OPTIMIZING DEFOAMER USAGE IN DRILLING & CEMENTING APPLICATIONS: TECHNOLOGY REVIEW & TESTING METHODOLOGIES

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ABSTRACT

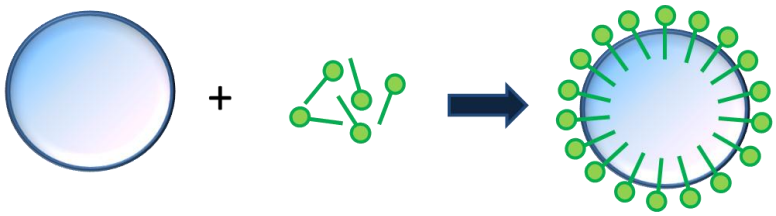
In drilling and cementing applications, the reliable administration of defoaming chemistries has been a key step in controlling and preventing excessive foaming and avoiding operational difficulties due to entrained air. Although conventional liquid defoamers are predominantly used in common operating conditions, winterized liquid and dry alternatives are preferred in extreme climates, mainly due to ease of handling and long lasting stability.

This paper presents a comprehensive study of various defoamer chemistries in liquid and dry solid forms. Traditional blender foam tests and a novel dynamic foam analyzer are used to benchmark defoamer performance during simulated service fluid mixing operations. In-depth evaluation of the initial and persistent efficiency enables accurate dosage comparisons in the lab resulting in effective and reliable field operations.Testing on high-foaming media comprising PVA, latex and dispersant systems indicates that non-silicone formulations outperform silicone chemistries. These findings relate to the different defoaming mechanisms of silicone emulsions versus solid-free (non-silicone) products. The evaluation of dry defoamers brings another level of complexity associated with the adsorbent structure which strongly impacts defoamer release and subsequent performance. Although high surface area substrates are chosen for increased adsorption capacity, they often lack performance due to poor and slow release of active material (sacrificial defoamer). Our structure-performance correlations indicate superior performance of products that deliver complete and fast release of defoaming chemistry.

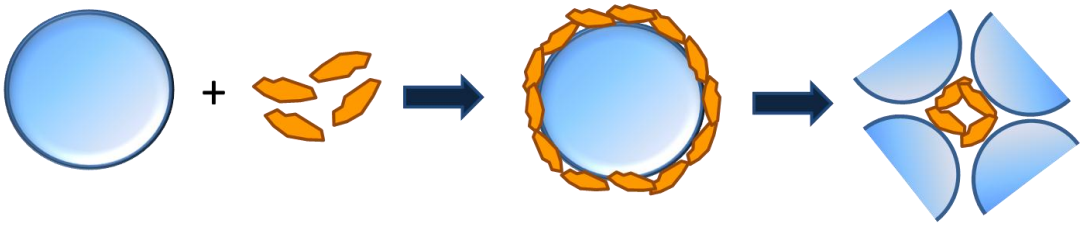
The oilfield industry is presently facing several challenges both from increasing environmental restrictions and also from specific field application requirements. The focus on finding suitable replacement additives for cementing and drilling systems without compromising the properties of completion fluids is a priority for many oil service companies. The use of a systematic approach for material selection is instrumental in reducing or eliminating risks to ensure maximum operational efficacy and longevity of cementing and drilling jobs while accommodating the unique factors pertaining to each individual project.

INTRODUCTION

A system in which a large number of gas bubbles are dispersed in a continuous liquid or solid phase is called foam. The gas can be air, nitrogen, carbon dioxide, etc. and can coexist with the liquid vapor; the liquid can be water (aqueous based systems; such as water-based drilling muds and cement slurries) or oil (non-aqueous based systems; such as oil-based drilling muds and produced crude oil). In general, ionic or non-ionic surfactants and surface active compounds are used as the stabilizing agents for foams, because they can be adsorbed at the air-water interface, and thereby reduce the interfacial energy or surface tension. In addition to such molecular foam stabilizers, it has been well known that amphiphilic particles can also act as foam stabilizers (See Scheme 1).



Foam Stabilization by Surfactants/ Surface Active Molecules



Foam Stabilization by Amphiphilic Solids

Scheme 1: representation of foam stabilization mechanisms

Most additives needed to make cement slurries and drilling muds functional are surface active molecules with amphiphilic structure; on one hand soluble and on the other insoluble (or of limited solubility) in aqueous phase [Lea, 2004]. This surfactancy is responsible for the stabilization of air-liquid interfaces and the potential generation of excessive foam and air entrainment that leads to undesirable operating conditions and/or pose severe hazards during cementing and drilling jobs.

Next sections describe the different additives used in water-based drilling muds and cement slurries and their effects on foam generation and stabilization during drilling and cementing operations.

Foaming in Cement Slurries

Amphiphilic additives perform based on their interaction with the cement particle surface. Such additives include cement retarders, dispersants, fluid loss control additives, gas migration control agents and ductility improvement additives. Chemicals used to enhance cement grinding are also known to cause foaming to some extent. Table 1 describes cement additives, their chemistry and effect on foaming.

Table1. Chemistry and foamability of common cement additives.

Additive	Chemistry	Description	Effect on Foamability
Gas migration control and fluid- loss control	Latex dispersion	Aqueous dispersion of latex particles with surfactants creates an impermeable barrier that prevents annular gas migration into the cement slurry during the critical hydration period. When formation gas enters the cement slurry, the latex particles coalesce to form a coherent, low-permeability plastic film that blocks migration. The additive also controls gas migration by improving cement bond to the casing and formation interfaces, and it creates a thin, low-permeability filter cake to reduce fluid loss from the cement slurry.	Highly foamy

Cement retarders	Sodium gluconate, sucrose, or calcium lignosulfonate	Use to extend the thickening time of cement for sufficient time to achieve placement in high temperature cementing applications.	Foamy
Dispersants	Sodium and calcium lignosulfonate,	Use to reduce the cement slurry viscosity to improve fluid flow characteristics. Adequately dispersed cement slurries exhibit improved fluid-loss control, can displace drilling fluid more efficiently and be successfully mixed and pumped at higher densities.	Foamy
Fluid loss control additives	Poly(vinyl alcohol)	The design properties of slurries are significantly influenced by the water content. Slurries that lose water can also be subject to a loss or degradation of design properties. There are a number of conditions that can induce fluid loss: • Water being drawn from the slurry into the permeable formation, in particular when pumping has ceased and the slurry is static, but not yet set. • Displacing or squeezing water from the slurry as it passes through constrictions such as tight clearance between the casing and the annulus. Fluid loss additives help operators retain the key characteristics of their cement slurries, including viscosity, thickening time, density and compressive strength development.	Highly foamy

Excessive slurry foaming can have several undesirable consequences such as loss of hydraulic pressure during pumping due to cavitation in the mixing system. In addition, air entrainment may cause undesired slurry densities at downhole. During slurry mixing, a densitometer or mass flow meter is used to help field operators proportion the ingredients. If air is present in the slurry at the surface, the density of the system "cement + water + air" is measured by the densitometer. Since the air becomes compressed downhole, the true downhole slurry density becomes higher than the measured surface density. Furthermore, large air voids and channels may also contribute to gas and fluid migrations downhole.

