Basic Modeling and Best Practices

Knowledge Retention
Sharing why we do what we do

November 3, 2010

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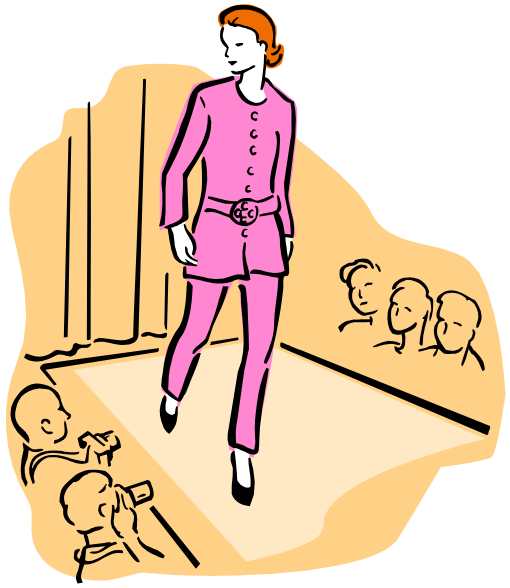
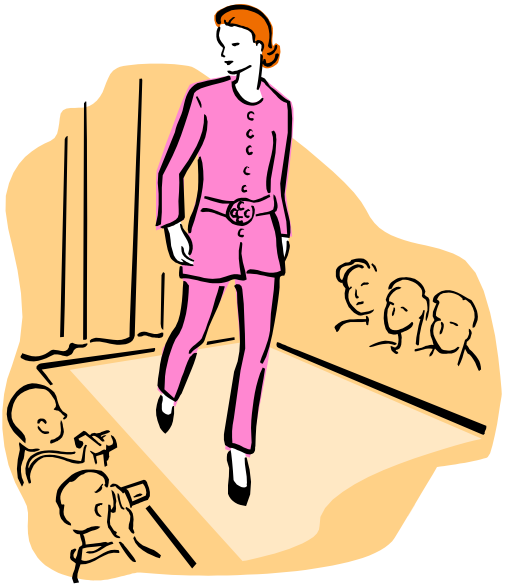
What We'll Discuss

