Hydraulic Simulations of Pipeline and Wellfield Network in West Texas

Executive Summary

This report presents a hydraulic analysis of a pipeline and wellfield network in West Texas, conducted using the EPANET modeling software. The primary goal of the study is to evaluate system performance under different demand scenarios, optimize control strategies, and assess potential risks such as pressure variations, water hammer, and air entrapment.

Study Purpose

The objectives of this analysis are to:

1. Establish control rules to maintain supply to terminal storage reservoirs (TSRs) while keeping system pressures stable.
2. Analyze the impact of control strategies on the wellfield system, approximately 20 miles upstream of the terminal storage.
3. Identify locations where high and low pressure conditions may occur under different demand scenarios.
4. Recommend optimal locations for pressure relief valves to protect the pipeline.
5. Suggest locations for air-release valves to prevent vapor lock.
6. Evaluate water hammer effects due to sudden shutdowns.

Study Area & Model Development

The study focuses on a 21-mile transmission pipeline connecting a wellfield to terminal storage reservoirs. The elevation profile ranges from 2800 ft (wellfield) to 2600 ft (terminal storage). A digital elevation model (DEM) and GIS-based QEPANET tools were used to develop the EPANET hydraulic model, incorporating:

1. A wellfield system with multiple wells supplying raw water.
2. Intermediate Storage Reservoirs (ISRs) acting as buffer storage.
3. A transmission pipeline carrying water to terminal storage tanks (TSRs).
4. Control rules governing pump and valve operations.

Modeling Assumptions

Key assumptions in the analysis include:

1. System pressure must remain above 35 psi downstream of the booster station.
2. Negative pressures are unacceptable anywhere in the pipeline.
3. Total system storage capacity is approximately 4 million gallons, with tankage designed to meet a 7-day average demand of 250 gpm.
4. The system uses flow control valves (FCVs) to regulate pipeline inflows.

Demand Scenarios

The report evaluates system performance under various demand conditions:

1. Steady Demand (1500 gpm constant flow) – used for baseline hydraulic validation.
2. Step-Function Demand (210 gpm to 2100 gpm variation) – tests how well storage tanks and pipeline handle large flow fluctuations.
3. Hourly Variation Demand (diurnal cycle) – simulates realistic daily fluctuations with morning and evening peak demands.

Simulation Results

Key findings from the hydraulic model simulations include:

1. The system generally maintains stable operation under all tested demand patterns.
2. A low-pressure zone was identified near Nodes J141 and J142. A deeper trenching solution was recommended to mitigate this.
3. Water age analysis indicates an average residence time of 35-53 hours, demonstrating that stored water remains fresh.
4. Flow control rules were successfully optimized to regulate tank levels and pump operation.

Water Hammer Analysis

The study includes a water hammer assessment to determine potential surge pressures during sudden shutoffs. Simulations explored various closure times, revealing:

1. Fast shutoff (0 seconds) caused pressure spikes up to 75 psi, which could lead to pipeline stress.
2. Controlled shutoff (130 seconds) significantly reduced surge effects, keeping pressures within safe limits.
3.

Recommendations

To enhance system performance and longevity, the following measures are suggested:

1. Deepen pipeline sections near Nodes J141 and J142 to prevent negative pressure conditions.
2. Install pressure relief valves at strategic low points to protect against overpressure.
3. Deploy air-release valves at elevation peaks to prevent vapor lock.
4. Ensure flow control valves operate within a 2-minute closure timeframe to mitigate water hammer risks.
5.

Conclusion

The EPANET-based hydraulic analysis successfully optimized control strategies for this West Texas pipeline system, ensuring reliable water delivery, pressure stability, and surge protection. Further refinements can be made using real-world operational data.

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