Reducing Methane Emissions from Transmission Pipelines

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Methane to Markets

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Reducing Methane Emissions from Transmission Pipelines: Agenda

- Methane emissions from transmission pipelines
- Opportunities for methane recovery:
  - Pipeline pump-downs
  - Hot taps
  - Composite wrap
- Contact and further information

Source: TransCanada

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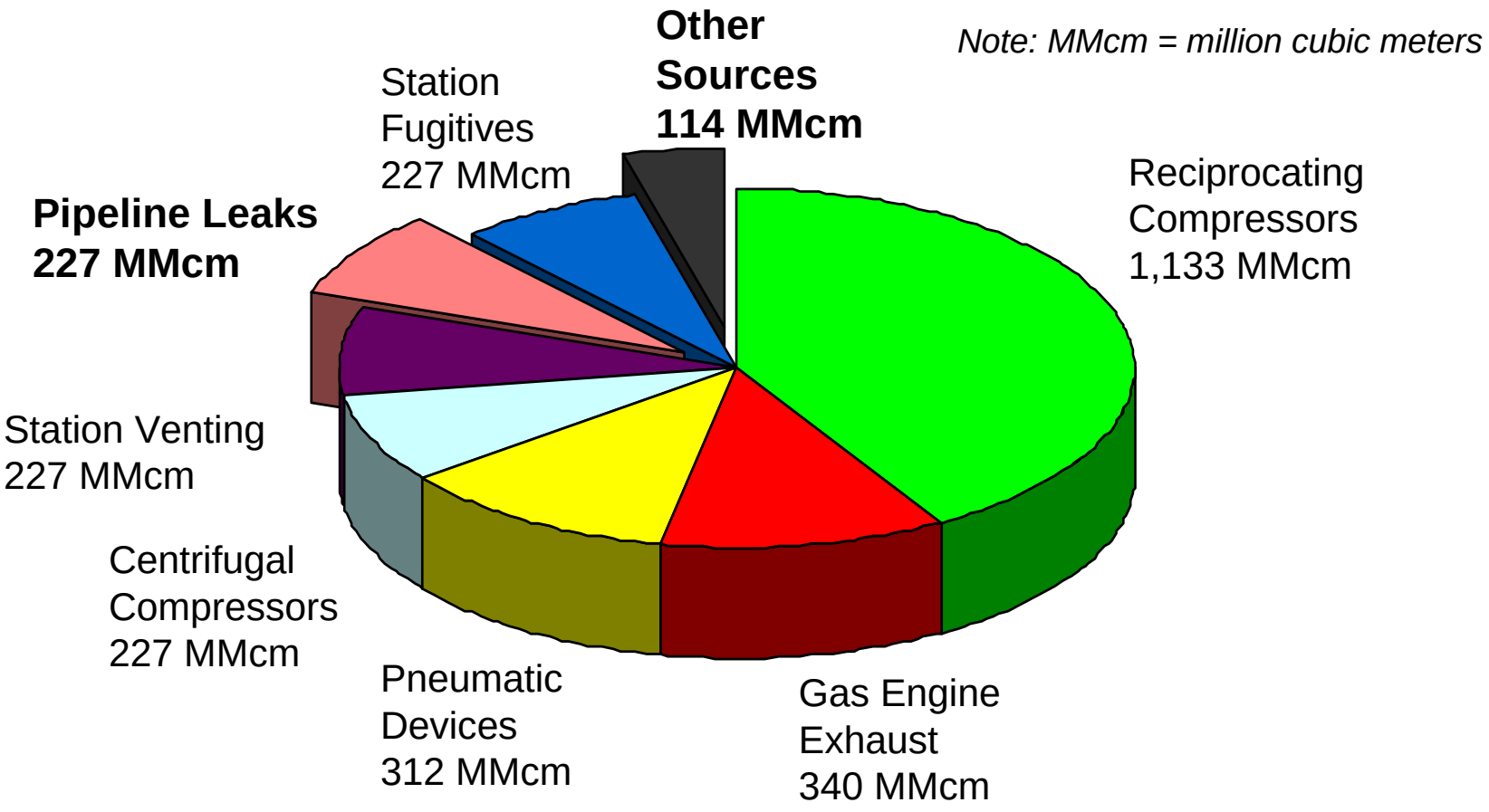
U.S. Methane Emissions from Transmission Pipelines

