Nuts & Bolts of Hydrocarbon Liquid Dropout and Impacts on the Distribution System

Gas Standards and Integrity Management

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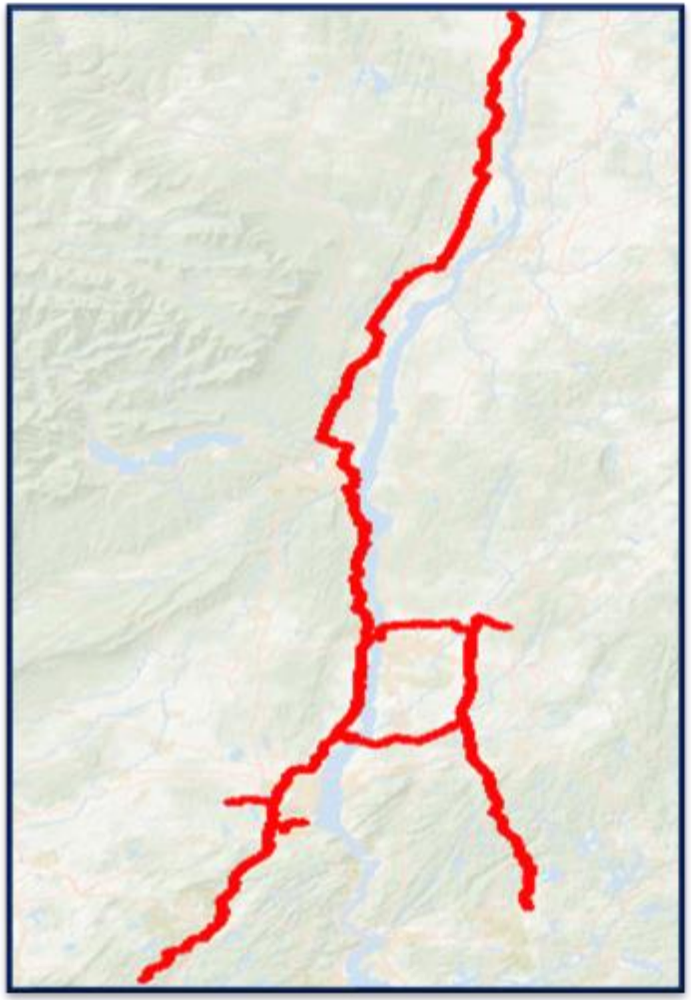
Background

Central Hudson's Gas System



- Central Hudson receives natural gas from four different suppliers
- Central Hudson's natural gas system consists of around 1,400 miles of pipeline and serves around 90,000 customers
- In 2022, the total amount of natural gas delivered by Central Hudson was 11,013,860 Mcf

Natural Gas Composition

- Natural gas is made up of mostly methane
- Trace amounts of CO_2, H_2S, and water vapor can also be found
- The composition of the natural gas mixture directly affects the properties

Constituents
Methane
Ethane
Propane
Butane
Pentane
Hexane+
Oxygen
Carbon Dioxide
Nitrogen
Hydrogen Sulfide (H2S)

Natural Gas Quality

Properties
BTU (Energy Content)
Specific Gravity
Hydrocarbon Dew Point
Interchangeability Index

» **Protects Customer Equipment & Compatibility** : Poor gas quality can reduce efficiency and create unsafe combustion. Additionally, it can cause issues with equipment designed for specific gas standards

» **Maintains Pipeline Integrity**: Impurities like moisture lead to corrosion, increasing maintenance costs and risking pipeline failure

» **Ensures Accurate Billing**: Consistent gas quality makes sure customers are charged correctly based on energy content

