services contracted from ULC Robotics
- CISBOT estimated to reduce rehabilitation costs 30 – 40% over traditional trenching operations
- Hardware cost of a complete CISBOT system is approximately $200,000 to $250,000

Video: CISBOT in Operation

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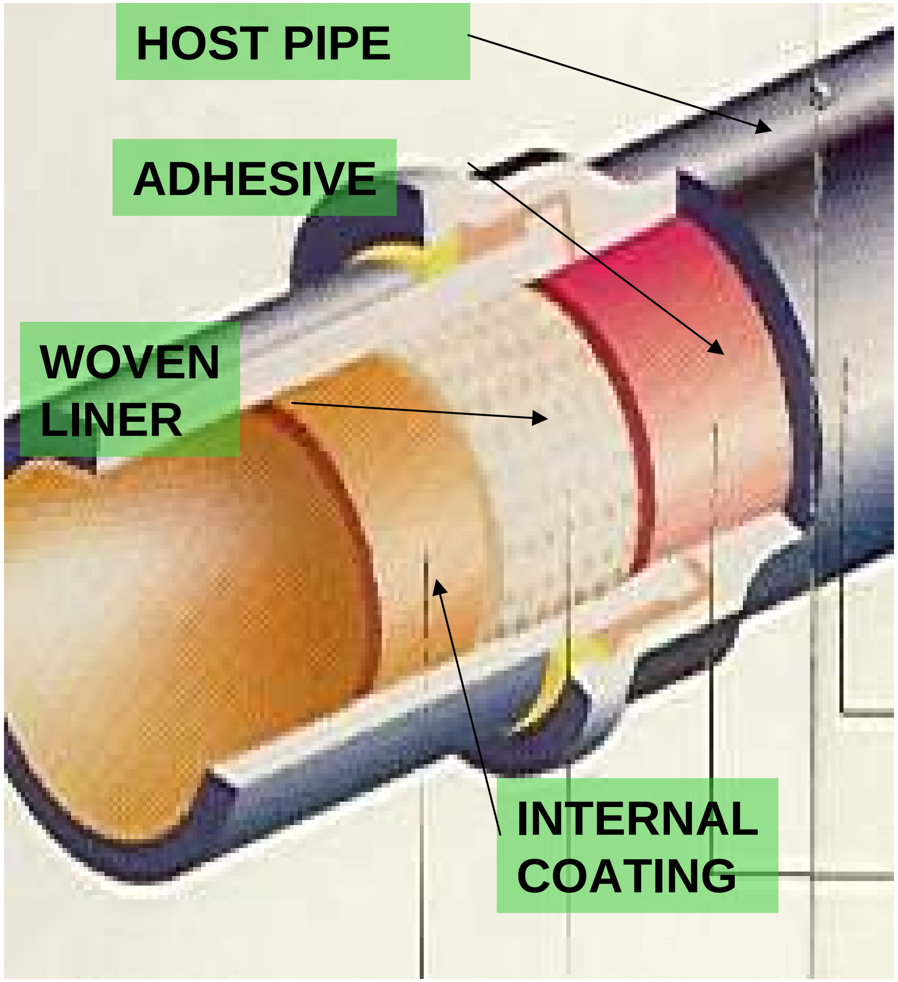
Overview: Internal Lining Methods

- Cured in Place Liners
  - Starline
    - Minimal reduction of capacity
- Tight Fit Polyethylene
  - Rolldown
    - Size for size insertion
    - Reduction of capacity
  - Subline
    - Size for size
    - Minimal reduction of capacity

Starline – Cured in Place Liner



Components of Liner

- Polyester woven liner
- Polyurethane coating

Source: Consolidated Edison of New York

Starline Process

- Surface preparation / Pipe cleaning
  - Grit-blasting method
  - Required to obtain the proper bonding strength
  - Abrasive is propelled through the blast hose at 7.8 atm
  - Recovery of the grit is obtained by a high capacity vacuum system

Source: Consolidated Edison of New York

Starline Process

- Adhesive Mixing
  - 2-part Polyurethane adhesive mix
  - Adhesive
  - Hardener
- Liner wet–out / Adhesive application
  - Pour adhesive into liner
  - Pull liner through calibrated rollers

