Produced Fluid Foaming Tendency Considerations

Artificial lift design, sizing and optimization needs to consider produced fluid's foaming tendency or the level of gas entrainment in the liquid. A higher severity foaming tendency means a higher level of gas entrainment. Entrained gas cannot be efficiently separated downhole and reduces artificial lift system performance.

- foamy fluids are highly compressible and can reduce pump efficiency by > 40% (my pump calculator says it should be making 200 bbls/day, but I'm only getting 100 bbls/day)
- Easily identified when downhole pump cards show gas interference, but such gas interference continuously overlays at 50-75% pump fillage and with a high gaseous fluid level in the annulus (see figure)
- for when selecting downhole separators, maximization of the cross-sectional area for separation, avoidance of high flow turbulence generation and avoidance of side intake slots/ports are most important selection considerations

Two pseudo-qualitative methods are used and contrasted determine a risk-based produced fluid foaming tendency:

Method 1 Procedure – Ratio of Gas Free Liquid Above Pump (GFLAP) to Acoustic Annular Fluid Level

Please note, the GFLAP calculation is misleading, as it is simply a hypothetical annular fluid level above a pump if all the gas is removed from the liquid – this does not occur in reality and it does not mean there is a pumpable fluid density at the depth of the pump (ref: https://www.downholediagnostic.com/fluid-level). A foam depression test is required determine the gaseous fluid density gradient as a function of depth below the initially determined fluid level. From a foam depression test, the actual fluid density in the annulus adjacent to the pump can be determined and if it is actually pumpable; generally a gas entrained fluid density > 0.2 psi/ft or > 5 kPa/m is pumpable, otherwise pump fluid pound or pump gas locking will likely occur.

Determine the ratio of GFLAP to Fluid Level:

1. Shoot acoustic fluid level (FL) at current casing pressure
2. Shoot Echometer depressed fluid level and determine GFLAP
3. Calculate the ratio of GFLAP divided by the FL

Method 2 Procedure – ASTM D-3601 (Modified) Foaming Tendency Bottle Test

This method is a simple wellhead sample foam break bottle test to and identify foaming tendencies.

1. Equipment: 500 ml (16 oz) narrow mouth screw-top bottle with straight sides, stopwatch, ruler, marker.
2. Place 200 ml (6.75 oz) of gas free (let it settle), room temperature, produced emulsion in the bottle.
3. Mark and record the Initial Height of the liquid in the bottle to the nearest mm (1/32"). See Figure 1.
4. Place a second mark, the Foam Broken Line, 10 mm (13/32") above the Initial Height. See Figure 1.
5. Vigorously shake the sample bottle 40 times and then place bottle on a flat surface. See Figure 2.
6. After shaking, record the time in seconds it takes for the foam to settle to the Foam Broken Line. See Figure 3.
7. If foam does not break to Foam Broken Line within 120 seconds, then stop and indicate > 120 seconds.

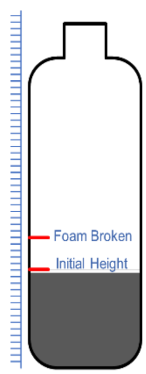

Figure 1

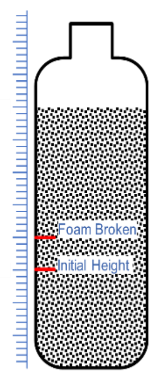

Figure 2

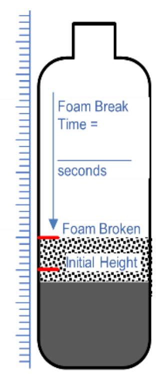

Figure 3

Recommended Practices

Risk assess foaming tendency to a rod pump artificial lift system using the following Risk Assessment Matrix:

Green (low risk) – apply standard practices, select separators using 6 in/second bubble rise velocity, horizontal well bend section reduced ID velocity strings are beneficial

Yellow (moderate risk) – tortuous and/or restrictive fluid paths create turbulence, which worsens foaming tendencies (a common risk/problem with packer-style separators and tight annular clearance tubing anchors); design the pumping system with extra capacity to offset pump efficiency reductions; expect 40-70% pump fillage as normal; maximize pump plunger size, stroke length and rate for more displacement capacity to effectively pump the foam; select separators using 2-3 in/second bubble rise velocity, horizontal well bend section reduced ID velocity strings can be beneficial but require larger ID's to compensate for foamy flow added friction

Red (high risk) – indicates rod pumping and bend section reduced ID velocity strings should be avoided (i.e., gas lifting is likely the better artificial lift solution)