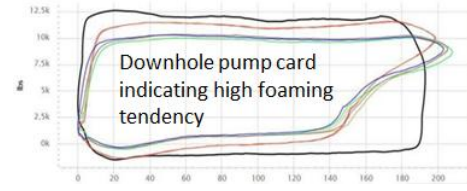


Produced Fluid Foaming Tendency Considerations



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 to 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.downholeidiagnostic.com/fluid-level>). A foam depression test is required to 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:

- Shoot acoustic fluid level (FL) at current casing pressure
- Shoot Echometer depressed fluid level and determine GFLAP
- 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.

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

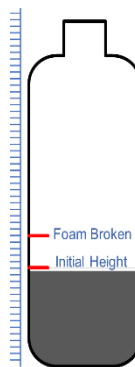


Figure 1

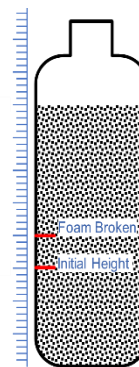


Figure 2

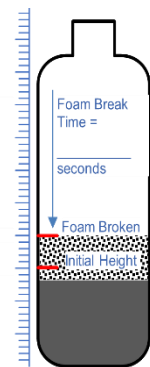


Figure 3

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 tailpipes can be highly 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 tailpipes 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 tailpipes should be avoided (i.e., gas lifting or plunger lifting are likely the better artificial lift solution)