Cement foaming, also called chemically entraining air in cement slurries to account for additives involved, is difficult to be categorized in the sense of a conventional process. It can be viewed as an emulsion of air in the cement – water system or foam formation in the liquid phase and retained by the gel or solid network, or both. Origins of air in cement slurries include air already contained in the system and air entrapped during mixing. Reviewing literature on air entrainment revealed that it is clearly an extremely complex process, which is affected by many factors such as the mixing process, physical and chemical properties of oilwell cement, water ratio and quality, dosage and properties of the foaming agent, other chemical additives and supplementary cementitious materials (SCMs), and a range of other parameters. See Figure 1 for a cement foaming case.

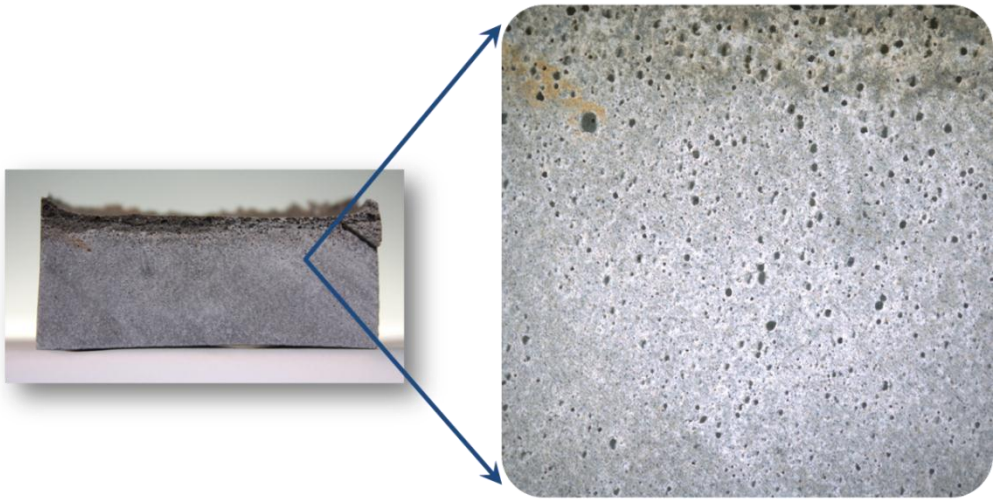


Figure 1: Photograph of the a cement G cube with 2% sodium lignosulfonate and 10% sodium chloride, (no defoamer was used) indicating foaming problem.

Anti-foaming and defoaming chemistries are typically added in small quantities, 0.1 – 0.3 % by weight of cement (BWOC), either in solid or liquid (solution) form to remove foaming during the mixing of cement slurries. These chemicals do not necessary remove all entrained air from the slurry, however, the goal is to minimized foaming and prevent adverse effects after slurry is left to set. Defoamers that are commonly used in oilfield applications include fatty alcohols, polypropylene glycols, sulfonated oils and silicone emulsions [1].

Foaming in Drilling Muds

Drilling fluids are complex formulations of a variety of chemicals designed to deliver specific properties under very specific drilling conditions. The composition of muds using water as a continuous medium (water-based muds) is particularly challenging, as many additives are used to overcome the limitations of the water-based compare to oil-based muds (e.g: low lubricity, lack of inhibition, etc.).

Typical water-based drilling fluid consists of bentonite (a clay mineral) and barite ($BaSO_4$) suspended in water. Salt is added to the water to act as an inhibitor for reactive clays, in combination with polymers, and it also adds to the weight of the mud. Early water based muds were simple mixes of brine, bentonite and barite, however with time there has been an increased use of special additives such as gel strength agents and both natural and synthetic polymers. Most of the additives are surface active molecules used to control the degree of emulsification, aggregation, wetting and dispersion. Although their functions are crucial to the performance of a drilling mud, they tend to concentrate at air/liquid interfaces potentially causing severe foaming by stabilizing the air-water mixtures. This is to be avoided as it leads to a decrease in mud weight and makes estimation of mud volumes very difficult. Undesirable foaming when mixing the muds in the field gives rise to severe service quality problems as the operator is unable to mix the fluid at the correct rate and/or at the required density. Foaming in drilling muds not only represents a nuisance during operation (e.g. during mixing), but also a severe hazard when the release of formation gas is impeded. Lowering the gel strength reduces the degree of foaming encountered, but will often compromise the cutting support and removal properties of the mud. The addition of the defoaming and/or antifoaming agents such as silicone oils and polyalcohol based products is used to eliminate the problem. Required treatment concentrations vary between 0.03 – 3 kg/m^3. Table 2 presents a summary of water based mud additives, their chemistries and functions, and the effect on foaming.

Table 2. Chemistry and foamability of various drilling additives.

