Pipeline Pumpdown Practices and Hot Taps

Lessons Learned
from Natural Gas STAR

Transmission Technology Transfer Workshop

Duke Energy Gas Transmission,
Interstate Natural Gas Association of America (INGAA) and
EPA's Natural Gas STAR Program

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Pipeline Practices: Agenda

- Methane Losses
- Methane Recovery by Pumpdown
- Is Recovery Profitable?
- Industry Experience
- Methane Recovery by Hot Taps
- Is Recovery Profitable?
- Industry Experience
- Discussion Questions

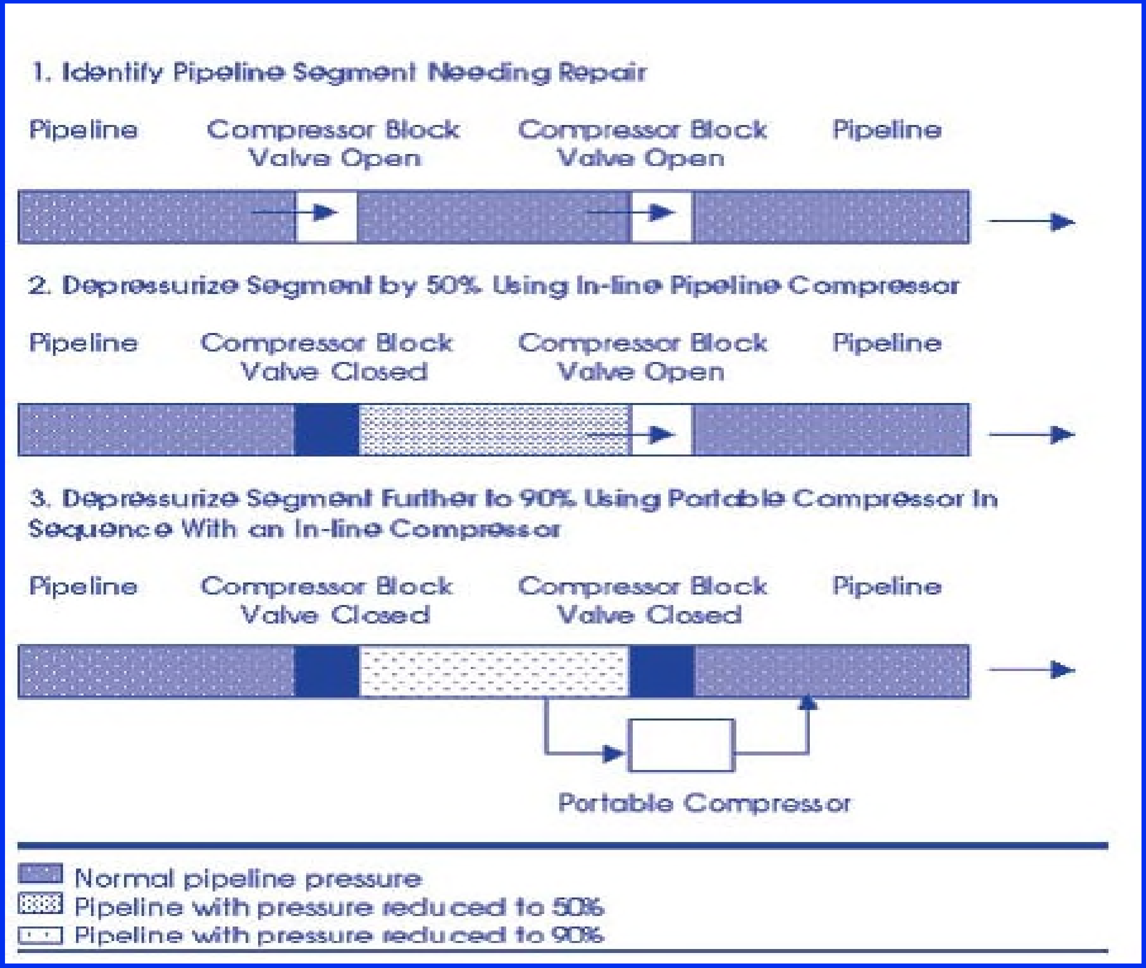
Methane Losses from Current Pipeline Maintenance Practice