- Modeling Basics



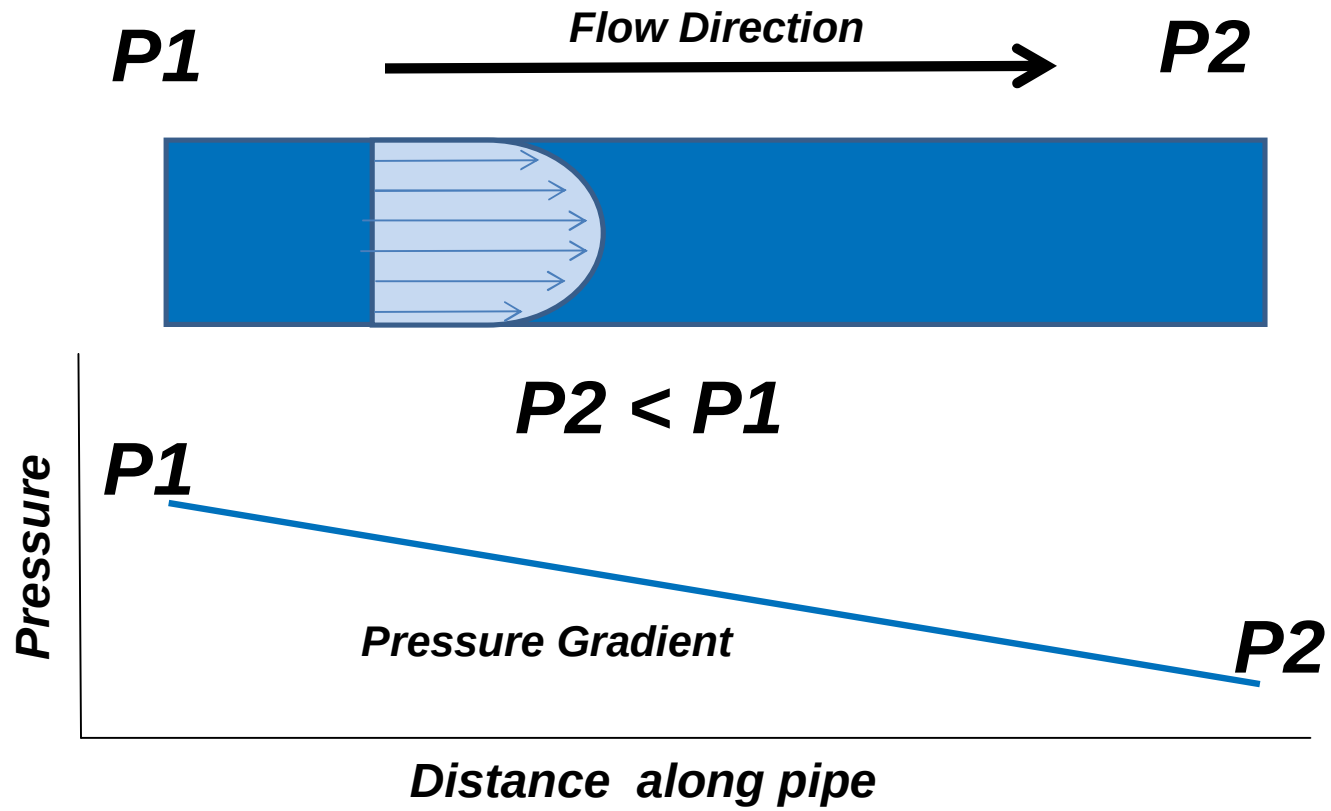
- Your Tool Belt

Modeling Basics

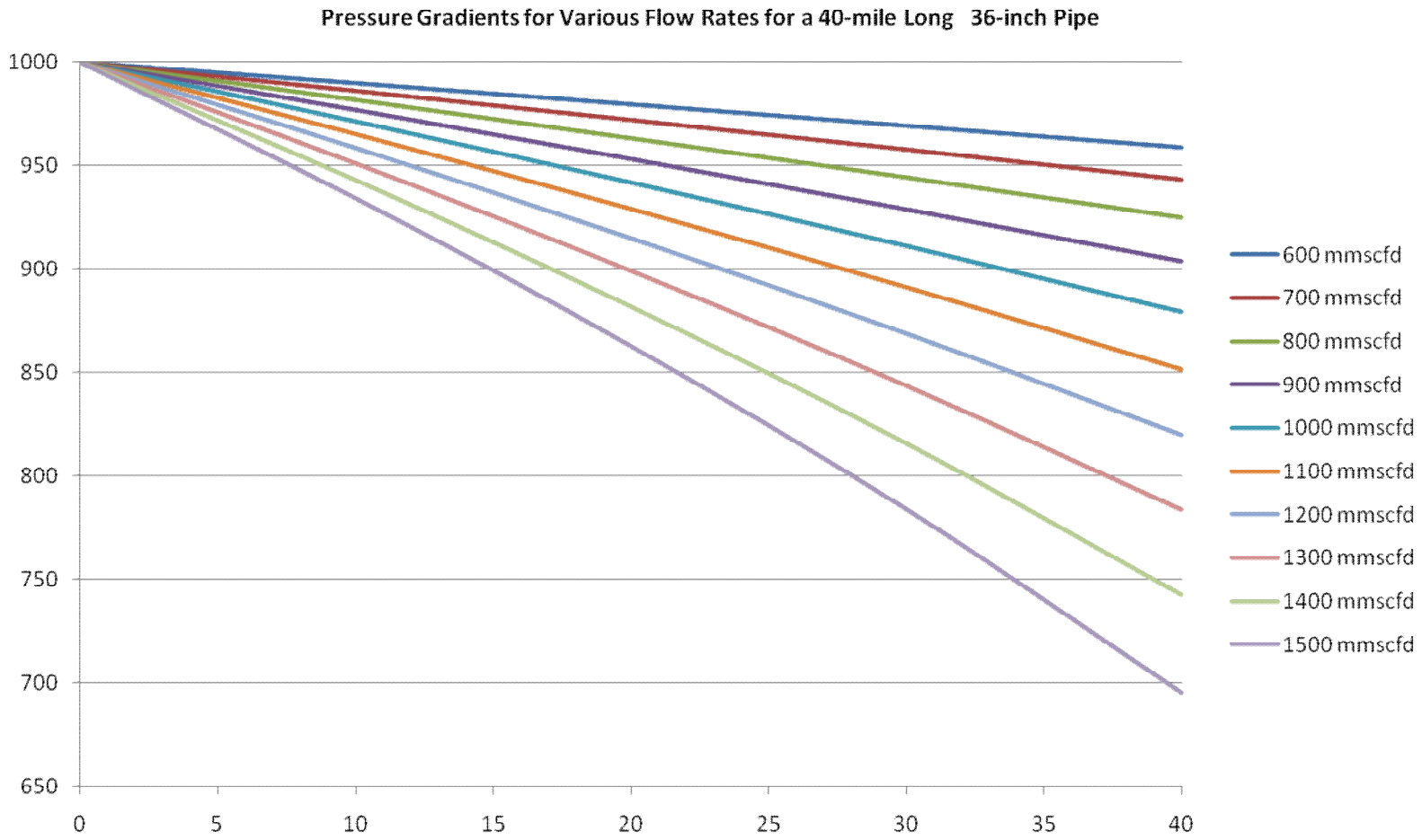


Hydraulics

- **Some basic principals:**
  - As gas flows in a pipe, friction results in gas pressure decreases (pressure gradient)

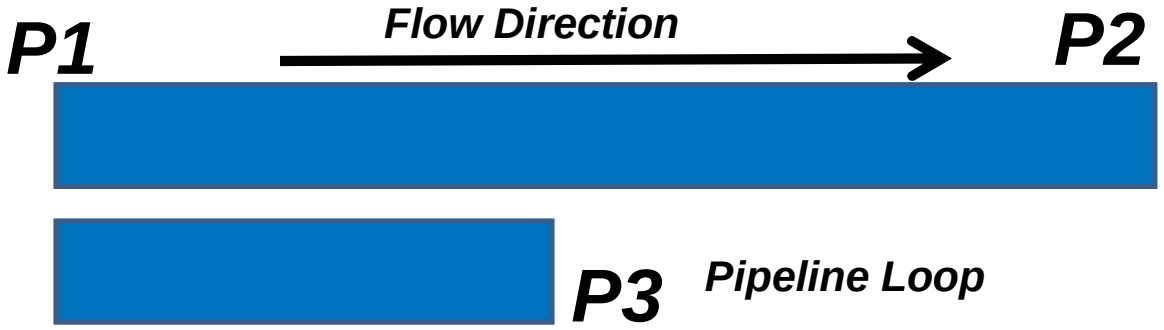