Additive	Chemistry	Description	Effect on Foamability
Gelling Agents and Viscosifiers	bentonite, biopolymers, carboxymethyl cellulose (CMC), polyanionic cellulose, guar gum (polysaccharide) and synthetic polymers	Although gelling products do not directly generate foam, the high gel strengths of these fluids contribute to the retention of air or gas. It is important to control gel strengths and allow gases to break out of the fluid at the same time.	Low (Indirect)
Salinity chemicals	NaCl, KCl, $CaCl_2$	Inorganic salts are added to form brines which control the properties of suspended clays and prevent the dissolution of formation salts. Salt-saturated systems display high foaming tendency by inducing formation of amphiphilic solids from organic additives.	Highly foamy (indirect)
Lost circulation material	synthetic polymers, CMC, cellulose, starch, lignites and resins	When large amounts of drilling fluids are lost in the formation, either through existing pores or voids, or through induced fractures, measures are taken to reduce the loss rate. In many cases, this is done by introducing solid material to the drilling fluid that will plug the points in the formation where losses are occurring. A diverse range of materials are used, most are supplied and added in solid form as fine or coarse powder. These products contribute to foam formation and stabilization.	Foamy
Dispersants	polyacrylates, lignosulphonates, tannins	The term dispersant is used for a variety of products with different functions. However, in all cases, the role of the agent is to disperse or separate particles or droplets within the mud: • Thinners: lignosulphonates and lignites. Thinners are chemicals added to reduce the interaction between the clay particles and platelets, and thus reduce viscosity and gel strength. • Emulsifiers: fatty acids, sulfonates and polyoxylates. Emulsifiers are predominantly added to water based muds to disperse small amounts of oil, which arise from the formation being drilled or are added to increase lubricity. Emulsifiers can contribute to foam generation.	Highly foamy
Drilling lubricants	Sulfonates asphalts, hydrocarbon emulsions, fatty acids, fatty acid salts and triglycerides	These compounds are added to reduce downhole friction. Most of this materials will contribute to foam generation.	Foamy
Scale inhibitors	Phosphate esters, phosphonates and synthetic polymers	Added to prevent the precipitation of calcium carbonates on surfaces within the recirculation system, are used in low concentration to interfere with the crystal structure of scale deposits.	Highly foamy

Defoaming Chemistries

Most common defoaming chemistries currently used comprise silicones (polydimethylsiloxanes) and polyalcohol based products. Non-silicone based defoamers are becoming more desirable due to increasingly strict environmental regulations. Although silicone products are traditionally the first choice for many applications, non-silicone and solid-free products present several advantages in terms of diverse

formulation, stability and performance in selected additive systems. In general, desirable antifoaming or defoaming agents, have the following characteristics to be effective:

a) chemically inert to the system
b) insoluble in the foaming system
c) dispersible in the foaming medium and
d) lower surface tension than the foaming system

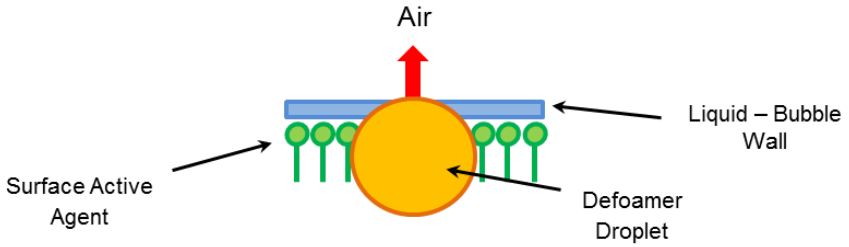
Defoaming Mechanisms

Foam is generated by the presence of surface active components (e.g. surfactants, fatty acids, particles, certain polymers, etc.) and the addition of energy (e.g. mixing). Foam bubbles are structured as liquid polyhedral cells encapsulating a gas, and the cells are separated by a thin liquid-air face called lamella and stabilized by the surfactants. These surfactants can have the form of traditional liquid surfactants as well as amphiphilic solid particles (very commonly encounter in cement and drilling mixtures). Both forms preferentially adsorbed at the liquid-air interface and act as foam stabilizers. Thus, in order for a defoamer to be effective it must penetrate the foam or bubble lamella as droplets when emulsified in the foaming medium. As the defoamer droplet approaches the foam surface an uneven three phase film, consisting of oil, water, and air, is formed. A positive entry coefficient is necessary for this to occur and for the defoamer to be effective.

Entry coefficient: $\mathbf{E} = \gamma w/a + \gamma w/o - \gamma o/a$

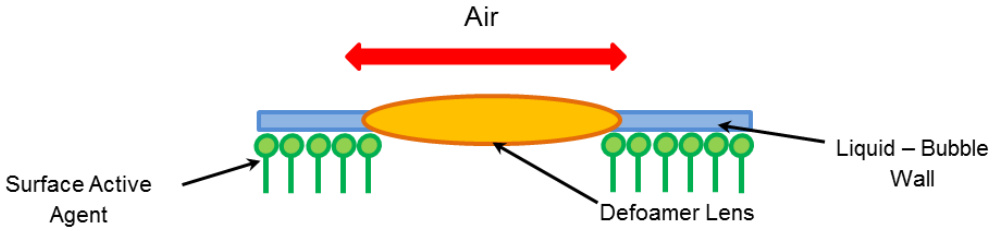
where:

$\gamma w/a$ = surface tension of the foaming liquid
$\gamma w/o$ = interfacial tension between the defoamer and the foaming liquid
$\gamma o/a$ = surface tension of the defoamer



After the defoamer droplet penetrates the surfactant film at the foam surface the defoamer must spread. The defoamer spreads and expands into a lens at the liquid/air interface. As the lens spreads it destabilizes the bubble wall. In order for this to take place the spreading coefficient must be positive.

Spreading coefficient: $\mathbf{S} = \gamma w/a - \gamma w/o - \gamma o/a$



Distinction between conventional versus molecular defoamers

Unlike conventional defoamers, which utilize hydrophobic particles that physically break the lamella of a foam bubble, molecular defoamers are low surface tension fluids which break foam on a molecular level by adsorbing at the Liquid/Gas interface of the lamella and, thereby, displacing some of the foam-stabilizing surfactants and allowing liquid drainage to proceed until the bubble bursts. Most defoamers work in a hybrid form combining both mechanisms. This is schematically shown in Figure 2.

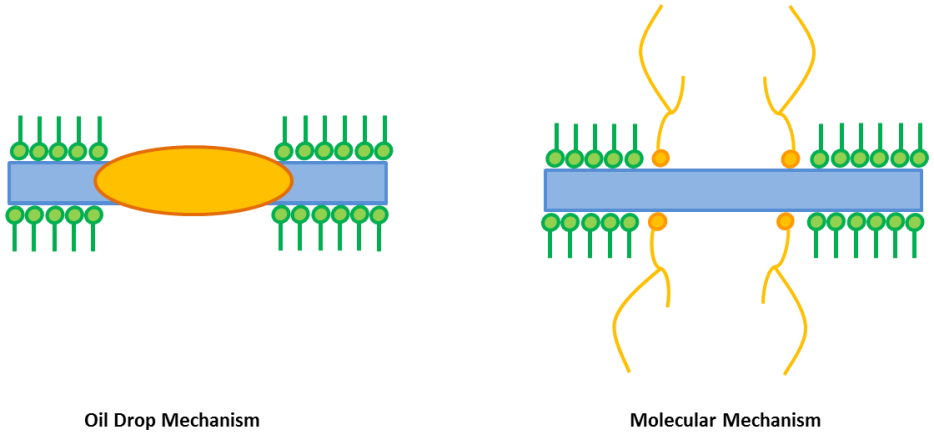


Figure 2. Schematic representation of oil drop and molecular mechanism of defoaming.