- Emissions from transmission pipelines accounts for a significant portion of transmission sector emissions

Note: MMcm = million cubic meters



EPA. *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 – 2007.* April, 2009. Available on the web at: epa.gov/climatechange/emissions/usinventoryreport.html

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Reducing Methane Emissions from Transmission Pipelines: Agenda

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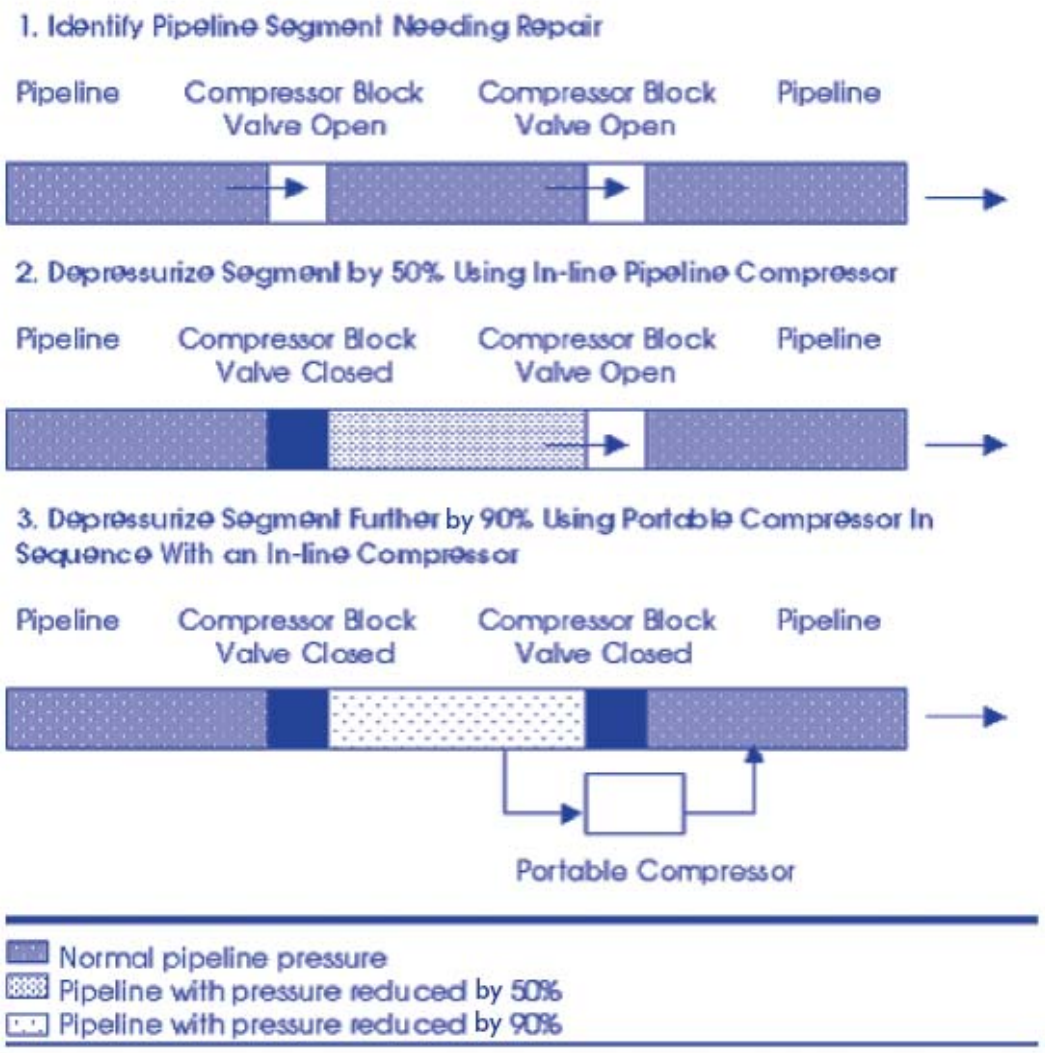
Source: TransCanada