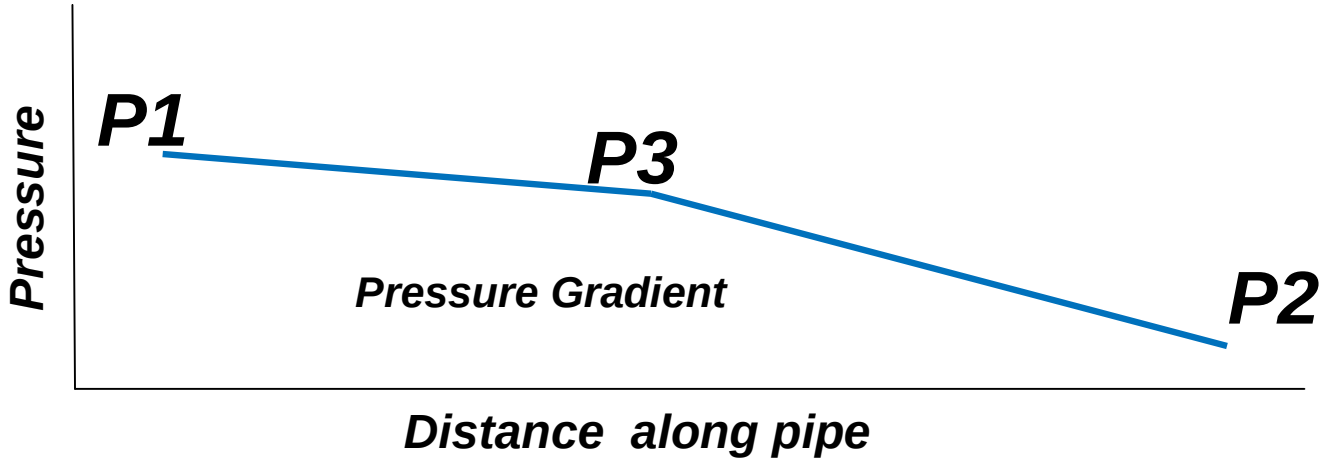
Hydraulics


Pressure Gradients for Various Flow Rates for a 40-mile Long 36-inch Pipe
1000
950
900
850
800
750
700
650
0
5
10
15
20
25
30
35
40
600 mmscfd
700 mmscfd
800 mmscfd
900 mmscfd
1000 mmscfd
1100 mmscfd
1200 mmscfd
1300 mmscfd
1400 mmscfd
1500 mmscfd

