

THERMODYNAMIC CAUSES OF GAS LIFT COMPRESSOR FAILURES IN UNCONVENTIONAL WELLS

Sofia Rodriguez

Bob L. Herd Department of Petroleum Engineering

Texas Tech University

Gas lift (GL) compressor downtime in unconventional reservoirs is primarily driven by temperature and pressure driven phase behavior changes. In liquid rich gas streams hydrocarbon dew points often approach normal surface operating temperatures, causing liquid drop out during compression. As modern unconventional wells demand higher discharge pressures, both condensation and hydrate risk increase. With increasing operating pressure, the margin between normal compression conditions and phase change becomes smaller. Understanding how pressure, temperature, and gas composition interact is critical to preventing liquid formation and protecting compressor reliability.

ABSTRACT

Modern unconventional wells are increasingly dependent on GL compression. By 2024, GL accounted for roughly 30% of initial artificial lift selection across the Midland Basin and nearly 40% across the Delaware Basin.¹ In the Permian, produced gas contains high concentrations of propane and butane resulting in liquid rich gas compositions⁵, forcing compressors to operate near phase boundaries. Recorded gas specific gravities range from 0.72-0.785 or in some cases 0.80-0.97³. Temperature fluctuation within compression stages can allow liquid dropout, shown in Figure 1, both of which contribute to compressor downtime. Field runtime data collected over multiple years found that 53% of shutdowns were due to process upsets and gas conditions.⁵ The data suggests that downtime in these systems are driven by gas conditions, temperature and pressure phase changes rather than strictly mechanical issues. Higher discharge pressures are often required to sustain production from unconventional wells, increasing hydrate formation risk. Additionally, exposure to low ambient temperatures promotes hydrate formation as well.

1.31 MMscfd Water-Saturated, Suction Temp = 80 °F; IC1/IC2/AC Temp = 80 °F

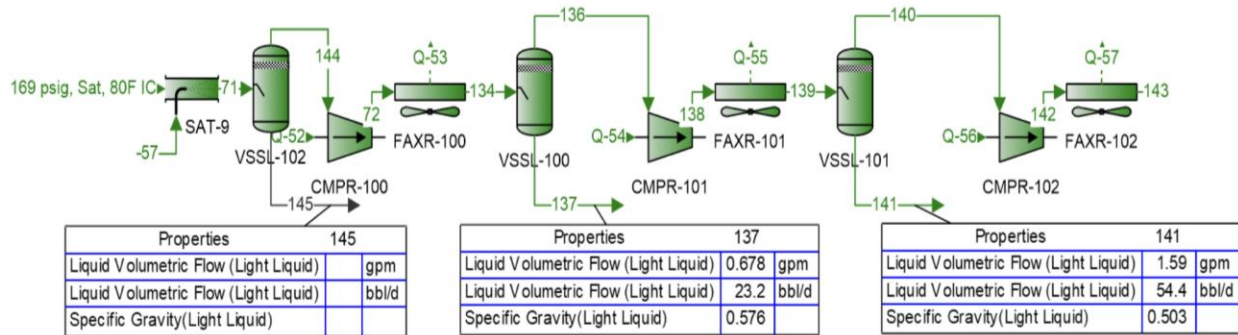


Figure 1-Process flow model at operating conditions (5)

INTRODUCTION

The demand for GL across the Delaware basin has grown rapidly over the past four years. The increased deployment of GL systems emphasizes the need for reliable compression.¹ GL is commonly applied to high GORs, deviated trajectories, production streams containing solids and a range of production rates.⁶ Similarly, the demand for high pressure (HP) GL in modern unconventional has increased as deeper injection points improve lift performance. HPGL refers to GL operations injecting at significantly higher injection pressure than conventional GL ~1440 psig < 5000 psig⁷ While GL operations offer flexible operating conditions it depends on continuous compressor runtime. Liquid rich gas increases downtime due to condensation at higher temperatures compared to lean gas resulting in liquid drop out within the cylinder. As shown in Figure 2, hydrocarbon condensate forms when temperatures drop below 120F due to the richness of the gas. Cold weather also increases downtime due to hydrates forming within the system leading to flow restriction and over pressurized shutdowns.² As shown in Figure 3, the hydrates form when water and natural gas reach pressure and temperature that fall within the hydrate stability region. At higher pressure typical of HPGL, hydrates can develop even at moderate temperatures, while colder weather further pushes operating conditions into this region increasing risk. Following the February 2021 winter storm, the Texas Railroad Commission (RRC) established the Critical Infrastructure Division (CID) to enforce weatherization standards across natural gas facilities.⁴ Under this ruling, gas wells producing more than 250 Mcf/day and qualifying oil leases are designated as critical suppliers during energy emergencies.⁴ Facilities necessary to maintain production which includes compression must be included in weatherization planning and compliance documentation. A significant portion of unconventional wells in the Permian Basin exceed this threshold. Downtime due to weather is no longer only an operational inconvenience or loss in production; it now represents potential regulatory exposure and critical infrastructure non-compliance.