Pipeline Pump-down: Overview

- 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 Pump-down: Process



Pipeline Pump-down: Economics

- Quantity of gas saved by pump-down:
  - Total gas in pipeline segment:
    $M = L^*(1{,}000\ m/km) * (\pi/4 * D^2) * (P/101.3\ kPa) * (1\ Mcm/1{,}000\ m^3)$
  - Gas saved by in-line compressor:
    $Ni = M - (M/Ri)$
  - Gas saved by portable compressor:
    $Np = Ni - (Ni / Rp)$

Note: 1 Mcm = 1,000 cubic meters

- Example:

- Pipeline isolated length (L) = 16.1 km
- Pipeline interior diameter (D) = 0.724 m
- Pipeline operating pressure (P) = 4,134 kPa
- In-line compression ratio (Ri) = 2
- Portable compression ratio (Rp) = 8

Note: TMT = Turkmenistan New Manat
Gas Value = 855 TMT per thousand cubic meters

	Volume of Gas (Mcm)	Value of Gas Saved
Total gas in pipeline segment (M)	270	-
Gas saved by in-line compressor (Ni)	135	TMT 115,425
Gas saved by portable compressor (Np)	118	TMT 100,890
Total gas saved by pump-down	**253**	**TMT 216,315**

Pipeline Pump-down: Economics

- Potential costs associated with using a portable compressor:
  - Capital or compressor lease cost
  - Fuel costs to run compressor
  - Maintenance costs of compressors
  - Pipeline stopple for valve leaks
  - Labor costs
  - Installation costs
  - Freight costs
  - Parallel pipeline for extra fuel gas
- Example: Lease portable compressor for one year, perform 30 pump-downs per year
  - Lease portable compressor = TMT 88,350/month x 12 months = TMT 1,060,000 for one year
  - Maintenance & fuel = TMT 1,425/month x 12 months = TMT 17,100 for one year
  - Freight costs = TMT 54,150 for one year
  - Total costs = TMT 1,131,450 for one year
- Net value = gas savings in-line + (gas savings portable – portable compressor costs)
  - = [30 x TMT 115,425] + ([30 x TMT 100,890] – [TMT 1,131,450])
  - = TMT 5,358,000

Pipeline Pump-down: Time

- Time required for pump-down affects:
  - Potential service interruptions
  - Fuel use by portable compressor
  - Fuel use by downstream compressors
  - Labor costs

Source: Ariel Corporation
Sm^3/hr = standard cubic meters per hour

ARIEL JGA/4 WITH 2X7-1/2JG+1X6-12JG+1X4-1/8JG AND CATERPILLAR G3406TA GAS ENGINE AT 1800RPM

ASSUMPTIONS:
Flow (Sm3/hr at 1.01325BarA & 15DegC)
Gas Temperature (DegC)