Heavy Hydrocarbons

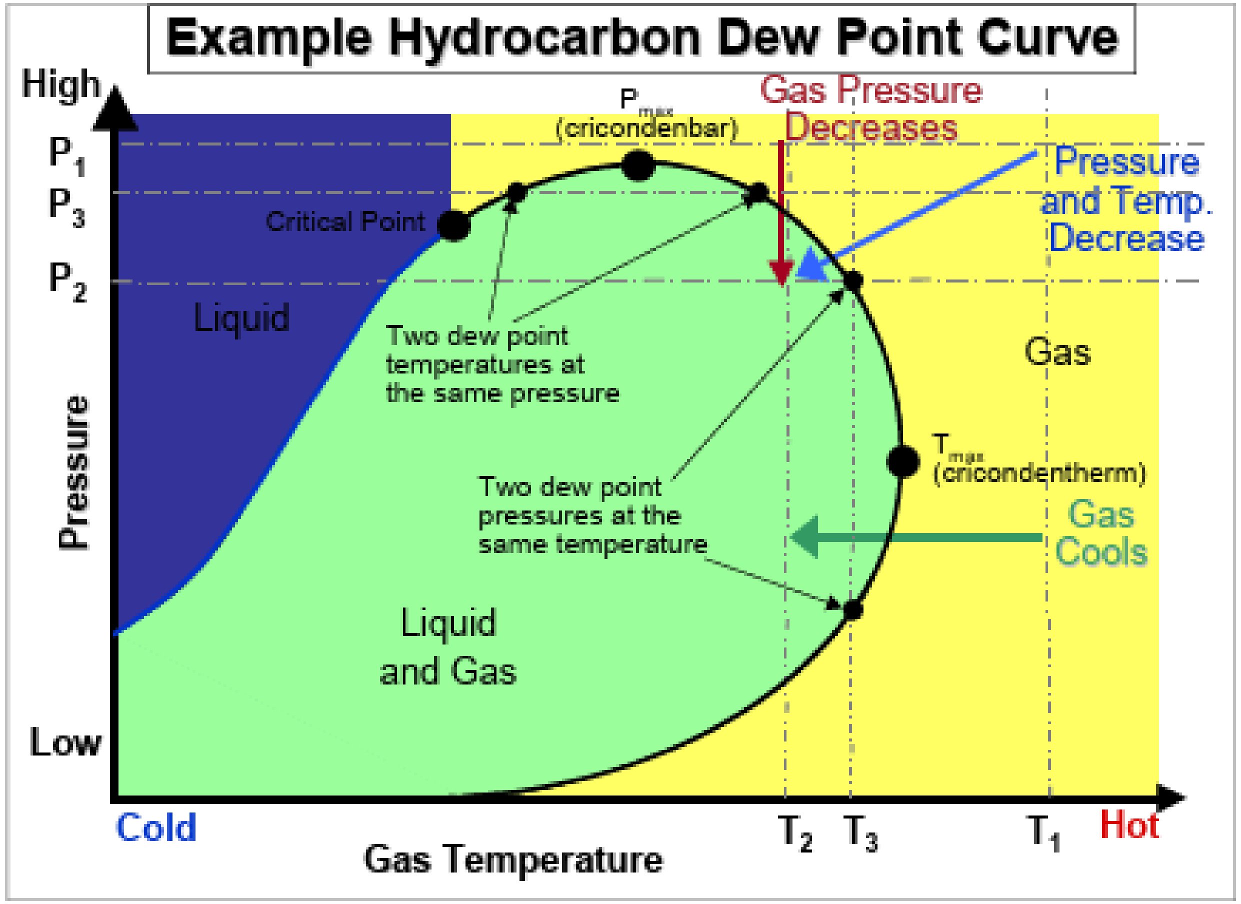
- Heavy hydrocarbons can condense in pipelines, causing blockages or damages
- "Wet" natural gas is processed to meet pipeline specifications
- Small amounts of heavy hydrocarbons can have effects on local distribution systems