- Methane is often vented to the atmosphere in preparation for pipeline maintenance or new connections
- The smallest possible linear section of pipeline is blocked in, and the natural gas contents, often under high pressure, are depressured to the atmosphere
- "Hot work" may require purging the pipeline with inert gas
- These practices results in methane emissions
  - **Loss of Sales**
  - **Occasionally cause customer inconvenience**
  - **Costs associated with evacuating the existing piping system**
- Nationally, 9 billion cubic feet (Bcf) of methane are vented during routine annual maintenance and pipeline upsets

Methane Recovery by Pipeline Pumpdown

- Use pipeline 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 the gas usually vented is recoverable
- In 1998 Gas STAR Partners reported savings of 1.1 Bcf methane

Sequence of De-pressurization Events



Pipeline Pumpdown Technique

- In-line pipeline compressor
  - **Typically has compression ratio of 2 to 1**
  - **By blocking upstream valve the pressure in the pipeline is reduced to safe limits for some maintenance**

- Portable compressor
  - **Typically has compression ratio of 5 to 1**
  - **Can be used in conjunction with in-line compressor to further reduce pressure in the pipeline section**
  - **Justifiable only when multiple sections of pipeline are to be serviced (i.e. long sections of maintenance or pipeline valve station maintenance where stopples are not feasible)**

Applicability of Pipeline Pumpdown Techniques

Repair Class	Pump-Down Technique	Description of Applicability
Class 1	**In-line and Portable**	**Repairs primarily involve non-emergency situations**
Class 2		
Class 3	**In-line only**	**Involves emergency repair with no time for mobilization of portable compressors**
Class 4	**In-line only**	**Involves large projects with new lines running parallel to old ones with opportunity to recover gas from old pipelines during startup of new pipeline**

Calculate Gas Vented by Depressuring Pipeline

- Estimate the quantity and value of gas that would be lost
  - **Given:**
    - **Pipeline length (L) = 10 miles**
    - **Pipeline internal diameter (I) = 2.375 feet**
    - **Pipeline operating pressure (P) = 600 pounds per square inch gauge (psig)**
    - **In-line compressor compression ratio (Ri) = 2**
  - **Calculate amount of gas in pipeline (M):**

M = L*(5,280 ft/mile) * (π * I^2/4) * (P/14.7 psig) * (1 Mcf/1,000 cf)

M = (10*5,280) * (π*2.375^2)/4 * (600+14.7)/14.7 * 1/1,000

M = 9,781 Mcf

Calculate Gas Saved with In-line Compressors

- Gas recoverable using an in-line compressor (Ni)

  Ni = M – (M/Ri) = 9,781 – (9,781/2) = 4,891 Mcf

- Value of gas recovered using an in-line compressor (Vi)

  Vi = Ni * $3/Mcf = 4,891 * 3 = $14,673

- Annual value of gas recovered assuming 4 actions per month

  = $14,673 * 4 * 12 = $704,304

Calculate Gas Saved with Portable Compressor

- Calculate the volume and value of the gas recovered by a portable compressor
  - **Given:**
    - **Portable compressor compression ratio (Rp) = 8**
    - **Rate of compressor = 416 Mcf / hour**
  - **Gas available for recovery**

    = M – Ni = 9,781 – 4,891 = 4,890 Mcf
  - **Gas recoverable using a portable compressor**

    Np = Ni – (Ni / Rp) = 4,891 – (4,891 / 8) = 4,280 Mcf
  - **Value of gas recovered using portable compressor**

    Vg = Np * $3/ Mcf = 4,294 * 3 = $ 12,840

Steps to Evaluate the use of In-line and Portable Compressors

- Verify technical feasibility of using a portable compressor
  - **Check for available connections to bleeder valves upstream and downstream of a mainline block valve**
- Determine the appropriate-sized portable compressor for the project
  - **Amount of gas to be recovered**
  - **Discharge pressure requirements**
  - **Schedule**