Pipe length(mile) 10
Pipe dia.(inches) 48
Volume (m3) = 18791

Pipe line pressure (BarG)	Compressor capacity (Sm3/hr)	Stages	Calculated power (kw)	Avg. Flow Rate During Interval (Sm3/hr)	Total Gas Volume in Pipeline (Sm3)	Volume Removed During Interval (Sm3)	Interval Time Required (hrs)	Cumulative Running Time (hrs)
31.03	10048	3	85		613080.9			0
29.65	9609	3	95	9828.5	599081.6	27959.695	2.84	2.84
28.96	9429	3	100	9519	585121.2	13982.611	1.47	4.31
27.58	8776	3	106	9102.5	571138.6	27724.882	3.05	7.36
24.13	7591	3	125	8183.5	543413.7	72227.952	8.83	16.19
20.68	6307	3	137	6949	471185.7	66715.975	9.60	25.79
17.24	7165	3	248	6736	404469.8	66903.964	9.93	35.72
13.79	5744	3	244	6454.5	337565.8	65518.72	10.15	45.87
10.34	5708	3	283	5726	272047.1	64579.849	11.28	57.15
6.89	4557	3	283	5132.5	207467.2	63642.176	12.40	69.55
3.45	2963	3	261	3760	143825	102908.8	27.37	96.92
0	635	3	102	1799	40916.24	40916.243	22.74	119.66
TOTAL TIME TAKEN TO EVACUATE A SECTION OF THE PIPELINE (HRS)							=	119.66

Pipeline Pump-down: Case Study

- TransCanada implements pump-downs on:
  - 32 to 48 kilometer segments
  - 64 atm operating pressure
  - 1.1 meter pipeline
- Performs 30 pump-downs per year
  - In-line compressors draw down to 48 atm
  - Portable compressor draw down to 5 to 14 atm

- Uses trailer-mounted centrifugal compressor
  - 8 stages
  - Fuel gas for compressor drawn off discharge side
- Saves 1.38 million m^3 per pump-down of 32 kilometer segment
  - 41.6 million m^3 per year with 30 implementations annually

Reducing Methane Emissions from Transmission Pipelines: Agenda

- Methane emissions from transmission pipelines
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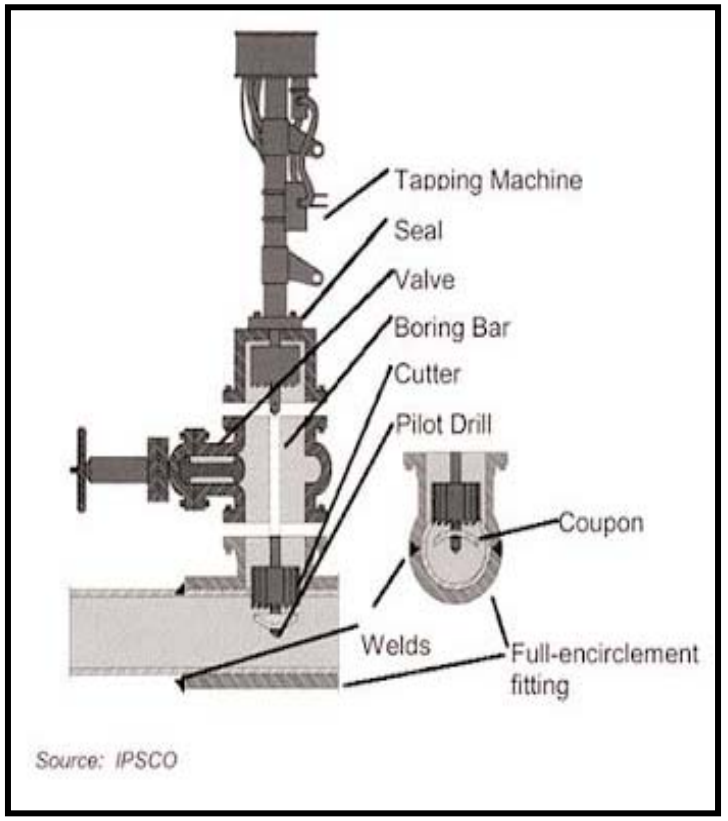
  - Pipeline pump-downs
  - **Hot taps**
  - Composite wrap
- Contact and further information

Source: Williamson Industries Inc.