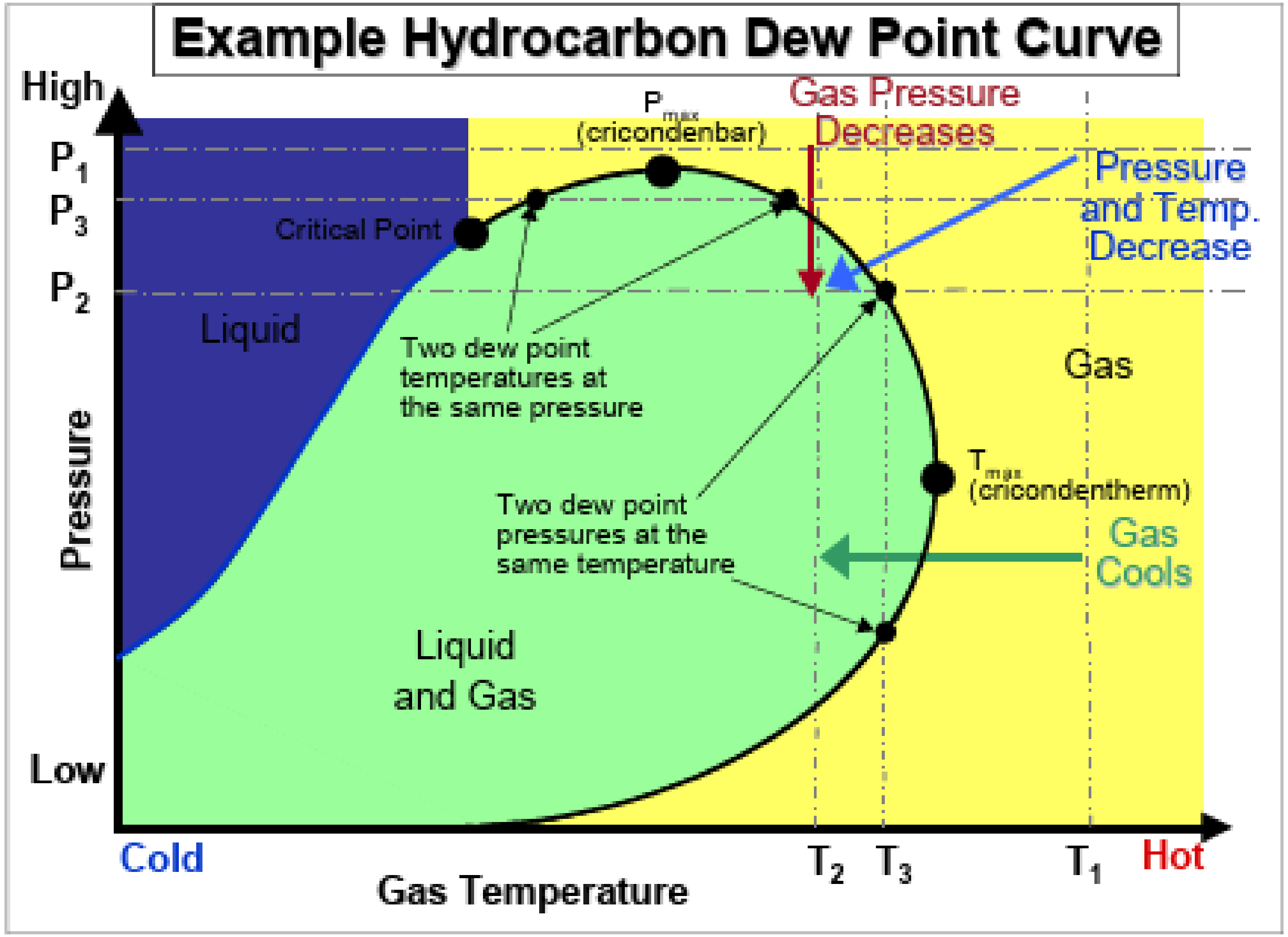
Hydrocarbon	Formula	Boiling Point (°F)
Methane	CH_4	-258.7
Ethane	C_2H_6	-127.48
Propane	C_3H_8	-43.78
Butane	C_4H_{10}	31.1
Pentane	C_5H_{12}	96.98
Hexane	C_6H_{14}	155.66
Heptane	C_7H_{16}	209.12
Octane	C_8H_{18}	258.08
Nonane	C_9H_{20}	303.44
Decane	$C_{10}H_{22}$	345.38