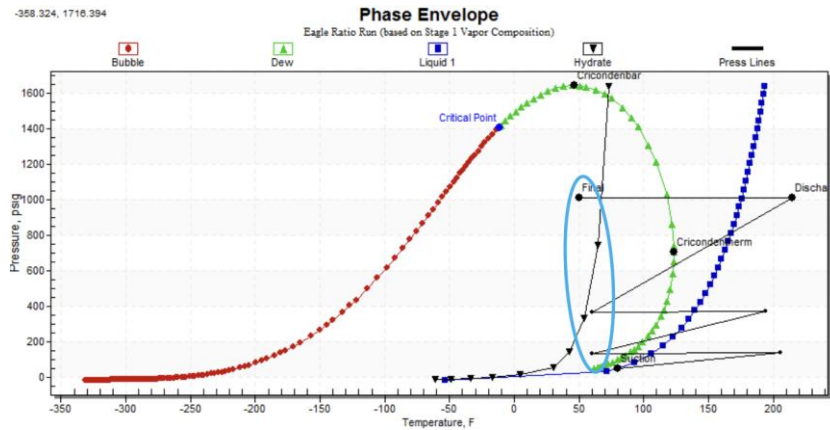


Figure 2-Phase Diagram 30F Ambient Liquid Rich Gas (3)

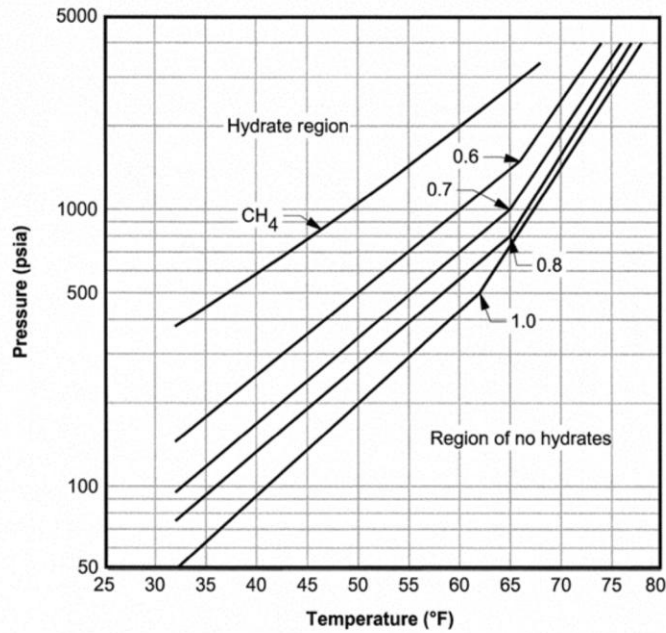


Figure 3-Hydrate Chart for Natural Gas (2)

METHODOLOGY

The methodology for this study began with defining the core problem: determining whether gas lift compressor shutdowns are due to mechanical failures or thermodynamic phase change incidents. A comprehensive literature review was conducted, including reviewing technical papers, conference presentations, and training

workshops. In addition, discussions were held with industry professionals who have direct experience with gas lift compression systems in the Permian Basin. A detailed analysis was then performed to identify primary compressor downtime causes, focusing on gas composition impacts on phase behavior, hydrate formation, and temperature-pressure sensitivity within multistage compression along with the implications of compressor vulnerability under weatherization regulations. This process identified recurring thermodynamic vulnerabilities in gas lift compression systems and evaluated their operational and regulatory significance.

CONCLUSION

Gas lift compressor downtime is largely due to phase changes within the compression system. When the gas is cooled below its dew point during staged compression, liquids form and in cooler ambient temperatures or higher pressures, hydrates can also form. Field shutdown patterns suggest the same. This demonstrates that compressor reliability issues are due to gas conditions, temperatures, and pressure, not only mechanical failures. Mitigation strategies for liquid rich gas include: hot gas bypass⁵, reduce cooler size, automatic cooler bypass and louver controls, insulation on first stage³. To address cold weather hydrate formation operators may implement closure of louvers, bypass coolers, insulation, wind walls, heat exchangers, external heating, and/or inject methanol². In addition, the Texas Railroad Commission weatherization methods emphasize the need for documented and proven mitigation practices.⁴ Across all approaches, the common link is temperature control, which prevents condensation and hydrate formation therefore stabilizing the compressor operation.

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ACKNOWLEDGMENTS

The author would like to thank Wille Nelle from Flowco for their support and technical guidance in this research along with Ivory Villegas from Mewbourne Oil.