Source: Consolidated Edison of New York

Starline Process

- Liner Inversion

Wound on reel of pressure drum

Bolted onto inversion cone

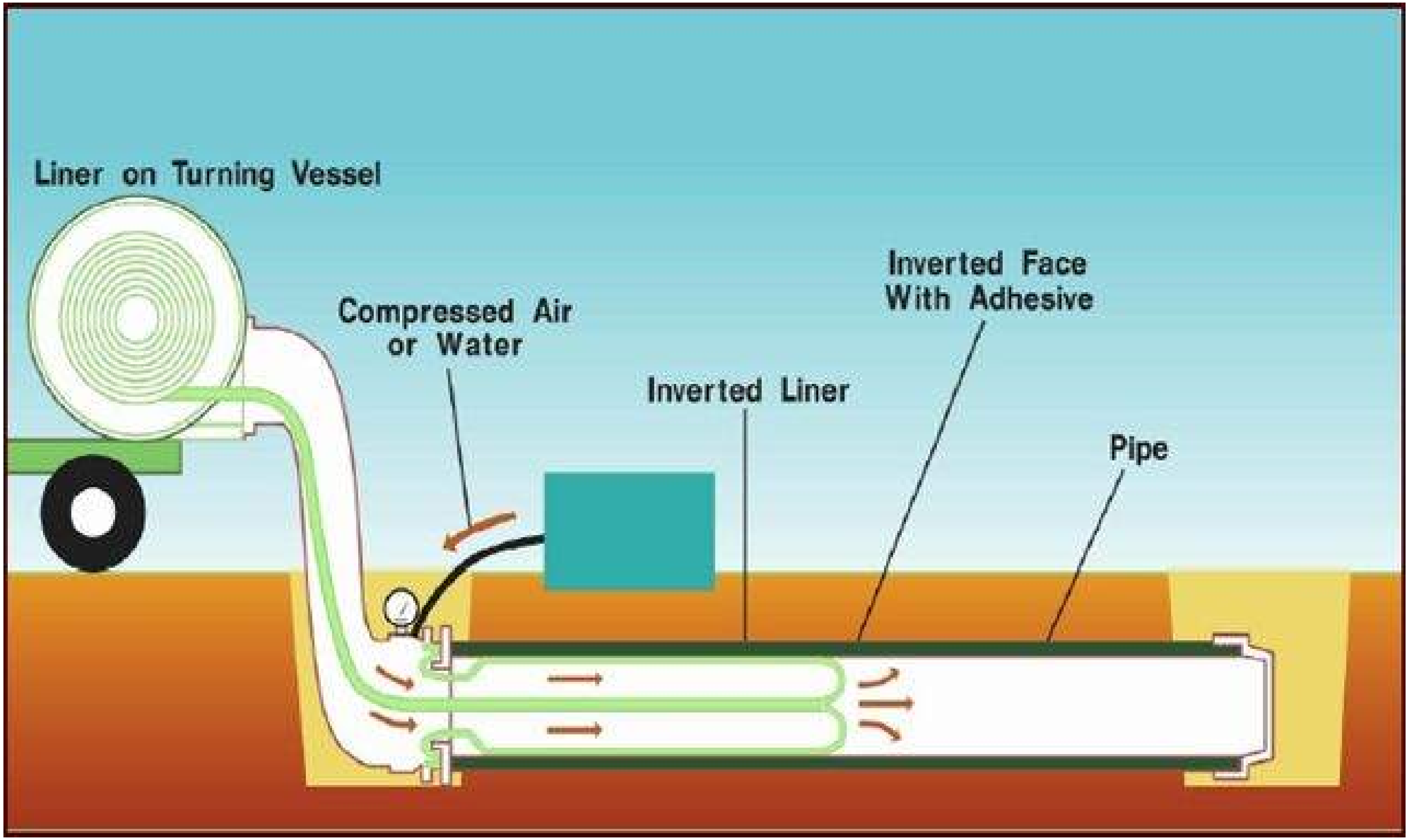
Attached to host pipe

Liner forced to invert inside host pipe

Liner ends at catch basket

Source: Consolidated Edison of New York

Starline – Cured in Place Liner



Source: Consolidated Edison of New York