Hydrocarbon Dew Point

Hydrocarbon Dew Point

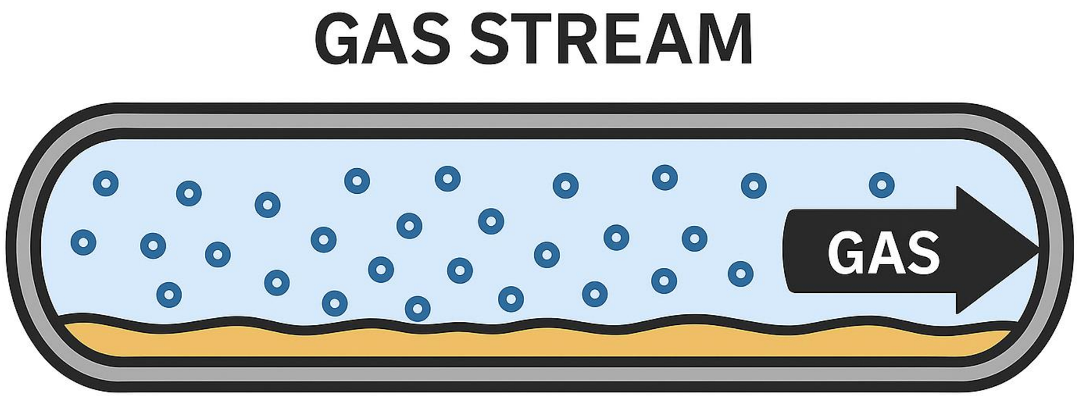
- **Hydrocarbon Dew Point**: the temperature at which hydrocarbons begin to condense into liquid form
- **Cricondentherm:** the maximum temperature at which liquid and vapor phases of a hydrocarbon mixture can coexist
- Phase diagrams can be used to predict the behavior of natural gas. They can be developed using the Peng-Robinson Equations of state



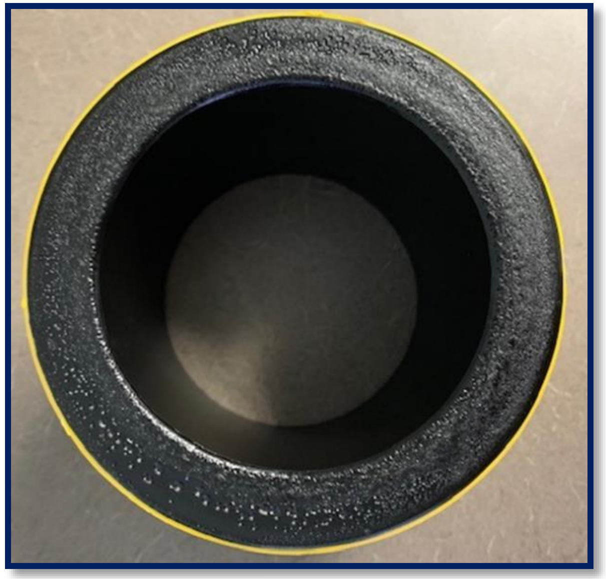

Example Hydrocarbon Dew Point Curve
High
P1
P3
P2
Low
Pressure
Pmax
(cricondenbar)
Gas Pressure
Decreases
Pressure
and Temp.
Decrease
Critical Point
Liquid
Two dew point
temperatures at
the same pressure
Gas
Tmax
(cricondentherm)
Two dew point
pressures at the
same temperature
Gas
Cools
Liquid
and Gas
Cold
Gas Temperature
T2
T3
T1
Hot

Hydrocarbon Liquid Dropout

- As natural gas depressurizes and cools below the dew point, tiny liquid droplets condense and are carried in the gas stream
- The droplets will begin to fall due to gravity and the difference in density between the constituents. The liquid will pool at the lowest point of the pipe
- This most frequently occurs at pressure reductions. Based on the Jules-Thomson effect, every 100 PSI dropped the temperature will lower by ~7°F