Hot Taps: Overview

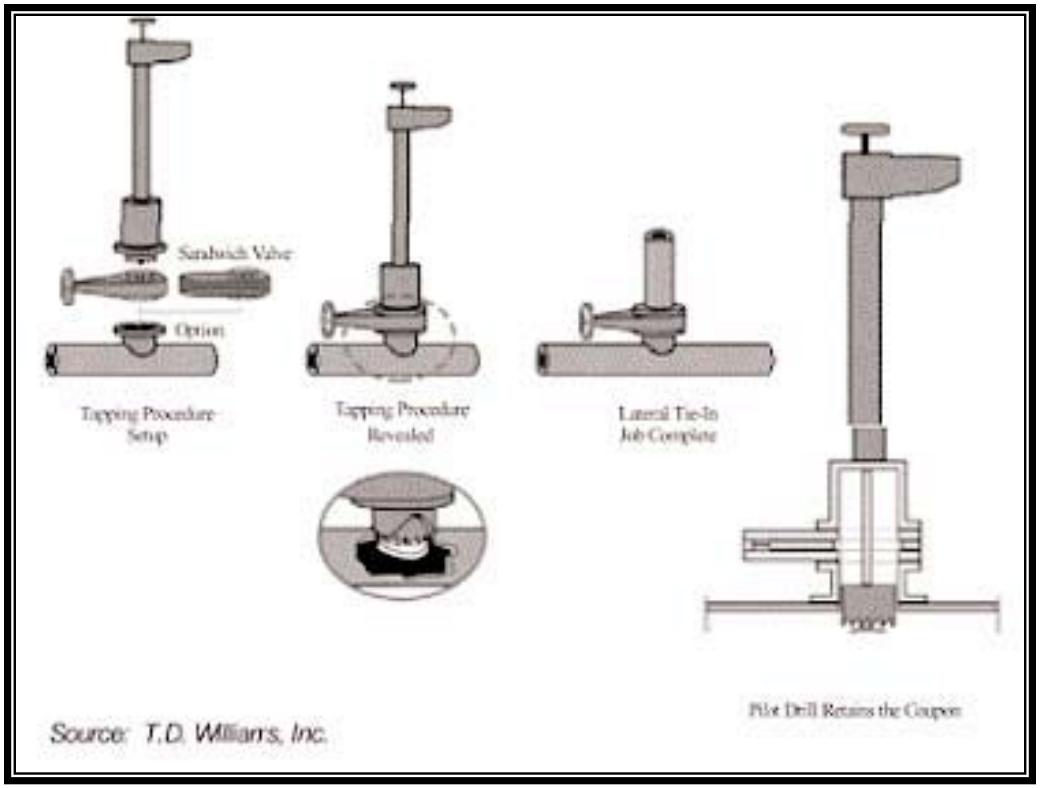
- New branch connection while the pipeline remains in service
  - Attach a branch connection and valve to the main pipeline
  - Cut-out a section of the main pipeline wall through the valve to connect the branch to the main pipeline
- Current technology has improved reliability and reduced complications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



Schematic of hot tapping machine

Hot Taps: Process

- 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 Taps: Economics

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	TMT
10.2 cm pipeline, 24.8 atm, 3.2 km	250	0.6	155.7	0.05	14.1	144,474
20.3 cm pipeline, 7.8 atm, 1.6 km	30	0.4	11	0.1	3.4	12,142
25.4 cm pipeline, 69.0 atm, 4.8 km	25	16.7	417	0.5	13.4	367,322
45.7 cm pipeline, 14.6 atm, 3.2 km	15	7.2	108.3	1.2	17.4	106,604
Total Annual	**320**		**692.1**		**48.4**	**630,708**

Note: Natural Gas Value: TMT 855 per thousand cubic meters
Nitrogen Gas Value: TMT 805 per thousand cubic meters

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

Hot Taps: Economics

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, TMT	(135,115)	0	0	0	0	0
Contract service cost, TMT	0	(154,650)	(154,650)	(154,650)	(154,650)	(154,650)
O&M cost, TMT	0	(22,683)	(22,683)	(22,683)	(22,683)	(22,683)
Total cost, TMT	(135,115)	(62,222)	(62,222)	(62,222)	(62,222)	(62,222)
Natural gas savings, TMT		591,746	591,746	591,746	591,746	591,746
Inert gas savings, TMT		38,962	38,962	38,962	38,962	38,962
Net benefit, TMT	(135,115)	740,386	740,386	740,386	740,386	740,386
Payback (months)						2
IRR						548%
NPV[2], TMT						2,428,664

[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.