Starline Process

- Steam curing & pressure monitoring

Steam Boiler

Air Compressor

Mixing Chamber

Temperature and Pressure Control

Liner

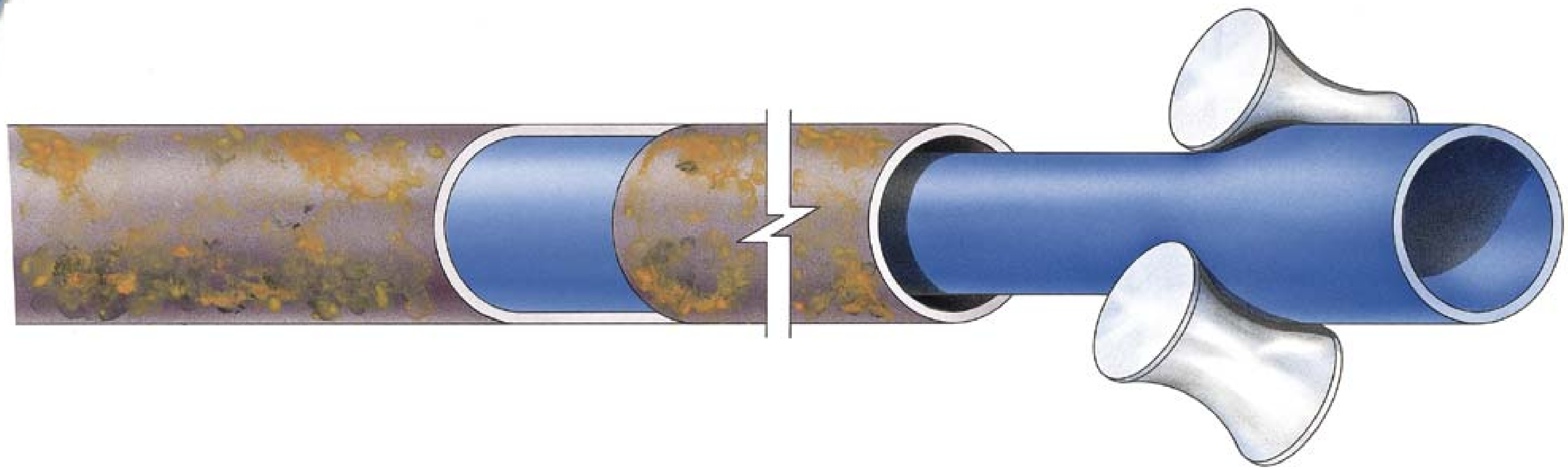
Source: Consolidated Edison of New York

Starline Process

- Post-lining inspection
- Service reinstatement (if necessary)
- Final pipe construction and restoration

