Phase Transition Control
A method to improve gas-lift compressor operations

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Phase Diagram for Liquids-Rich Gas

- Yellow region is where our gas-lift compressors need to operate
- Keep gas temps above hydrocarbon dewpoint temperature in 100% vapor phase – typically 130°F
- No fluid condensing means:
  - No scrubber dumps
  - No dump line freezes
  - No hydrates, no methanol
  - No high vapor pressure crude
  - Reduced tank vapor emissions / flaring
The Problem: Compressor Package Design

• Gas Sales design utilized for gas-lift application
  • Gas Sales requires 110°F temperatures or lower for glycol dehy
  • Condensing out hydrocarbons in middle stages helps prevent glycol fouling / foaming

• Cooler gas outlet temperature normally not measured
  • Only requires additional thermowell and thermocouple
  • Control panel often have spare inputs for these

• Engine jacket water in same cooler housing as gas sections
  • Fan operates at same speed, summer or winter
  • In winter, air exits the jacket water section slightly above ambient
  • Fan “stirs” this cold air, and it cools the backside of the gas sections
  • Despite closed gas section louvers on the front, gas temps drop
The Result: Problems

- Propanes, Butanes, Pentanes, and Hexanes+ condense
  - Collect in scrubbers, then freeze dump lines when they vaporize
  - Frozen dump lines then cause compressor shutdown due to high level
  - When condensing in aftercooler, will form hydrates in downstream piping
  - Traditionally solved by methanol injection
  - In cold climates, heat tracing and insulation provide questionable solution to heat of vaporization related freezing

- Not all scrubber liquids vaporize when dumped to tank
  - Some mix with crude, elevating the Reid vapor pressure
  - Regulations require keeping it separate (dispose in water tank?)

Seems far better to prevent these liquids from forming in the first place by keeping the temperatures elevated....
Is there a downside to Methanol Injection?

• Some say it works against corrosion inhibitor proper film development (Natural Gas Hydrates: A Guide for Engineers, John Carroll 2009)

• Methanol normally contains dissolved oxygen, returns as iron oxide

Quoting NACE 07663 (Park 2007):

“High quantities of methanol may reduce the success of a corrosion inhibitor program. Although corrosion mitigation is used in conjunction with methanol injection, as an industry-wide and commonly accepted practice, there is very little literature on the subject.”
What are the options?

• Build gas-lift compressors instead of gas sales compressors
  • Strict control of gas temperatures a priority
  • May utilize shell and tube exchangers with antifreeze mixture
  • Not practical due to the huge inventory of existing gas sales compressors

• Design a retro-fit solution to the existing gas sales design
  • Bolt-on system that maintains elevated cooler outlet temperatures

This is our Phase Transition Control Solution

Continue if you want the nitty gritty details....
Phase Transition Control Basics

• Conserve adiabatic heat of compression from first two stages
  • Third stage normally does little work, and has largest cooler, so needs heat passed on from the first two stages
  • Smart controller sees aftercooler discharge temp, then elevates outlet temp setpoint for second interstage gas cooler
  • If second interstage cannot reach its temp setpoint, then Smart controller elevates outlet temp setpoint for first interstage gas cooler
  • First interstage gas cooler outfitted with actuator, while louvers shut on second and third stage

• Smart Controller pulls 8 temperatures from the Murphy Centurion
  • 3 Cylinder Discharge Temps, 3 Gas Cooler Outlet Temps, Oil Temp
  • If engine driven, pulls engine jacket water temp, and Smart Controller measures cooling water return temperature
Phase Transition Control Basics

• Controller keeps temperatures within allowable windows by
  • Changing VFD speed setting and operating louvers as needed

• Allowable temperature windows:
  • Second and third stage cylinder discharge maximum temps of 295°F
  • Three cooler outlet temps above 130°F
  • Compressor oil temperature below 185°F
  • Engine jacket water below 200°F
  • Cooling water return between 120°F and 130°F

• Typical Results:
  • Discharge temps between 240°F to 300°F
  • Interstage scrubber temps (first and second cooler outlet): 140°F to 190°F
  • Final discharge temps: 90°F to 150°F depending on conditions
Phase Transition Control - Advanced

• Smart Controller determines theoretical discharge temp, and subtracts from actual temp for great performance KPI
  • Pulls pressure information from Murphy
  • Also pulls RPM and shutdown information

• Compatible with any Scada system

• Host webpage accessible only within operator firewall (no cloud)

\[ T_2 = T_1 \left( \frac{p_2}{p_1} \right)^{(k-1)/k} \]

k: Ratio of Specific Heats
Challenge:

• Check your compressors:
• Do they measure the gas temps coming out of any cooler? Going into any cylinder?
• Measure ambient temperature, then measure the temps going in and out of each cooler

How do they compare to the temperatures with PTC?
Try PTC today, and start saving money on methanol, while putting your rich gas downhole instead of down the flare line.