Cost of a Portable Compressor

- Check the availability and cost of purchasing (Vcp) or leasing a portable compressor

Portable Compressor Purchase and Lease Cost Range*					
1,000 psig – High Flow		600 psig – Medium Flow		300 psig – Low Flow	
Purchase	Lease	Purchase	Lease	Purchase	Lease
$2 - $5 million	$60,000 - $150,000 per month	$0.8 - $1.2 million	$24,000 - $36,000 per month	$400,000 - $600,000	$12,000 - $18,000 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					

O&M Costs of a Portable Compressor

- Estimate the operating costs associated with using a portable compressor
  - **Fuel costs (mostly natural gas) (Vcf)**

    7,000 – 8,400 British thermal unit (Btu) per brake horse power per hour
  - **Maintenance costs (Vcm)**

    $4 - $9 per horsepower per month
  - **Labor costs (Vcl)**
  - **Taxes and administrative costs (Vct)**
  - **Installation costs (Vci)**
  - **Freight costs (Vcs)**

Calculate Annual Savings

- Calculate total gas savings
  - **Gross value of gas recoverable during a 12-month period, assuming average of 4 pump-downs per month**

    = Vg * 4 * 12

    = $12881 * 4 * 12

    = $ 618,288 per year

Calculate Fuel Costs

- Compressor fuel costs
  - **Hours portable compressor will operate**
    = Np / rate of compressor = 4,294 / 416
    = 10 hours
  - **Given:**
    - **Fuel consumption = 7,000 Btu/hr/horsepower**
    - **Natural gas heat content = 1,020 Btu/cf**
    - **Compressor rating = 1,000 horsepower**
  - **Fuel used by compressor for 10 mile stretch per month**

$$= \frac{(7{,}000 \text{ Btu / hp / hour} * 1{,}000 \text{ hp} * 10 \text{ hours})}{(1{,}020 \text{ Btu / cf} * 1000 \text{ cf / Mcf})} = 69 \text{ Mcf}$$

  - **Fuel costs assuming four 10-mile stretches per month**
    = $ 3/Mcf * 69 Mcf * 4
    = $828 per month

Is Recovery Profitable?

- Calculate total annual costs for portable compressor
  - **Total cost of using the portable compressor during a 12 month period**

    = Fuel costs + lease and maintenance costs + freight costs

    = 12 * ($828 + $24,000) + $15,000

    = $312,936

- Compare savings with costs
  - **Total net value of recovered gas during a 12- month lease using a portable compressor**

    = gross value of recovered gas – cost of using a portable compressor

    = $618,288 - $312,936 = $ 305,352

  - **Net savings**

    = inline + portable = $706,608 + $ 305,352

    = $1,011,960

Partner Experience

- Partner used compressors at one location three times in 1998
- Estimated cost = $52,600
- Gas saved from being vented = 32,550 Mcf
- Net savings = $40,600
- Estimated payback period ~ 16 months