Source: Consolidated Edison of New York

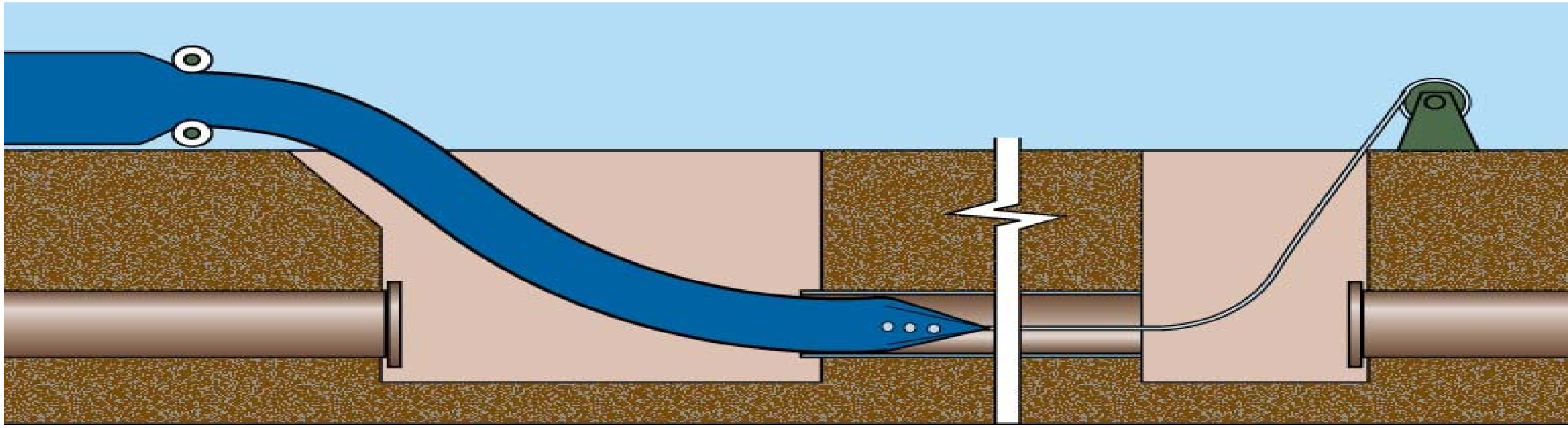
Rolldown – Tight Fit Polyethylene



- Developed by Subterra UK.
- Concentric reduction and installation of close-fit polyethylene pipe liners
- Uses thick-walled polyethylene pipe
- Diameter reduction is typically 10%
- Reverted to a close fit by cold water pressurisation

Source: Consolidated Edison of New York

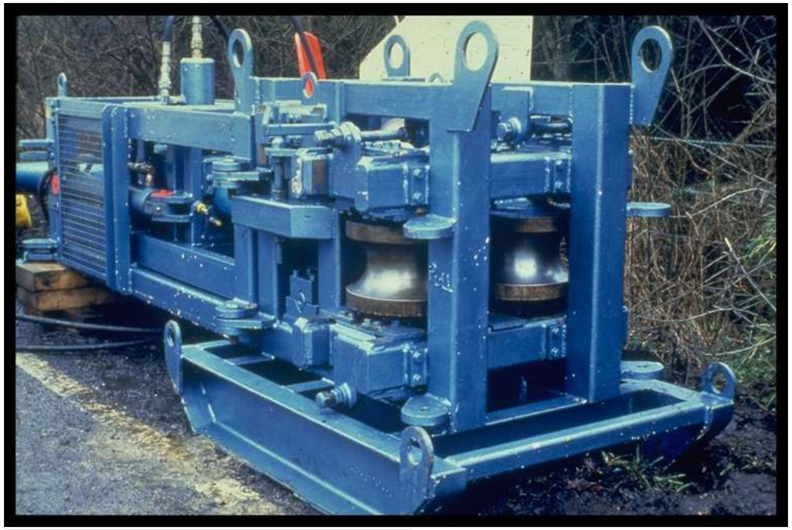
Rolldown Process



- Diameter range 10 – 50 cm
- Bends up to 11¼º can be negotiated
- Typical lining lengths 300 meters
- Long insertion trench required
- Excavations required to reconnect service connections/laterals etc.