Hydraulics

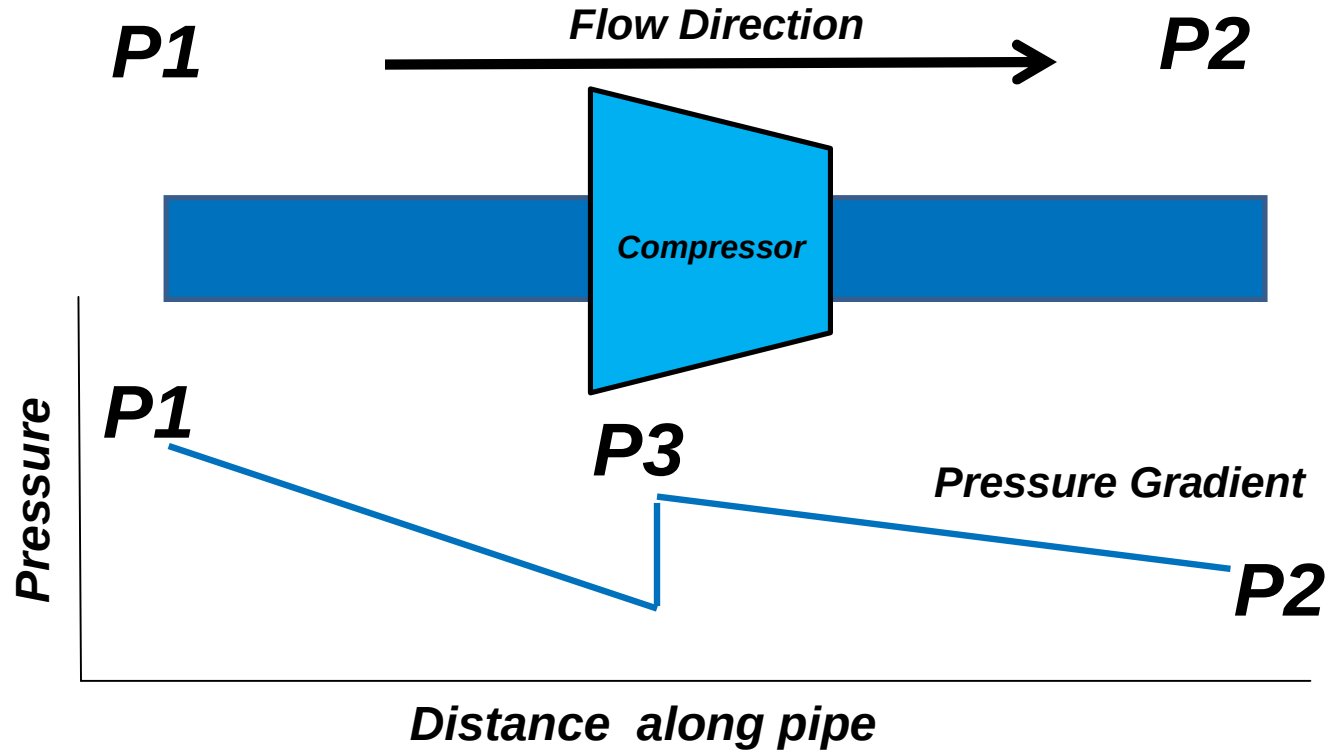
- **Some basic principals:**
  - Looping of existing pipes improves overall segment pressure gradient, allowing more flow





Hydraulics

- **Some basic principals:**
  - Compression is used to increase the gas pressure in a pipeline system. This increases flow in the system and can improve the pressure gradient in the pipeline downstream of the compression.