Hot Taps: Case Study

- One hot tap vendor reported helping a gas transmission client avoid a service outage
  - One-day gas delivery in a 914.4 millimeters natural gas pipeline operating at 68.07 atm is worth TMT 1,732,800 in gross revenue*
  - Performing shutdown connection required 4 days
  - TMT 6,962,550 estimated revenue savings*

Source: TransCanada

*Gas valued at TMT 855 / Mcm

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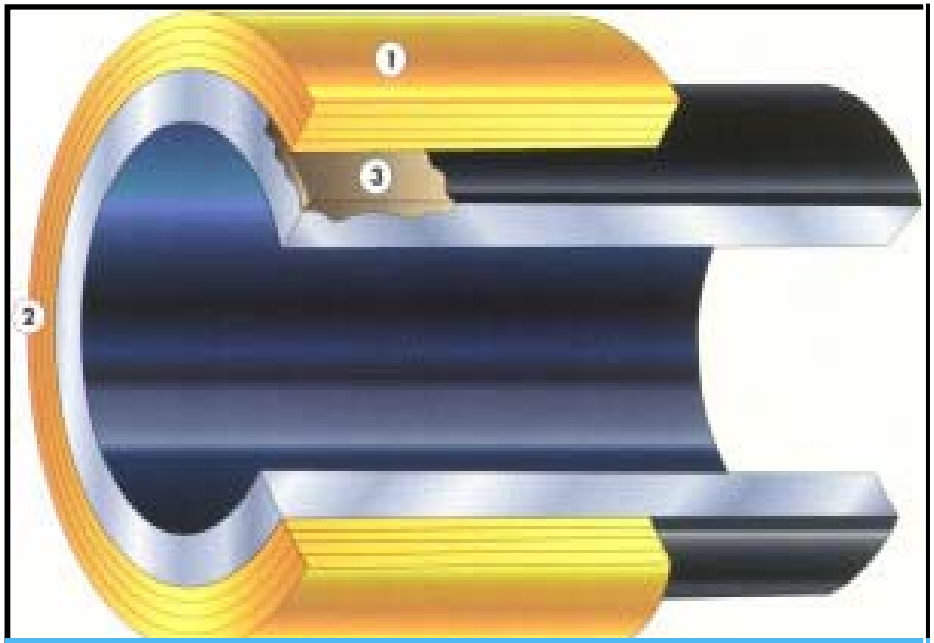
Source: Armor Plate

Composite Wrap: Overview

- 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

Composite Wrap: Economics

Cost Factors	At 285 TMT/Mcm ($100/Mcm)				At 855 RUB/Mcm ($300/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	31,920	0	31,920	0	95,760	0	95,760
Cost of purge Gas	0	4,540	0	4,540	0	4,540	0	4,540
Labor	1,065	3,824	2,129	5,736	1,065	3,824	2,129	5,736
Equipment and materials	4,408	11,505	88,159	20,807	4,408	11,505	88,159	20,807
Indirect costs	2,736	4,908	45,145	10,617	2,736	4,908	45,145	10,617
Total cost of repair	8,209	30,923	135,433	47,845	8,209	125,706	135,433	142,629
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: Case Study

- One Partner reported installing over 300 wraps on 254 millimeter or greater lines since 1995
- Limits repairs to 4 butted wraps then replaces
- 51-cm defects in line near creek bed:
  - Limited environmental exposure
  - Wrapped in 2 hours
  - Total repair 2 days from start to finish

Methane to Markets

Contact Information and Further Information

- More detail is available on these practices and over 80 others online at: epa.gov/gasstar/tools/recommended.html
- For further assistance, direct questions to:

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