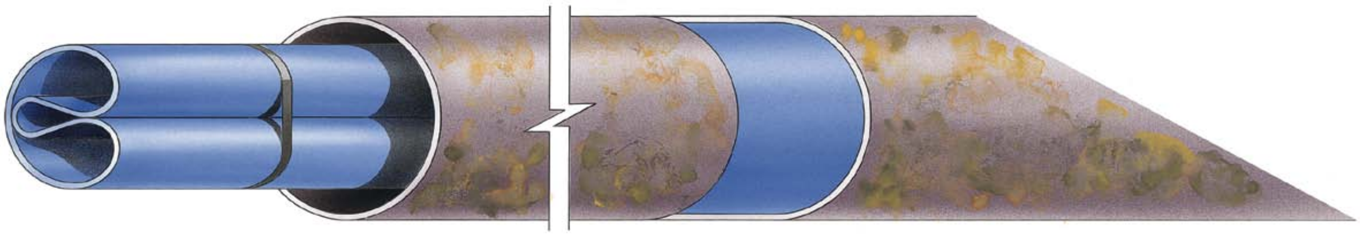
Source: Consolidated Edison of New York

Rolldown Process



Source: Consolidated Edison of New York

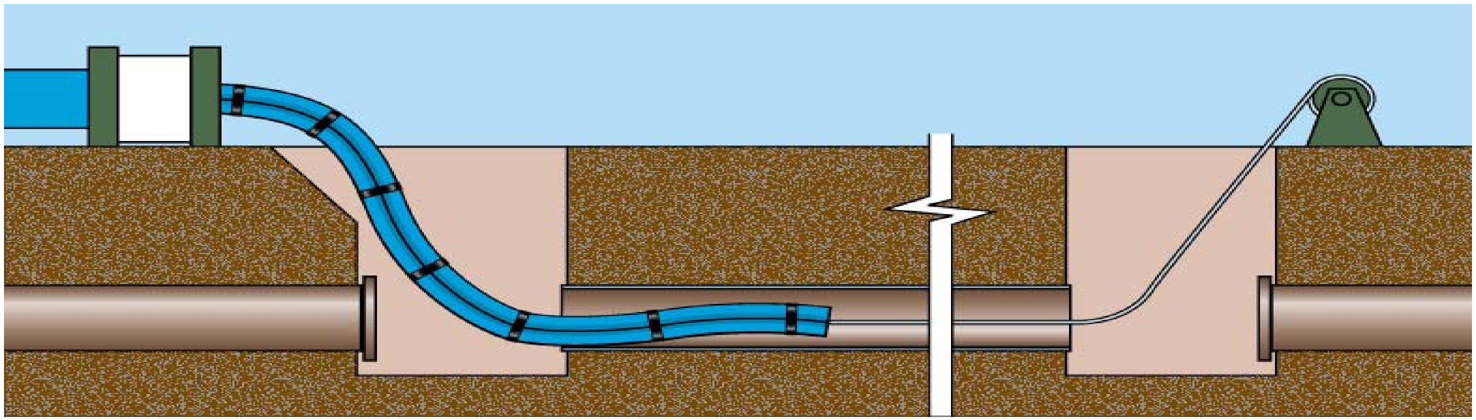
Subline –Tight Fit Polyethylene



- Subline is a process for the cold folding and installation of close-fit, thin-wall polyethylene pipe liners
- Subline was developed to allow lining of large diameter pipes & improve ability to negotiate bends
- Liner insertion process is simple slip lining
- Reverted to a close fit by cold water pressurisation

Source: Consolidated Edison of New York

Subline Process



- Available for polyethylene diameters 7 – 150 cm
- Folded shape helps insertion, bends up to 22½º can be negotiated
- Lengths up to 300 m
- Long lead-in trenches for welded polyethylene strings
- Local excavations to reconnect service connections/laterals etc.

Source: Consolidated Edison of New York

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Methane Emissions from Blowdown Activities

- Equipment taken out of service for operational or maintenance purposes are often depressurized to atmosphere
  - Compressors
  - Pipeline segments
- Venting pressurized gas results in methane emissions and loss of product

Recover Blowdown Gas By Injection into Low Pressure Pipelines

- Plan for recovering blowdown gas during scheduled maintenance activities
- Outlets for recovered blowdown gas
  - Fuel system
  - Low pressure mains
- To blowdown to a low pressure system
  - Take advantage of existing piping
  - Temporarily reset or bypass regulator valves
  - Install temporary piping between high and low pressure systems

Blowdown Gas Recovery

- Natural Gas STAR Partners have reported evaluating the recovery of blowdown gas on a case by case basis taking into account
  - Location of pipe or compressor
  - Outlet for recovered gas
- Typical savings reported by Natural Gas STAR Partners are approximately 4,200 m^3 through recovering gas from compressor blowdowns
  - 10 blowdowns per year
  - 420 m^3 per blowdown
- Savings of $1,050 per year at $250/Mcm

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Overview: Directed Inspection & Maintenance (DI&M)

- Fugitive losses can be reduced dramatically by implementing a systematic leak detection and repair program
- Natural Gas STAR refers to this practice as Directed Inspection and Maintenance (DI&M)
  - Program to identify and fix leaks that are cost effective to repair
  - Many options for leak detection technologies
  - Provides valuable data on sources of leaks with information on where to look
  - Strictly adapted to company's needs
  - Cost-effective practice, by definition

Infrared Leak Imaging Camera

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

Methane to Markets

Summary of Screening and Measurement Techniques

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	★★★	$$$

* - Least effective at screening/measurement

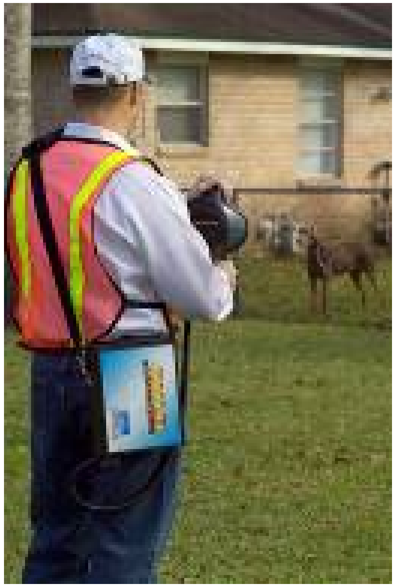
*** - Most effective at screening/measurement