Physical form (liquid vs dry) and defoamer selection

Liquid defoamers are predominantly used in normal operating conditions, but dry defoamers are preferred in extreme climates, mainly due to ease of handling and storage, long term stability and uniformity. In dry defoamers, the active defoaming chemistry is adsorbed/loaded on the surface of a solid substrate or carrier. The evaluation of solid defoamers brings another level of complexity associated with the adsorbent structure which strongly impacts defoamer release and subsequent performance. Although high surface area substrates (such as precipitated silica) are often chosen due to their high adsorption capacities or loading, they may lack performance owing to poor and slow release and thus defoamer misuse (sacrificial defoamer). A careful selection of a substrate and active defoaming agent should address several aspects ranging from environmental regulations and cost to operational conditions and practices such as dosage points, nature of additives used and the need of defoaming versus antifoaming functionalities.

Testing methods for defoamers

There is currently no industry standard for evaluation of defoamers for oil and gas cementing applications. Cementing service companies often use their own developed lab procedures, which often is based on:

- Slurry preparation using API procedure
- Blender foam test
- Measuring slurry density using a mud balance or other methods
- Visual investigation of air-entrainment in cement for voids and channels
- Effects on other properties such as rheology, thickening time and compressive strength
- Comparison of performance against a defoamer currently used in the field as a benchmark

We have developed a controlled approach for evaluation of cement defoamers using a unique foam and entrained air analyzer (FEAT) and a blender foam test method that provide more insights into cement foaming and defoaming processes [2].

The blender test was designed to address the effect of shear rate and time on foaming during mixing of cement slurries. In this work, a Waring laboratory blender model 7009S equipped with a digital Tachometer and a speed controller unit was used for preparation of slurries. Shear rates were adjusted manually at ± 200 rpm of the target speed. A clear protocol to evaluate densities of foamed slurries allow for much controlled testing and better reproducibility of the data.

The FEAT technique utilizes a fluid recirculation loop designed to dynamically measure fluid foaming characteristics. The instrument is temperature controlled, open atmosphere, and features an inline foam generation chamber to entrain air in the experimental media. The instrument column is filled with the experimental media and density is continuously recorded once recirculation begins. The effect of additives such as foamers and defoamers may be determined at any time by injection into the foam chamber.

Figure 3 represents a schematical defoamer density–time curve obtained by the FEAT Technique. The curve consists of several distinct areas. The first portion of the curve with a downward slope (d_{init} to d_{min}) indicates the quickness with which the test media entrains air and foams. Defoamer is then injected at a chosen density or time noted on the graph. The initial density minimum (d_{min}) of the graph represents the time which the defoamer has begun to affect the media. The upward slope from this minimum (d_{min} to d_{max}) represents the quickness with which the defoamer acts upon the media to remove entrained air. The curve then generally peaks at the defoamer's maximum effectiveness (d_{max}). An ideal defoamer would maintain the same density as the peak whereas a real defoamer gradually loses effectiveness causing the curve to drop as the defoamer becomes emulsified into the test media.

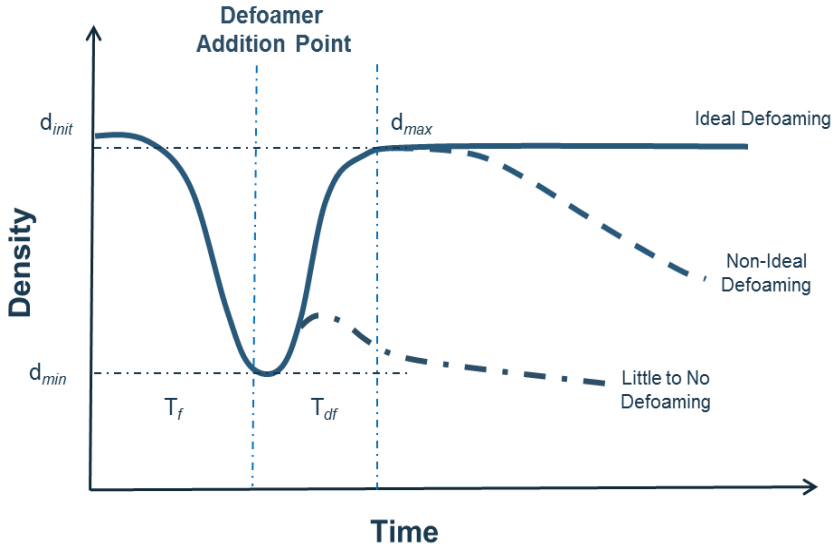


Figure 3: graphical representation of foaming/defoaming patterns from FEAT data.

Description of Application and Testing Methods

Depending on mixing practices in the field different laboratory approaches should be considered when evaluating foam control chemistries. In practice, cement slurry mixing is done in two steps: the premixing of liquid components is followed by the addition of the cement and slurry mixing in mixing tub. While

one type of chemistry may work on a specific mixing step, may lack performance on the other. In addition, it has been observed that some products work efficiently as antifoamer but do not carry any defoaming capability. In this paper two techniques are used to separately evaluate defoaming and antifoaming functionalities:

- **FEAT**: defoaming capability (relevant to liquid mixing prior to slurry preparation by addition of solid components)
- **BLENDER**: anti-foaming capability (relevant to slurry mixing and mud preparation)

RESULTS & DISCUSSIONS

Additive contribution to foamability – Foaming in Brine-Dispersant Systems

It is well known that brine systems provide significant challenges in oilfield operations from drilling, fracturing and well treatments such as Enhance Oil Recovery (EOR). As described in Table 2, in cementing operations brine-dispersant systems can cause cement foaming problems which are often hard to control using conventional defoaming chemistries. We investigated this problem by correlating surface tension and foamability trends of brine-dispersant systems.