Compressors – Two Types

Positive Displacement
- Reciprocating
- Rotary Lobe
- Sliding Vane
- Screw

Dynamic
- Centrifugal
- Axial Flow

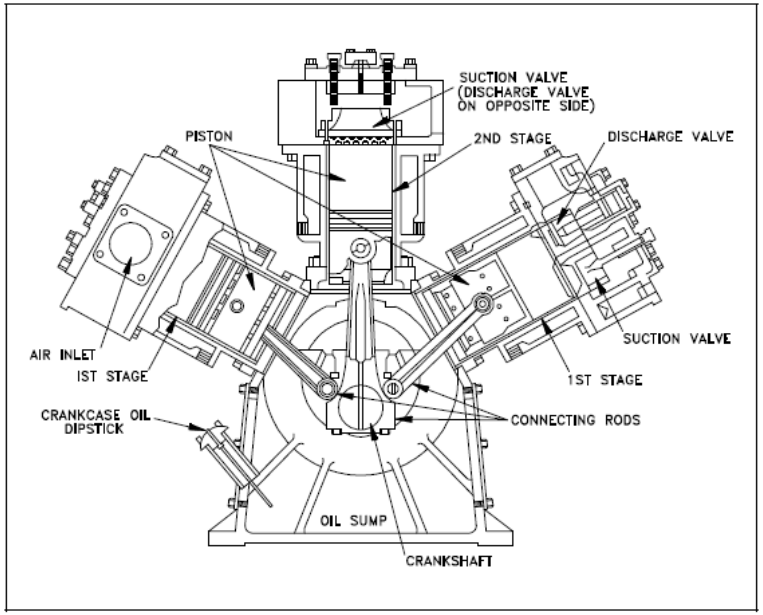
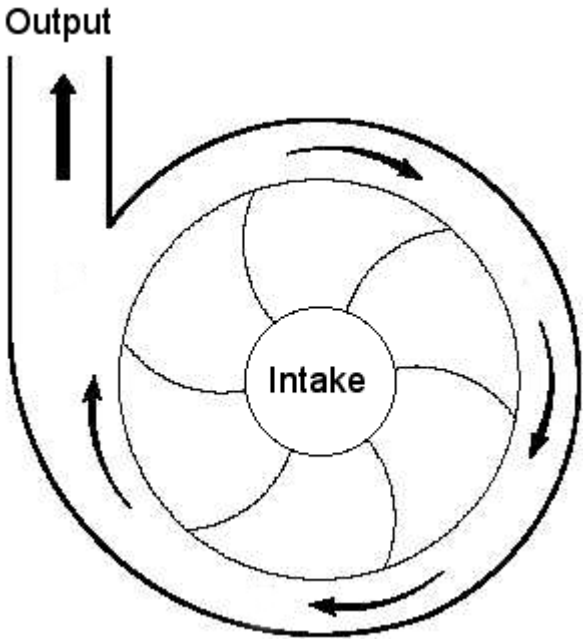
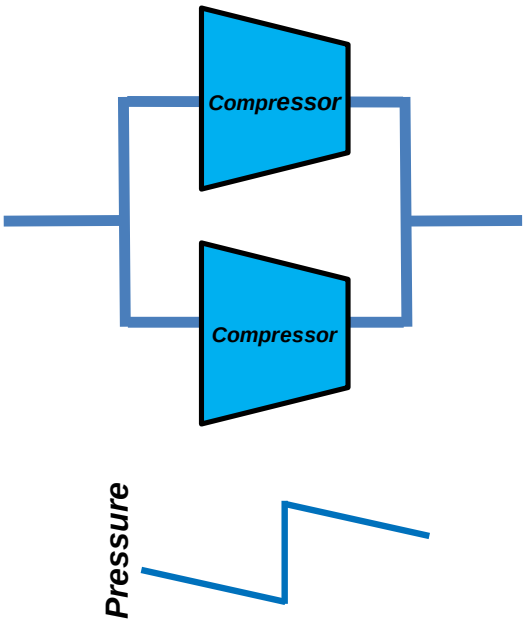