Hydrocarbon Permeation

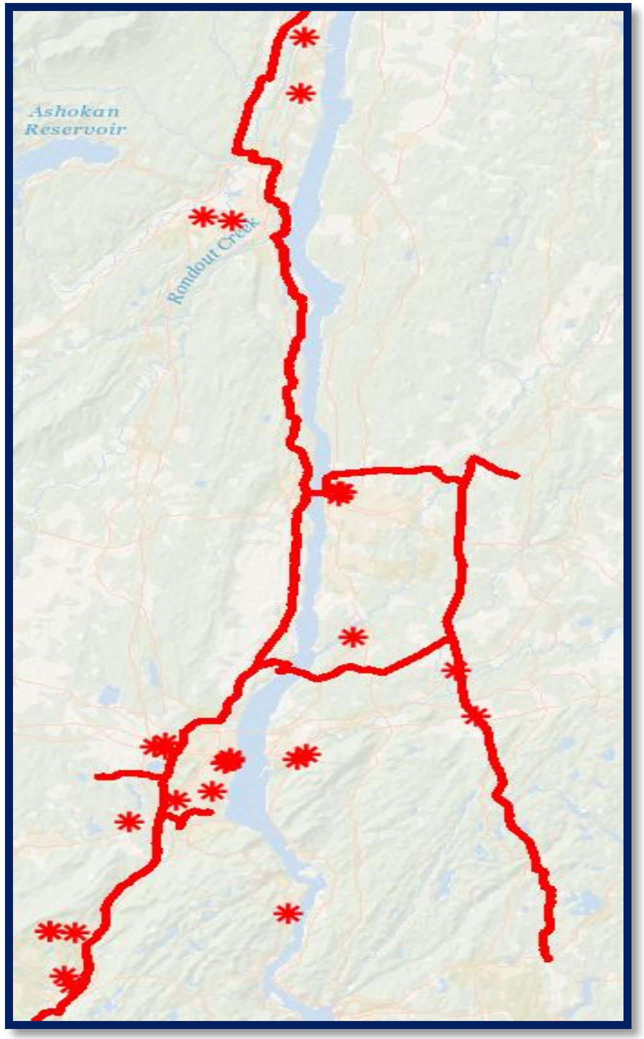


- Liquid hydrocarbons are absorbed into plastic pipe
- Hydrocarbons in the contaminated pipe will bubble and boil off when high heat is applied (e.g., during fusion) and create voids
- Using heated fuses would be unsafe and a mechanical coupling would be required

Remediation Steps

Preliminary Work

- » Central Hudson conducted an investigation to determine the source of the hydrocarbon contamination
  - » Investigated soil contamination from sources such as gas stations
  - » Investigated pipe distributors to ensure pipe is not being delivered already contaminated from the manufacturing process
- » Established testing procedures to ensure fusion is appropriate
- » Created a form to track contamination in GIS



Reference Materials

- These documents are useful for identifying when/where this happened in your system and how to mitigate the problem
  - NGC+: White Paper on Liquid Hydrocarbon Drop Out in Natural Gas Infrastructure
  - AGA: Natural Gas Quality Management Manual
  - NGA/GTI: Interconnect Guide for Emerging Fuels into Energy Delivery Networks
  - Jana: White Paper – An Operations Solution to Heavy Hydrocarbon Permeation in Gas Pipelines

Identified Steps

1. Review historic gas quality and contractual agreements
2. Estimate the historic hydrocarbon dew point
3. Develop phase diagrams for each gas supply
4. Use hydraulic modeling to trace gas supply in your system
5. Review pressure reductions using appropriate phase diagrams for liquid dropout
6. Field test trouble areas to confirm liquid dropout

Historic Gas Quality and Contractual Agreements

» It is important to review gas quality tariffs and understand how transmission pipeline operators are maintaining compliance. This includes the FERC Tariffs and any contractual agreements between the LDC and the transmission operators