Hot Taps: Agenda

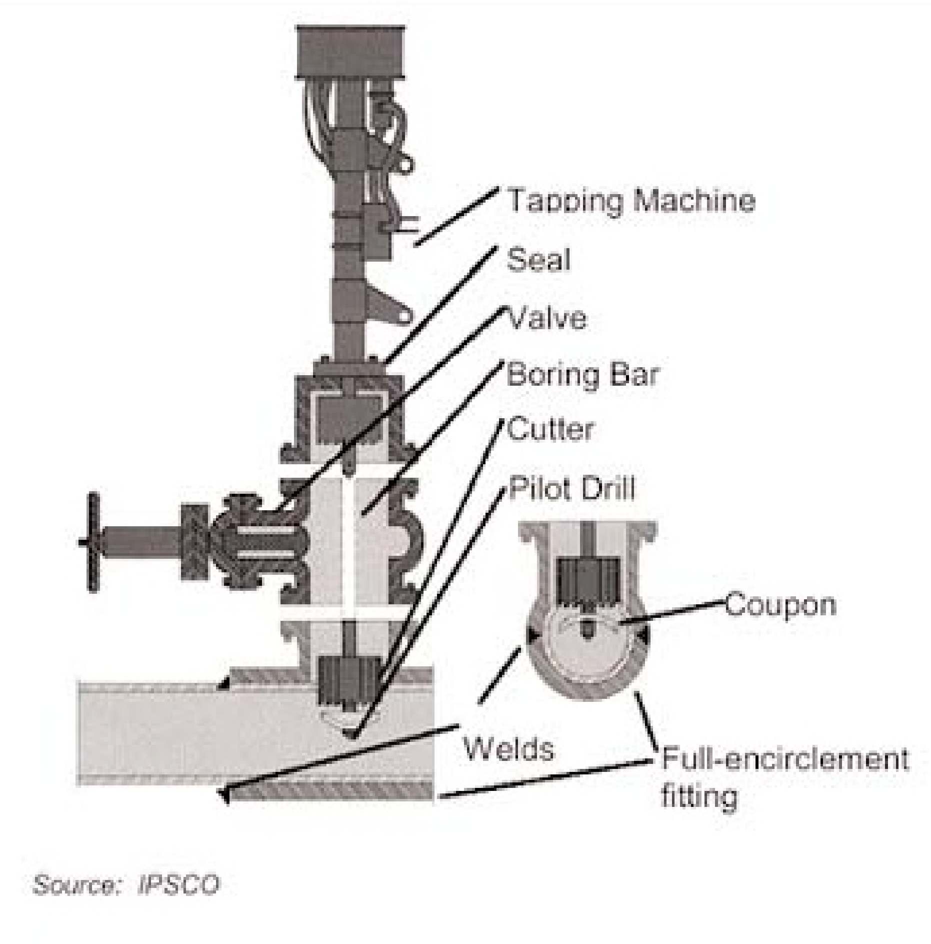
- Methane Recovery by Hot Taps
- Is Recovery Profitable?
- Industry Experience
- Discussion questions

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

Schematic of Hot Tapping Machine



Hot Tapping Machine

- Drilling Machine
  - **Consists of a mechanically driven telescopic boring bar with a pilot drill and cutting tool (hole saw)**
  - **Pilot drill makes a pilot hole which guides the hole saw to cut out the curved section of the pipeline**
- Branch fitting
  - **Consists of a simple welded nipple for a small connections to full-encirclement split-sleeve tee for same sized connection**
- Valve Drilling Machine
  - **Block or gate valve (but NOT plug or butterfly valve), with enough space to extract the coupon**

Hot Tapping Procedure

- Connect fitting and permanent valve on the existing pipeline
- Install hot tapping machine through the valve
- Perform hot tap and extract coupon
- 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
- Reduction of costs associated with planning and co-ordination
- Increased worker safety
- Elimination of obligations to notify of gas outage

Calculate Natural Gas Saved

- Calculate cost of performing a shutdown interconnect
  - **Volume of natural gas lost**

$$V_g = \frac{D^2 * P * \left[L / 1{,}000 \right] * 0.372}{1{,}000}$$

  - **Given: A pipeline company requires numerous shutdown or hot tap connections as follows:**

Pipeline diameter (D) = 4 inches	4	8	10	18
Pipeline pressure (P) = 350 psig	350	100	1,000	200
Pipeline length (L), miles	2	1	3	2
Annual taps	250	30	25	15

  - **First example from table**

$$V_g = \frac{4^2 * 350 * \left[2 * 5{,}280 / 1{,}000 \right] * 0.372}{1{,}000} = 22 \text{ Mcf/ connection}$$

Assessing Hot Tap Economics

- Avoided purge gas (assumed to be nitrogen)

$$V_{pgas} = \frac{\left(\frac{D^2 * L}{183}\right)}{1,000} * 2.2 = \frac{\left(\frac{4^2 * 2 * 5,280}{183}\right)}{1,000} * 2.2 = 2\ \text{Mcf}$$