Figure 1 Reciprocating Air Compressor

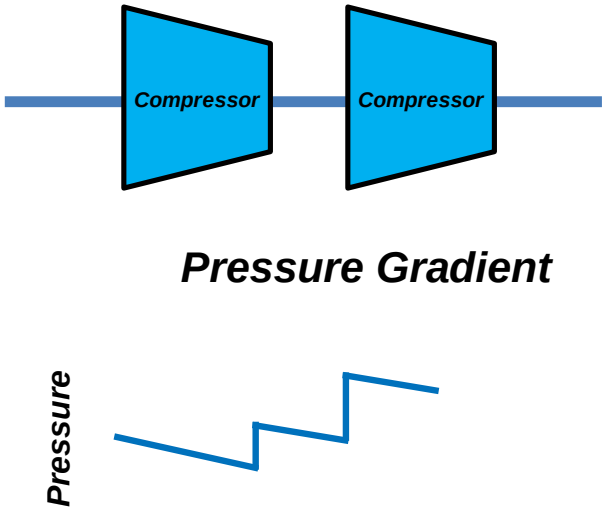


Compression

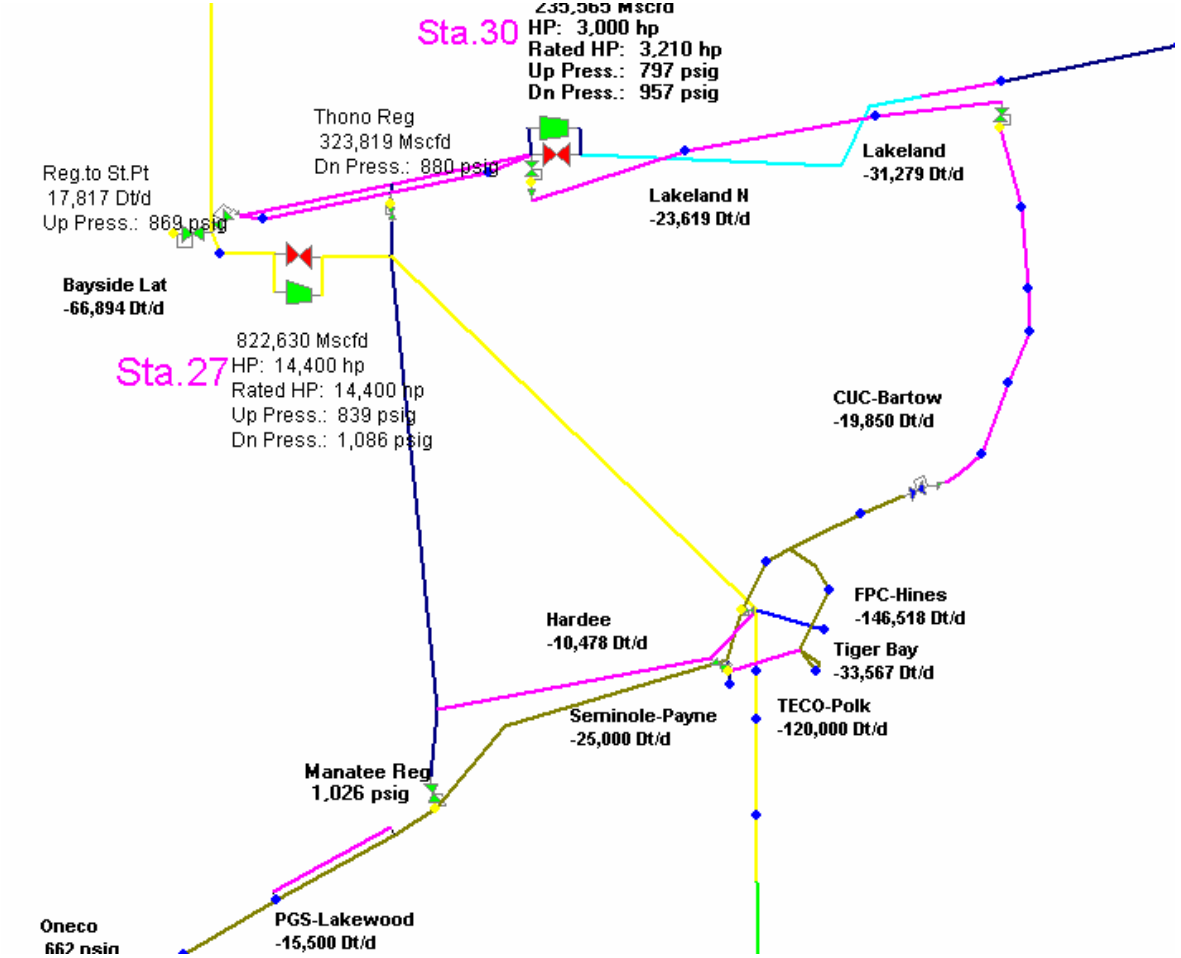
- **Parallel Operation**
  - Each unit handles a portion of the flow across the entire compression ratio needed



- **Series Operation**
  - Each unit handles the entire flow across a portion of the compression ratio needed



What is a Simulation Model?