- What is the hydrocarbon dew point limit and how it is measured
  - Companies use different measurements, e.g., calculating the HCDP and limiting C6+, C4+ and C2+
- Leverage existing gas quality data to compare historic quality to tariff limits
  - Review ensures compliance and can highlight a need to update quality measurements or equipment
- Any necessary updates that are identified should be supported by data

Historic Hydrocarbon Dew Point

» LDCs should use historic quality data to create an understanding of the hydrocarbon dew point.
  - Accuracy is dependent on available data. If only C6+ data is available, it can be broken down using common ratios. (C6/C7/C8 : 47%/36%/17%)
  - The hydrocarbon dew point can be estimated using the two equations below

- $\mathrm{GPM} = \sum_i \frac{10 * x_i}{\frac{ft^3}{gallon_{liquid}}}$ $\mathrm{GPM} = \sum_i \frac{1000 * y_i}{\frac{ft^3}{gallon_{liquid}}}$

x_i =mole percent of component "i" in the gas stream y_i = Volume percent of component "i" in the gas stream

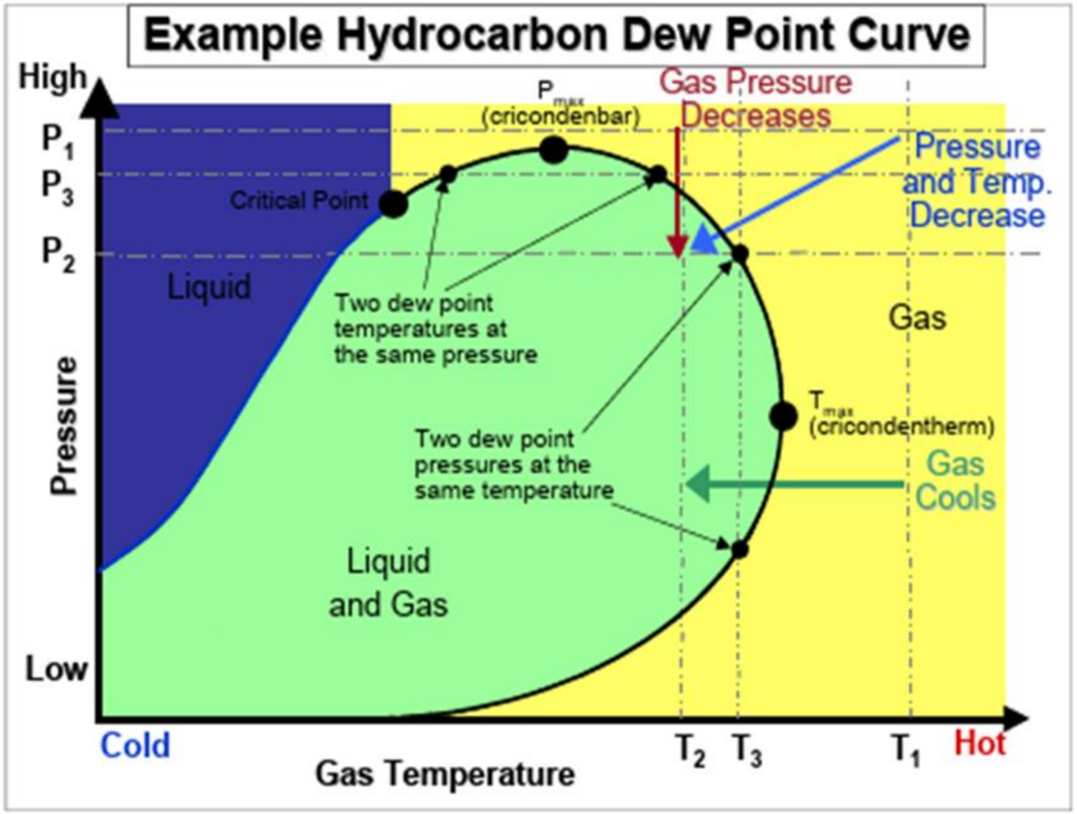
$\frac{ft^3}{gallon_{liquid}}$ can be found in GPA 2145-16 (The Gas Producers Association) for each component

  - CHDP(°F) = $A * (GMP)^B + C$

    A=323.451 B=0.195 C=-145.9

American Gas Association. (2013).