- Value of natural gas saved and purge gas avoided
  - **Given:**
    - **Cost of natural gas (C_g) = $3/Mcf**
    - **Cost of nitrogen (C_{pgas}) = $4/Mcf**
  - **Value of gas saved by hot tap (including purge gas)**

Cost = $C_g + C_{pgas} = V_g * P_g + V_{pgas} * P_{pgas}$

= (22 *3) + (2 * 4)

= $74

Reducing Emissions, Increasing Efficiency, Maximizing Profits

Costs of Hot Tap Equipment

- Calculate the cost of a hot tap procedure
  - **Cost of the hot tap equipment purchase and O&M OR cost of hot tapping contract**
  - **Purchase costs vary from $13,200 to $23,000**

Connection Size	Capital Costs ($)		Contracting Service Cost ($)	Equipment O&M Cost ($/yr)
	Machine[1]	Material		
Small Taps (<12”)	13,200 – 23,000	--	--	500 – 5,000
Large Taps (>12”)	100,000 – 200,000[2]	2,000 – 9,120[2]	1,000 – 4,000	--

[1] Hot tap machines can last from 5 to 40 years. A company can perform as many as 400 small taps per year.

2 Most companies will find it more economical to contract out large hot tapping jobs, and would not therefore incur these costs.

Note: Cost information provided Hot Tap manufacturers and contractors. Prices only provided for most economic options.

Total Costs for Hot Tapping

- Calculate various costs
  - **Given:**
    - **Equipment cost per machine = $18,100**
    - **Operations and Maintenance (O&M) cost per machine = $2,750**
    - **Contract Services cost per tap = $2,500**
    - **Number of hot tap machines = 2**
    - **Number of contracted taps = 15 (all taps 12 inches and larger)**
  - **Total equipment cost = $18,100 * 2 = $36,200**
  - **Total O&M cost = $2,750 * 2 = $5,500**
  - **Contract Service cost = $2,500 * 15 = $37,500**

Annual Hot Tap Program Savings

- Evaluate the gas savings benefits of hot tapping

Estimated Annual Gas Savings for the Hypothetical Scenario

Tap Scenario	Annual Tap Number	Natural Gas Savings		Purge Gas Savings		Total Gas Savings
Pipeline		Per tap Mcf	Annual Mcf	Per tap Mcf	Annual Mcf	$
4” pipeline, 350 psig, 2 mile line	250	22	5,500	2	500	18,500
8” pipeline, 100 psig, 1 mile line	30	13	390	4	120	1,650
10” pipeline, 1,000 psig, 3 mile line	25	589	14,725	19	475	46,075
18” pipeline, 200 psig, 2 mile line	15	255	3,825	41	615	13,935
Total Annual	320		24,440		1,710	80,160

Is Recovery Profitable?

- Compare the options and determine the economics of hot tapping

Economic Analysis of Hot Tap Versus Shutdown

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Capital Cost, $	(36,200)	0				
Contract Service Cost,$	0	(37,500)	(37,500)	(37,500)	(37,500)	(37,500)
O&M Cost, $	0	(5,500)	(5,500)	(5,500)	(5,500)	(5,500)
Total Cost, $	(36,200)	(43,000)	(43,000)	(43,000)	(43,000)	(43,000)
Natural Gas Savings, $		73,200	73,200	73,200	73,200	73,200
Inert Gas Savings, $		6,840				
Net Benefit, $	(36,200)	37,160				
Payback (months)						12
IRR						113 %
NPV[1]						$104,665

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

Vendor Experience

- One vendor reported helping a gas transmission client avoid a service outage
  - **One day gas delivery in a 36 inch natural gas pipeline operating at 1,000 psig is worth $365,000 in gross revenue**
  - **Performing a shut down connection required 4 days**
  - **Revenue savings was estimated at $1.5 million**
  - **This is in addition to the economics of hot tapping discussed earlier**

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 are the barriers (technological, economic, lack of information, regulatory, etc.) that are preventing you from implementing this technology?