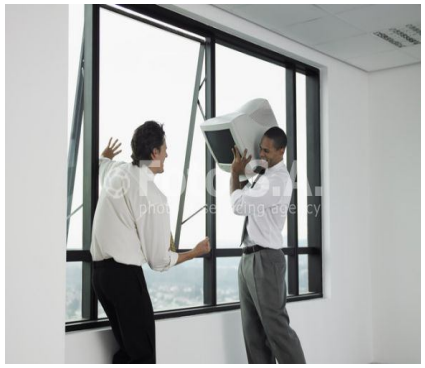
Pipeline Simulation

- Provides pressure, flow, temperature, volumes at each point in system
- Allows for determining impact to system capacity in event of outages
- Allows for determination of best facilities for incremental volumes
- Characteristics of a good simulation model:
  - Number of unknowns must equal the number of nodes in the model
  - Must have one unknown flow
  - Must have one known pressure
  - Make sure all nodes are connected!
  - Calibrate your model to actual data

Your Tool Belt

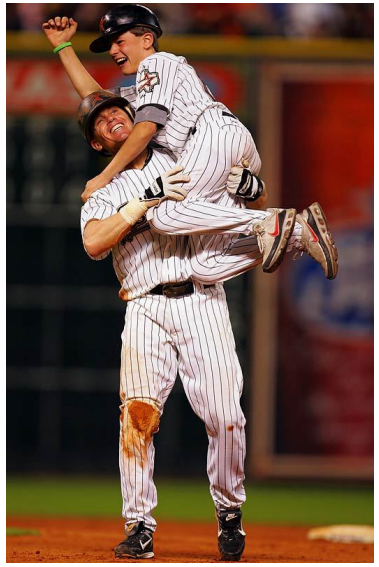
The Effects of Pipeline Simulation on a Facility Planner

Frustration



Fatigue

Elation



Ways to Expand a Pipeline System

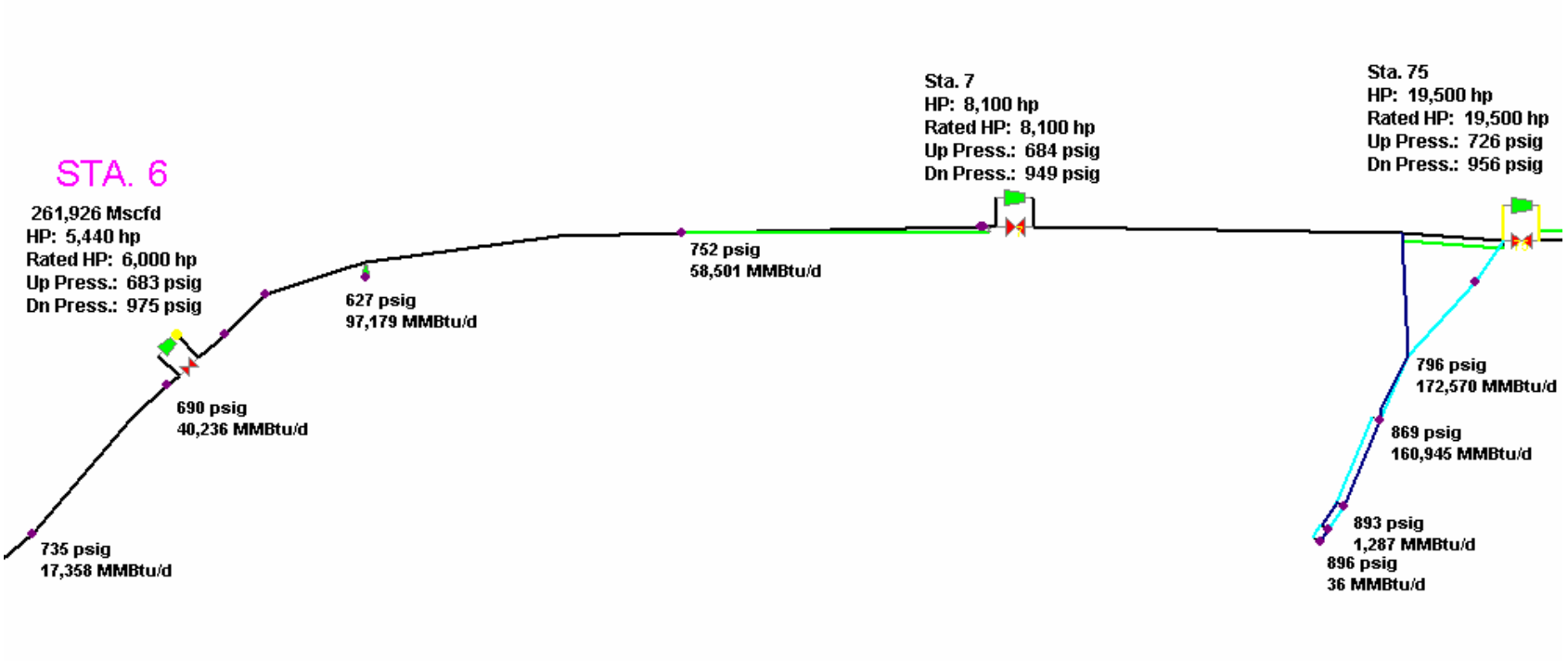
- Compression
  - Relatively inexpensive expansion on new systems
  - O&M, fuel or electric power cost increase
  - Utilizes more MAOP of system
- Loop
  - Increases line pack
  - Decreases pressure loss
  - Low O&M relative to compression
  - Increased operational flexibility (multi-line services vs. single-line)
- Combination of Compression and Loop
  - Economic considerations
  - Operational constraints
  - Tailored system
- Increase the MAOP of a system
  - Little or no construction activity relative to new pipe, looping or compression