Phase Diagrams

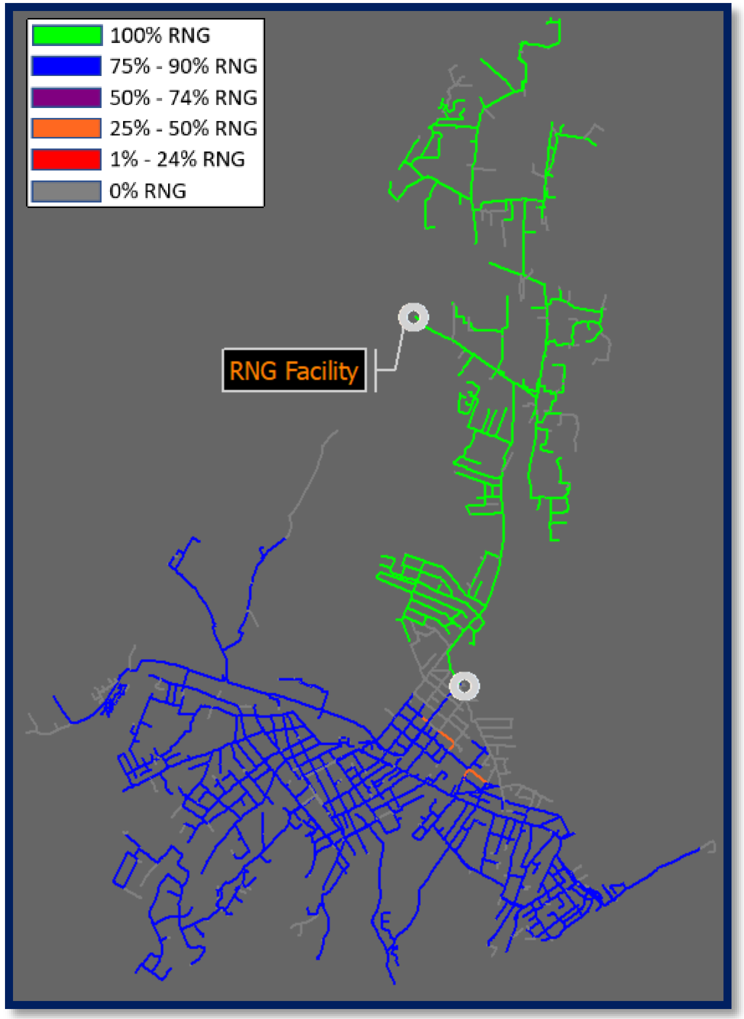


- » Phase Diagrams can be developed using Peng-Robinson equation of state
- » There are softwares available for purchase to create phase diagrams or LDCs can write their own programs
- » The curve on the phase diagram is made up of the bubble point and dew point curves