Sodium chloride was added to aqueous solutions of 4% sodium lignosulfonate at 5 to 30% ratio. As seen in the images in Figure 4, solutions turn foamy by addition of salt, and generated foam layers were found to be stable for days. A look at the surface tension as a function of salt concentration can help speculate on the mechanism of foam generation and foam stabilization on dispersant systems containing salt above and below the saturation levels.

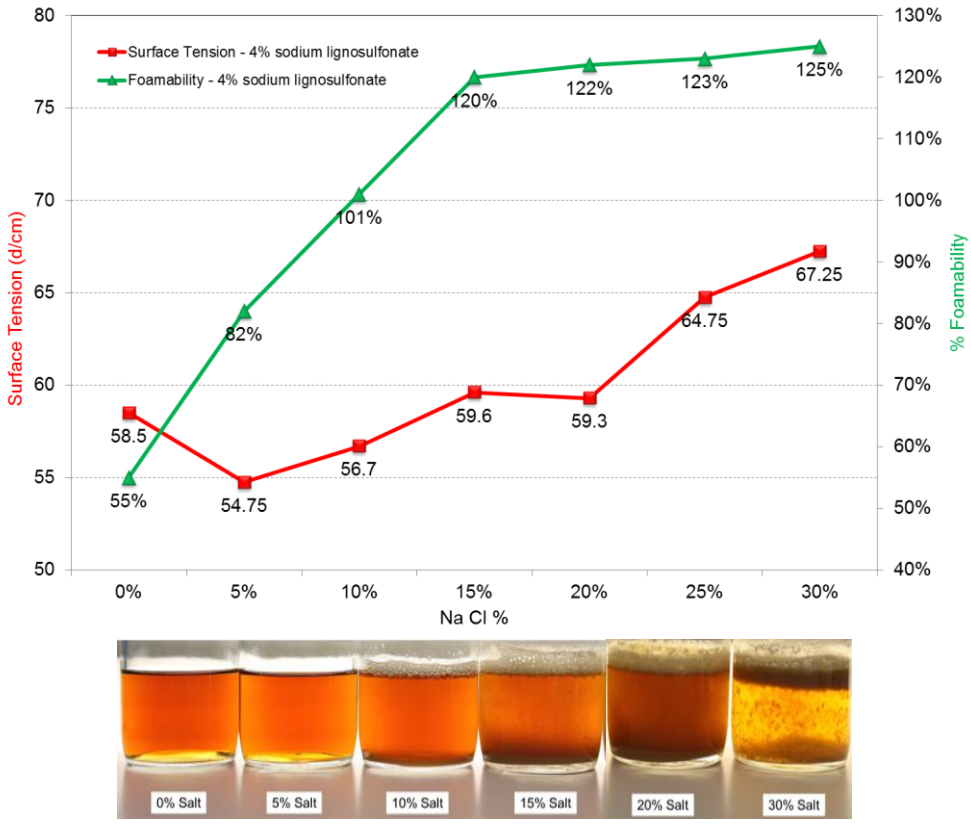


Figure 4: Effect of sodium chloride on static surface tension and foamability of water-dispersant system.

Figure 4 shows the effect of NaCl post added to 4% sodium lignosulfonate solutions. Several trends can be identified in the plot:

- Surface Tension: at 5% NaCl post addition resulted in a reduction of surface tension; at 10% NaCl and above the surface tension gradually increases. This increase is due to the salt contribution to the surface tension of the system (in a NaCl-water system, as the NaCl increased so does the surface tension of the water) [2].
- Foamability: foamability increases at a significant rate up to 15% NaCl post added. At 15% it is obvious the sodium lignosulfonate solution is salting out, the surface tension is increasing, and the foamability of the solution continues a marked increase (120% foamability at 15% NaCl). At 25% and 30% NaCl, the salting out and the surface tension continues to increase, the foamability of the solutions continues increasing at a significantly lower rate and plateauing at 30%.

The increased foamability of the solutions, as the NaCl increases, is due to some of the sodium lignosulfonate becoming insoluble in the salt solution (salt-out) and forming amphiphilic particulates which stabilizes the foam (refer to Scheme 1 on foam stabilization mechanisms). In general, one can expect increasing foam tendency with declining surface tension. However, in the presence of solid amphiphilic particles, both the surface tension and foaming can rise at the same time. The reduced amount of surfactant in the solution would account for the increase in the surface tension observed in Figure 4.

The effect of brine on the foam tendency of cement slurries was also studied on the blender test. Figure 5 shows the effect of salt addition on two dispersants at different defoamer dosages. The addition of salt leads to lower slurry densities. While slurries with no salt (Dispersant A and B) reach close to design density at very low dosages, the dispersant-brine slurries show densities much below design; in addition higher defoamer dosages do not improve performance.

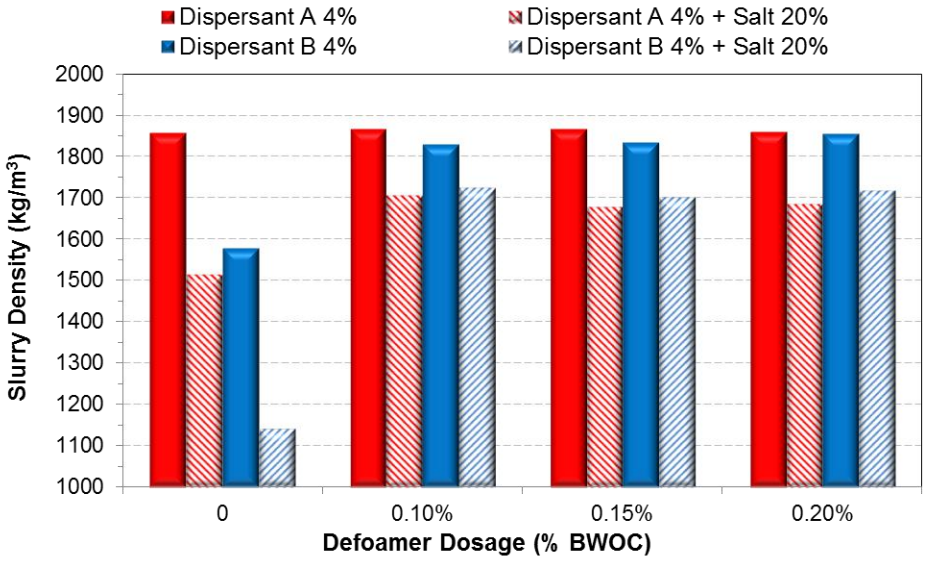


Figure 5: Blender foam test on dispersant-salt systems (design density 1900 kg/m^3), Dispersant A: Sodium lignosulfonate, Dispersant B: Sodium polynaphthalenesulfonate), Defoamer: Non-Silicone. BWOC: by weight of cement.

