Current State of Pipeline Optimization Efforts
February 2010

Presenter: Larry Bowden, Williams Gas Pipelines
Organization Topics

> Overview of How Pipelines Work
> How Efficiency is Defined for Pipelines
> Differences in Pipeline Design vs. Operations
> Optimization Opportunities (Current and Future)
> Q&A
Insight: Dense areas are the gathering systems with connections to market areas. These pipeline systems allow money to be generated by selling natural gas to market areas.

Source: Energy Information Administration, Office of Oil & Gas, Natural Gas Division, Gas Transportation Information System
How Pipelines Work

Engineering
How Pipelines Work

> Operations
  - Gas Control determines overall pipeline operation
  - Pipeline receipts give gas at a nominated steady flow rate
  - Pipeline deliveries take gas at transient non-steady flow rates
How Pipelines Work

> Linepack Management
  - Gas Control varies the amounts of compression throughout the system
  - When horsepower is not enough, storage inventories are used
  - Linepack is like sand in an hour glass…

Natural Gas Storage
Defining Efficiency

> E&P – equipment runs at 100% capacity 100% of the time
> Midstream – having equipment 100% available
> Transmission – (From INGAA white paper “Interstate Natural Gas Pipeline Efficiency” Oct. 2010)
  • Economic
  • Transportation
  • Hydraulic
  • Thermal
  • Compressor
  • Operational
Pipeline System Efficiency

> Transmission –
• **Overall**
  - Performing a task with the lowest amount of resources and undesired byproducts
• **Economic** – delivers gas at the lowest overall cost to customers
• **Transportation** – function of design, component efficiency, and operational efficiency
  - Hydraulic (frictional losses in pipeline segments)
  - Thermal (how much input energy is applied to moving gas – waste heat)
  - Compressor (how much fuel/power is applied to gas)
  - Operational (how much fuel/energy is needed to move gas over distance)
## Differences between Pipeline Design and Operation Engineers

<table>
<thead>
<tr>
<th></th>
<th>Design</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Economics</strong></td>
<td>Focus on the optimal selection of pipe and compression.</td>
<td>Focus on the maintenance of equipment at adequate performance.</td>
</tr>
<tr>
<td><strong>Primary Concerns</strong></td>
<td>Peak day capabilities and pressure commitments at design loads.</td>
<td>Everyday capabilities and requirements at non design conditions while operating efficiently and safely.</td>
</tr>
<tr>
<td><strong>Impact on Efficiency</strong></td>
<td>Have the greatest influence because they specify compression and pipeline diameter.</td>
<td>Choose how to operate transmission equipment at non design conditions. These decisions impact operational efficiency.</td>
</tr>
</tbody>
</table>
Operational Optimization Opportunities

> How do we measure operational efficiency?
> What is the potential for operational optimization?
> What can we accomplish with current technology? Is new technology needed?
Optimization Opportunities – A method to measure and potential for improvement of operational efficiency

2% reduction in fuel requirements without capital spending

With an annual fuel cost of over $200 million, a fuel savings of over $4 million is realized with a 2% decrease in total emissions.
Optimization Opportunities – Current Technology

> Operational efficiency
  • Depends on how the system is operated
  • Potentially improved by implementing waste heat recovery projects

> Steady State Optimization Simulation software allows:
  • optimization of throughput, capacity and/or fuel costs for liquid and gas pipelines
  • monitoring of hydraulic efficiency between compressor stations
  • engineers to reduce fuel costs and emissions
Optimization Opportunities – Current Technology

- Unexplained pressure drop observed
- Compressor station performing better than design
- Opportunity for reducing fuel requirements!
Optimization Opportunities – Current Technology

> Centrifugal Compressor Efficiency Impacts

Operational efficiency is increased by actively managing compressor unit selection and linepack.
Optimization Opportunities – Future Improvements

> Technology
  - **Transient Hydraulic Simulation and Optimization Software**
    - Quickly provide gas control feedback to manage linepack to reduce fuel and energy requirements
    - Much more difficult than steady state simulation
  - **More efficient compression**
    - Vendors and industry organizations are researching ways to improve efficiency to meet clean air requirements

> Business models
  - **Regulated pipelines with fuel trackers need a system to provide an incentive or mechanism for investment in fuel reduction technology**
    - Current technology that can reduce fuel enough to cover investment costs within a year is currently a justifiable expense.
Gas Electric Partnership

What about collaboration between gas transmission and power transmission companies?
### Gas Electric Partnership

<table>
<thead>
<tr>
<th>Differences between</th>
<th>Gas</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Transport rates</td>
<td>15-40 ft/s</td>
<td>speed of light</td>
</tr>
<tr>
<td>Response to demand</td>
<td>Varying flow rates and pressures</td>
<td>No intermediate between on and off</td>
</tr>
<tr>
<td>Transmission methods</td>
<td>Consumes 2-3% of throughput as fuel for compression to overcome frictional losses</td>
<td>Lose 6-7% due to electrical resistance</td>
</tr>
<tr>
<td>Customer Percentage</td>
<td>Natural gas supply to power generation plants is a large part of gas transmission load</td>
<td>Power supplied to gas transmission is a small part of power plant load</td>
</tr>
</tbody>
</table>
Gas Electric Partnership

> Optimization potential of collaboration of power plant operation with pipelines
  • None exists for short term power plant load requirements from transmission pipelines

> Challenge for Industry
  • Can the power grid be operated more efficiently if pipelines communicated electric motor power utilization in advance of operating the equipment?
All aspects of a company contribute to efficient operations. Q/A – Comments?