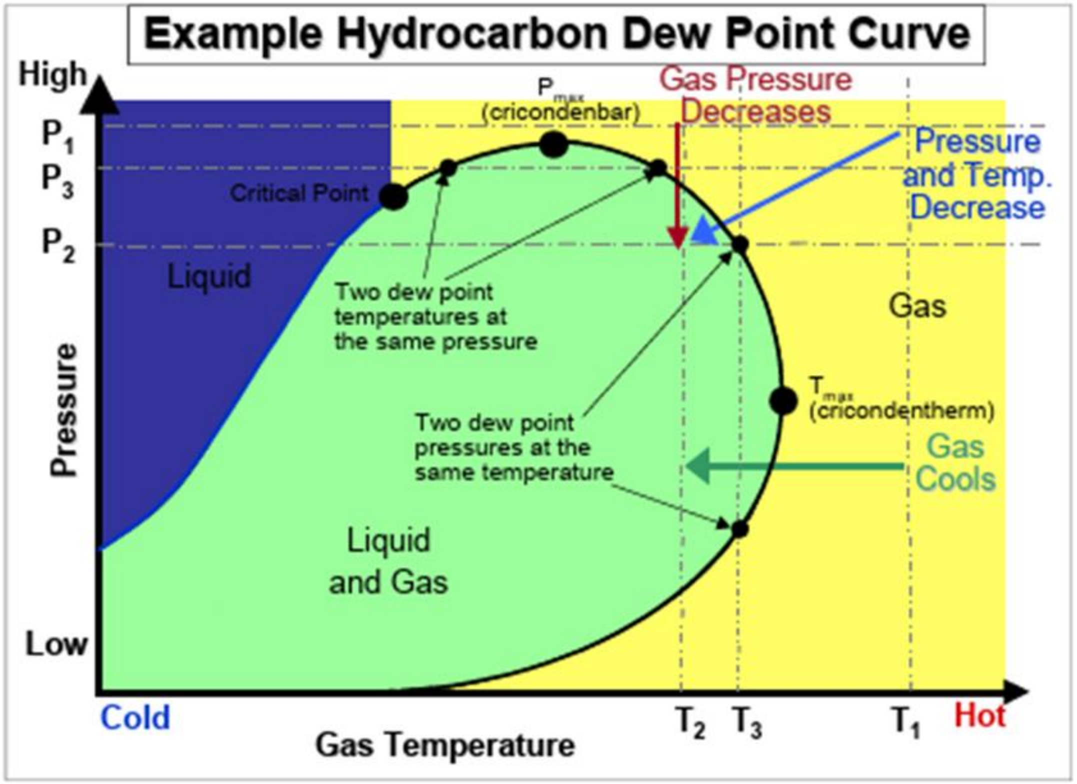
Peng, D.Y., & Robinson, D.B. (1976).
NGC+ Liquid Hydrocarbon Drop Out Task Group. (2005).

System Planning

- Therm zones for each gas supply can be found using hydraulic modeling and median gas quality parameters from each gas supply
  - Provides insight into the gas supply at each pressure reduction
  - Heating degree days matter as zone change based on demand
  - Median is used since it provides a real value seen by the gas system



Review of Pressure Reductions



» Each pressure reduction can be plotted on the appropriate phase diagram to check if the downstream gas will fall into the liquid and gas phase

- Heaters and multistage reductions should be accounted for in the plot
- Identify the lowest temperature and resulting highest pressure

Field Testing

- Strategic installation of a C9+ gas chromatograph(s) can confirm and monitor hydrocarbon liquid dropout
  - The previous steps should be used to minimize the capital investment and optimize the value of the collected data
  - Chromatographs can provide insights for circumstances, frequency, intensity, and remediation
  - Alternatively, a portable dew point tester can be used but insights will be limited

Future Steps

- Once problem areas have been identified various solutions can be used
  1. Installation of a heater to prevent temperature below the dew point
  2. Upgrade to a multistage pressure reduction to reduce temperature drop
  3. Update of contractual hydrocarbon dew point if appropriate (Recommended 15°F)
- After further hydrocarbon liquid dropout has been prevented the existing contamination will eventually desorb from the plastic pipe over time
  - Heating can be used to speed up and encourage desorption

References

American Gas Association. (2013). *Natural Gas Quality Management Manual*

M.F. Alfradique1 and M. Castier2. (2007). Calculation of Phase Equilibrium of Natural Gases with the Peng-Robinson and PC-SAFT Equations of State

JANA Corporation . (2021). *An Operations Solution to Heavy Hydrocarbon Permeation in Gas Pipelines*

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Northeast Gas Association , & GTI Energy . (2022). *Interconnect Guide for Emerging Fuels into Energy Delivery Networks*

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Questions