Silicone vs. non silicone chemistries: antifoaming vs defoaming agents

As discussed earlier, a careful evaluation of the effectiveness of a chemistry, either as an anti-foaming or defoaming agent, should reflect the mixing conditions and dosage practice in the field. This comprehensive evaluation requires separately testing under the different conditions. In this study we use FEAT and blender test; while blender test looks at the defoamer capability on a mud or cement slurry, FEAT analysis looks at the liquid mixing step prior to slurry creation. Silicone and non-silicone chemistries are benchmarked by the traditional blender test and FEAT analysis. Figures 6 – 9 show the FEAT results for two different additive foaming media: dispersant (sodium polynaphthalenesulfonate) and gas mitigation control additive (styrene-butadiene latex type). For highly foaming latex, the selection of non-silicone products will be more effective than silicone chemistries and in particular a better option when defoaming properties are needed in the liquid mixing step prior to slurry creation. For dispersant systems, both chemistries seem to deliver good defoaming ability.

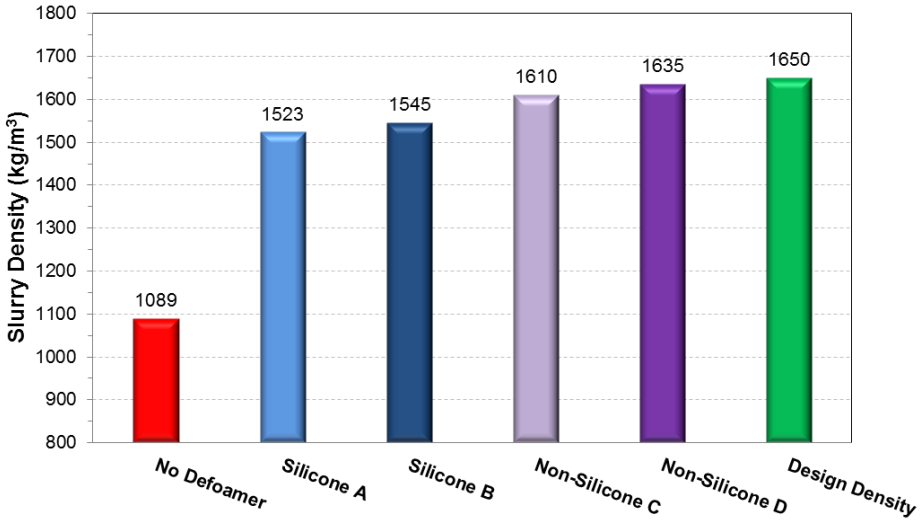


Figure 6: Blender foam test data in the dispersant-salt system. All defoamers are dosed at 0.20% BWOC.

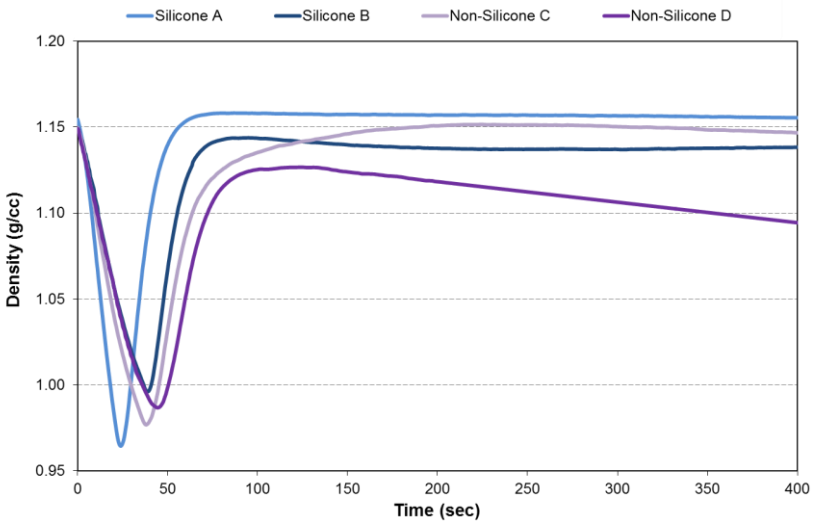


Figure 7: FEAT analysis of silicone and non-silicone chemistries on 4% sodium polynaphthalenesulfonate + 30% salt solution.

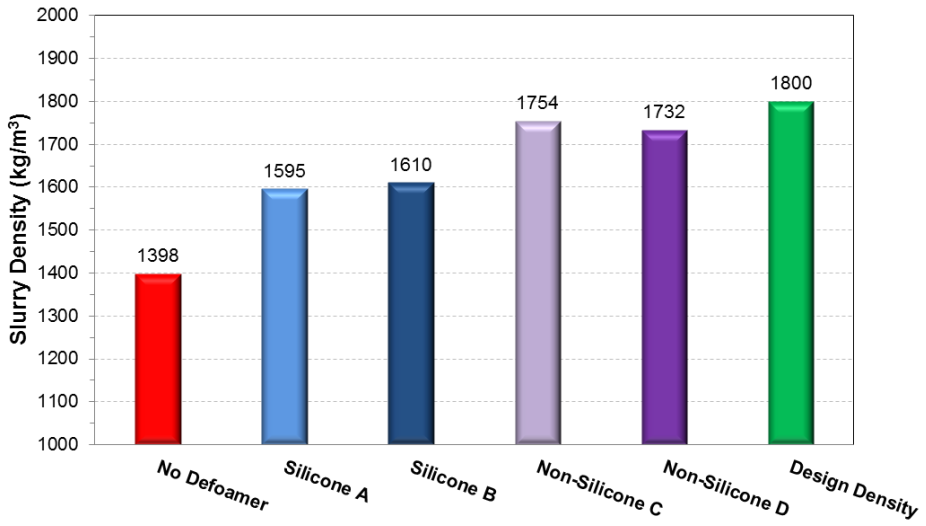


Figure 8: Blender foam test data in the latex system. All defoamers are dosed at 0.2% BWOC.