Loop versus Compression

- To achieve incremental volumetric flow, on a particular portion of a system, 1 incremental mile of 36-inch looping equates to approximately 1,500 hp of incremental compression:
  - So, if we assume 1 mile of 36-inch looping costs $7 million AND
  - 10,000 hp compressor station costs $60 million AND
  - An incremental volume of 100 mmcf/d requires 6 miles of looping or 9,000 hp of compression to maintain system integrity, THEN:
  - The cost of looping is less than a new compressor unit – USE LOOP.

When to Add Loop

- Loop is added to increase the amount of volume that can be moved between compressor stations
- Increase the suction pressure at downstream compressor stations
- Reduce bottle necks
- Increase line pack for high transient flows



Steady State Analysis

- Allows you to model a specific moment in time
- Assumes a constant flow rate
- Foundation of all pipeline systems and transient design
- Used to determine the maximum capacity of a lateral or pipeline system
- Analyze a specific situation
- Is the basis for design in the Supply Area of a system

Transient Analysis

- Looks at how a pipeline system performs under fluctuating loads
- Allows one to analyze system capacity and how the overall line pack is affected
- Determines how a system will operate over a several day period
- A transient analysis will help you to determine the need for additional facilities on a pipeline system
- Allows one to look at a pipeline system under various seasonal conditions

Things to consider when modeling

- Heating Value
- Frictional effects / pipe roughness
- Pipeline MAOP
- Specific Gravity
- Suction and discharge temperature
- Pipe wall thickness
- Gas velocity
- Ground temperature
- Heat transfer between the pipe and ground
- Compression ratio
- Fuel factor
- Compressor efficiency
- Pressure loss due to crossover valves and station yard pipe

Things to Consider when Designing

- Contracted volume and pressure obligations
  - System constraints
- Compressor spacing
  - Compression ratios
  - Discharge temperature limits
- Pipeline efficiency
- Load profiles, as necessary
- Always design for worst case (peak conditions)
  - Summer AND Winter Peaks
- Seasonal changes
  - Ground temperatures
  - Ambient air temperatures
- Lateral capacities
- Always ask your self “Does this make sense”
- Always remember that you are designing a system – not a segment!

Key Traits a Facility Planner Must Have!

- Knowledge of the Basics
- Patience
- Focus
- Persistence
- Positive Attitude
- Creativity
- Resourcefulness
- Industriousness
- Curiosity
- Ability to Communicate

Basic Modeling and Best Practices

Thank you

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