$ - Smallest capital cost

$$$ - Largest capital cost

Leak Detection and Repair at Metering and Regulator Stations

- Systematic leak detection and repair at metering and regulator stations must be approached differently than at compressor stations and processing plants
  - Lower pressures, smaller leaks
  - Fewer components per site
- Some US companies elect to conduct leak screening only
  - Forego leak measurement to reduce survey costs
  - Fix all leaks that are identified
  - Survey is low cost but does not collect data on leak rates and gas savings
    - This information is needed to determine which leaks are cost-effective to repair



DI&M Industry Experience: US Distribution Company

- One US distribution company reported survey of 306 facilities
- 824 leaks found
  - Four “large” leaks
  - Seven “medium” leaks
  - Rest “small” leaks (meaning soaping or electronic detector required to find leaks)
- Total survey and repair cost: $22,200
  - $73 per facility surveyed
- Total gas savings: 3,336 Mcm
  - $834,000 savings at $250/Mcm
  - Net savings of $2,725 per facility

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Common Emission Sources at Distribution Metering and Regulator Stations

- Study of U.S. and Canadian metering and regulator stations revealed common leaking components
  - Relatively small component counts per station

Average Emissions Factors for Equipment Leaks at Sixteen Metering and Regulating Facilities				
Component	**Emissions Factor (m^3/year per component)**	**Total Number of Components Screened**	**Average Number Components per Site**	**% Contribution to Total**
Ball/Plug Valve	6	248	18	0.002%
Control Valve	13	17	1	0.33%
Flange	4	525	38	0.09%
Gate Valve	22	146	10	0.6%
Pneumatic Vent	3,800	40	1	95.5%
Pressure Relief Valve	137	5	1	3.4%
Connectors	3	1,280	91	0.08%
Total		**2,261**	**160**	
Source: Indaco Air Quality Services, 1998.				

Estimated Repair Costs at Distribution 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 (m^3/year)**	**Estimated Net Savings[2] ($/year)**	**Repair Payback Period (Months)**
Ball Valve	Re-grease	$18	5	1,700	$330	3
Gate Valve	Replace valve stem packing	$4	5	1,900	$449	<1
Gate Valve	Replace valve stem packing	$4	1	2,600	$640	<1
Connector	Tighten threaded fittings	$4	4	300	$61	3
Sr. Daniel Orifice Meter	Tighten fittings	$44	1	1,900	$432	2
Flange[3]	Tighten (estimated)	$54	5	2,800	$423	5

1 – Average repair costs include labor and materials, 2006 dollars
2 – Assumes gas price of $250/Mcm
3 – Repair cost not reported in original study.
Source: Indaco Air Quality Services, 1998.

Valve Stem Packing Replacement

- Replacing valve stem packing is a common leak repair activity at distribution gate stations and surface facilities
- GORE-TEX valve stem packing is one option for replacement
  - Polytetrafluoroethylene (PTFE) material (no asbestos)
  - Chemical resistant, pH 0 - 14
  - -268ºC to 315ºC

Valve Stem Packing Replacement: Tveroblgaz Experience (Russian)

- Tveroblgaz Joint Implementation (JI) Project
  - Methane Emissions Avoidance in the Tver Gas Distribution Network
- Project Description
  - All valves screened and inspected for leaks
  - Replace all (leaking and non-leaking) valve stem packing with GORE-TEX packing
  - Use GORE-TEX packing for all new valve installations

Valve Stem Packing Replacement: Tveroblgaz Experience (Russian)

- Project results
  - Valve repairs completed between April 6, 2007 and August 16, 2007
  - 2,066 leaking valves identified out of 5,993 valves screened
  - Leaking valves lose 22,800 Mcm per year
  - Average leak rate of 4 Mcm/year (all valves)

Discussion

- What is your experience applying these technologies and practices?
- What are your limitations on application of these technologies and practices?
- What are your actual costs and benefits?