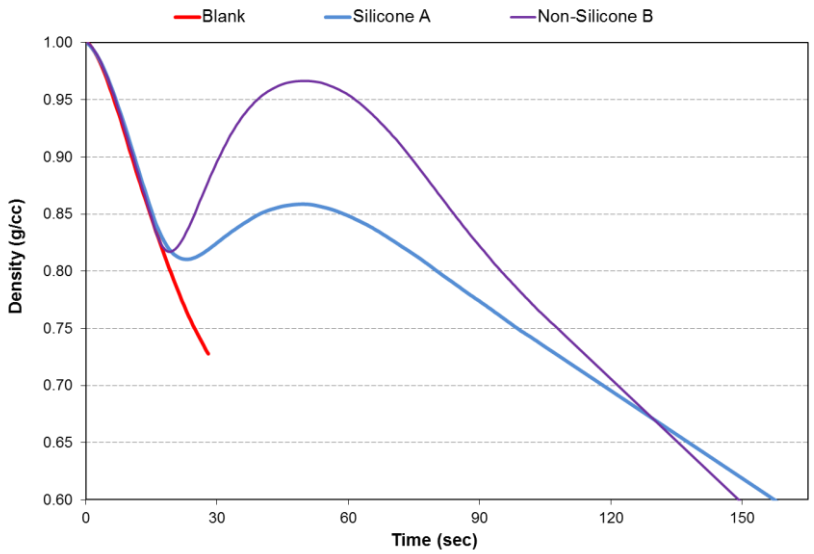


Figure 9: FEAT analysis of silicone and non-silicone chemistries in the latex system.

Performance of some silicone and non-silicone defoamers is evaluated for cement slurries containing a fluid loss additive: polyvinyl alcohol (PVA). As shown in Figure 10, silicone based defoamers were found to be not effective in PVA foaming systems, instead non-silicone based defoamers exhibit superior performance as indicated by measured slurry density in comparison to the design density. Various fluid loss additives are routinely used in preparation of cement slurries. They are often used at higher dosage in lightweight and ultra-lightweight cement slurries to provide adequate properties and controlled fluid loss during placing in borehole.

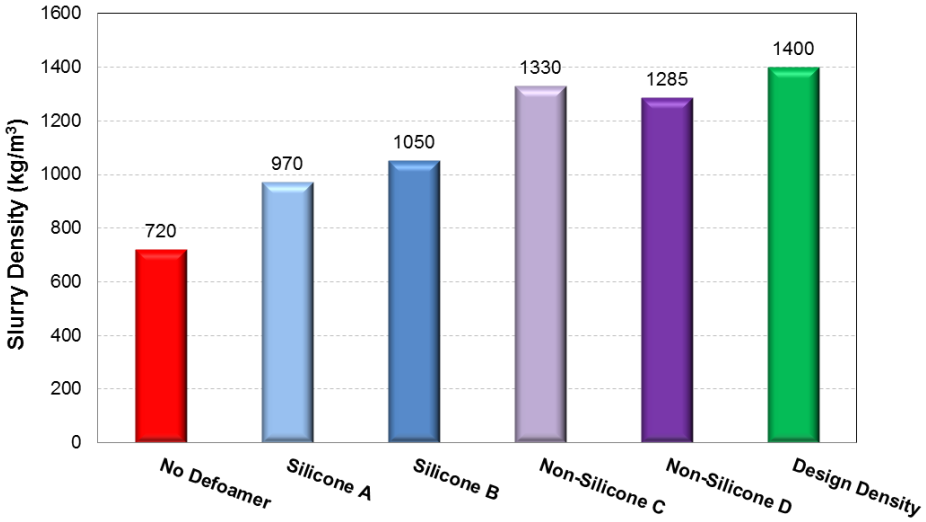


Figure 10: Blender foam test data for API Class G Cement and PVA (0.9%) system. All defoamers are dosed at 0.2% BWOC.

Convetional vs fast release defoamers

The evaluation of dry defoamers brings another level of complexity associated with the adsorbent structure which strongly impacts defoamer adsorption and release and subsequent performance. High surface area substrates are often chosen due to their high adsorption capacities or loading, but may lack performance owing to poor and slow release and thus defoamer misuse (sacrificial defoamer). Alternatively, low surface area (low porosity) substrates are preferred for their fast and complete release, but are limited on the adsorption capacity. Figure 11 shows the effect of substrate structure when formulating dry defoamers. An optimum formulation will then reflect the balance between adsorption (active defoamer uptake) and desorption (active defoamer release) kinetics to maximize performance.

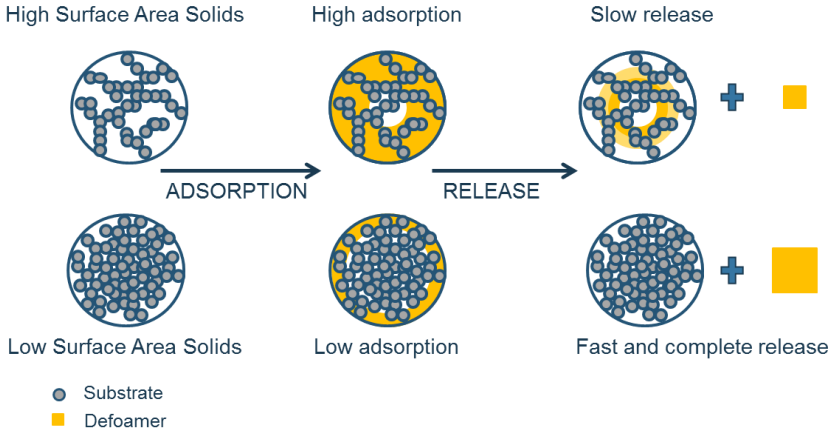


Figure 11: Formulation of dry defoamers, effect of substrate structure on defoamer adsorption and defoamer release

A non-silicone defoamer was formulated and studied in its liquid form ("Liq") and in two dry forms: one adsorbed on a traditional highly porous substrate ("Dry") and (2) adsorbed on a low porous substrate expecting faster release of the active (defoamer) from the substrate ("FR Dry"). Figure 12 shows the blender foam test results on dispersant and salt system at different dosages. It is noticeable how the liquid

and fast release sample remains close compared to the conventional dry product. This data proves the significant effect of the substrate structure on the release and hence, performance of the dry defoamer.

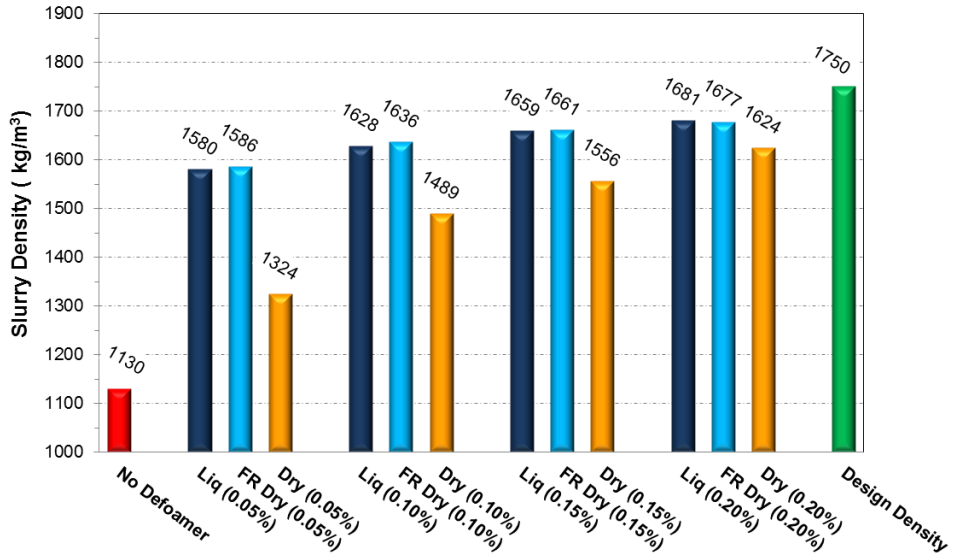
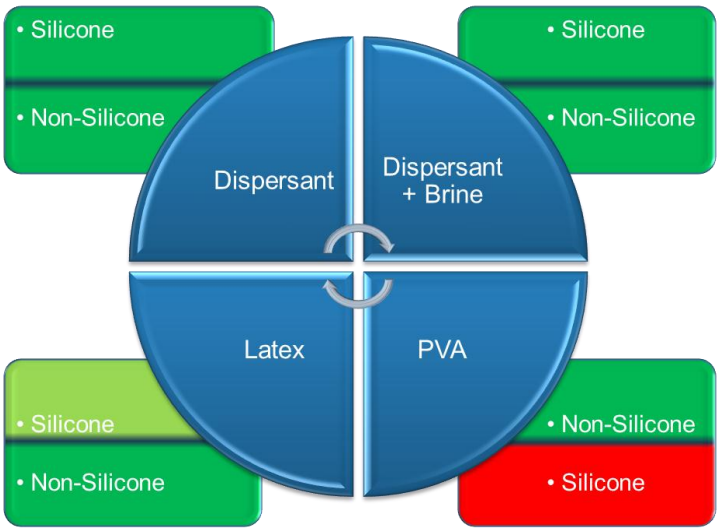


Figure 12: Blender foam test on cement A slurry using 2% Dispersant and 20% Salt System. **Liq** (liquid defoamer), **FR Dry** (Fast Release Dry Defoamer) and **Dry** (Traditional Dry Defoamer).

CONCLUSIONS

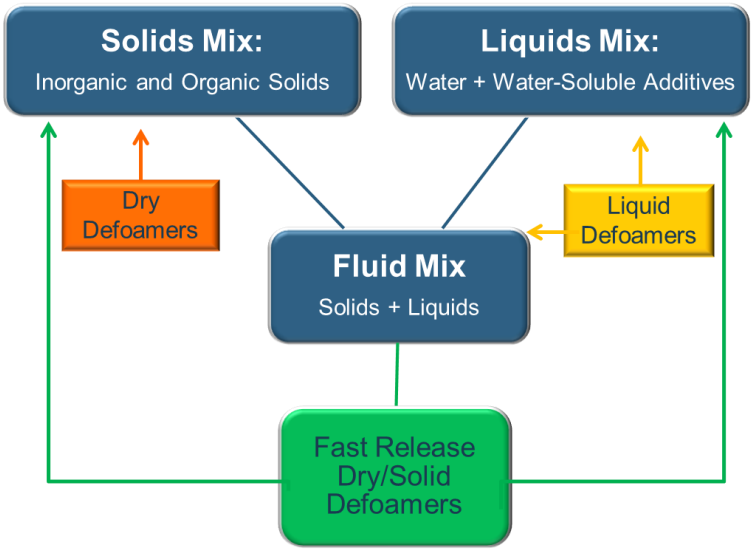
Although defoamers are not the main components of cement slurries and drilling muds, they are important chemical additives to control undesired foaming problems during mixing and placing the service fluids in oilfield drilling and cementing applications. Obtaining and maintaining design fluid density in the field is a key factor for successful drilling and cementing operations. Basic understanding about defoaming chemistries and proper lab testing for validation and qualification of a product is therefore essential for drilling and pumping service companies. As mentioned earlier, it is crucial to do a systematic study to find out the source of a foaming problem. Most performance additives used in drilling and cementing formulations are amphiphilic molecules and surface active chemicals and thus can contribute to foaming either directly or indirectly. Once the source of foaming is identified, one may refer to the defoamer chemistry selection chart (Scheme 2) shown below for choice of silicone or non-silicone products. As shown, non-silicone defoamers are performing very well for all foaming conditions, while silicone defoamers may not be suitable for highly foaming conditions such as PVA and Latex.



Scheme 2: Defoamer chemistry selection chart.

Choice of liquid or dry form is dependent on the nature of foaming media and occurrence in the mixing stage. While liquid defoamer agents can be added to mix water or to the slurry at the point of mixing, conventional dry defoamers are used solely in the dry mix (cement and solid additives).

Due to their poor dispersibility and slow/incomplete release, dry defoamers lack performance in the liquid media. In contrast, the improved dispersibility of the fast release dry/solid defoamers makes them also very suitable for the liquid systems. The flexibility for the dosage practices of the fast release products is represented in Scheme 3. Fast release defoamers play then a key role in controlling foaming as they can be used in several stages assuring anti-foaming properties throughout the entire mixing process.



Scheme 3: Recommended practices for use of liquid and dry defoamers in drilling muds and cement slurries.

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