Hydraulic fracturing operators are well aware of the water-intensive nature of their work. It can prove to be a problematic relationship, with the threat of microbial contamination looming over the success of an entire operation. Uncontrolled microbial proliferation can negatively impact production rates, asset integrity and hydrocarbon quality, which means that completion engineers must select the most effective biocide programme for their well.

It all comes down to microbial control efficacy – a major consideration when selecting biocides. A wide range of biocides are available to the completions engineer, and each one performs differently depending on the phase in the process in which it is used. All three phases of water treatment in hydraulic fracturing – preparing the water, decontaminating the well and protecting the reservoir (Figure 1) – have different conditions requiring different performance considerations, including temperature, salinity, water turnover rate, and the desired duration of control. An integrated microbial control programme deploys a biocide, or combination of biocides, that addresses each phase of the process.

Oilfield microbial control continues to progress with new advancements and knowledge that have the potential to unlock new opportunities for enhancing productivity and reducing costs, especially in light of the limitations of commonly used oxidisers, such as chlorine dioxide (ClO₂) and surface active biocides such as tributyl tetradecyl phosphonium chloride (TTPC). The following is a look at microbial control trends driving the industry, and proven
chemistry’s ease of use in the field, but because of their ability to be one of the most versatile biocides available – efficacious throughout the preparation and decontamination phases with short-term effectiveness as a protective biocide. However, when combined with quaternary ammonium (quat), glut’s performance sees a noticeable increase in kill speed. Glut-quat compounds are widely used for the control of microbes in water-intensive applications, such as hydraulic fracturing and waterflooding. These synergistic combinations are highly effective in controlling bacteria, and are ideally suited to meet the diverse demands of most oil and gas applications.

The efficacy of this combination was a driving force behind the development of AQUACAR™ 714 Water Treatment Microbiocide, an aqueous blend that combines the robust ability of glut and quat. It is especially effective in controlling both slime-forming and sulfate-reducing varieties of bacteria in oil and gas operations. Glut-quat blends are one of the most widely used biocides in hydraulic fracturing – not only because of the chemistry’s ease of use in the field, but because of their ability to improve the performance of surface-active biocides. For example, foaming is reduced when compared to using quat alone.

Additional benefits include efficacy over a broad pH and temperature range, greater operational sustainability, compatibility with the most commonly used frac fluid additives, and cost-effectiveness, as well as a reduction in sessile microorganism populations known to cause corrosion and reduce heat exchange efficiency.

**Glut-quat blend versus TTPC topside**

Oilfield water contains an abundance of microorganisms due to its natural nutrient composition and the recycling process, so treating the water from the start with a quick-kill biocide helps enhance the performance of late-stage biocides by causing a quick reduction in the initial bioload.

TTPC has gained industry acceptance as an option for hydraulic fracturing. While its kill speed is well known, TTPC is hindered in efficacy due to its incompatibility with anionic additives, such as friction reducers, and proppants. TTPC also presents a foaming issue that can cause complications on the job site.

The combination of glut and quat provides a quicker kill during the frac fluid preparation phase than TTPC, and the effects of glut-quat mixtures last much longer (Figure 2). Whether in freshwater or a combination of fresh and produced water, glut-quat blends outperform TTPC at every turn.

**Glut-quat blend versus TTPC downhole**

Downhole environments provide hot, saline-rich conditions that can lead to extremophilic microorganism proliferation. Biocide treatment used during the well decontamination phase aims to provide microbial control for a week or more during drill out up to initial production. Once again, glut-quat blends offer a more effective option in this scenario compared to TTPC.

TTPC’s incompatibility with proppants remains an acute problem, but there are several other issues with respect to its usefulness in downhole environments. TTPC is a surface-active biocide and will almost immediately adsorb onto shale, thereby losing its efficacy in the process. By contrast, the inclusion of glut gives the glut-quat mixture a reactive quality, which supports efficacy against planktonic bacteria, even in the presence of shale (Figure 3).

Glut-quat blends provide sustained microbial control for as many as seven days at temperatures of up to 158 °F (70 °C) when dosed according to label instructions. TTPC cannot match that timeframe, and the impressive balance of glut-quat’s kill speed and staying power is a clear performance benefit.
**Rising trends and dropping temperatures**

From well-established basins like the Permian to colder regions like Western Canada and the Bakken, hydraulic fracturing activity continues to rise across North America. Shale basins are dependent, in part, on their surrounding environment, so as demand for oil increases in the Canadian, Bakken and Marcellus Basins, so has the need for winterised biocide products.

The latest trend in meeting cold weather microbial control comes in the form of another glut-quat blend – specifically, the combination of glut and N-alkyl-dimethyl-benzyl-ammonium chloride (ADBAC). This blend is highly effective in controlling problematic microorganisms across a variety of conditions, and is engineered to meet the demands of harsh, cold temperature environments. The glut-ADBAC blend resists freezing at temperatures as low as -40 °C. This advanced technology is awaiting final US Environmental Protection Agency (EPA) and Canadian Pest Management Regulatory Agency (PMRA) approvals, which are expected later this year.

Similarly, AQUCAR™ TN 250 LT Water Treatment Microbiocide is an antimicrobial agent designed to control bacteria under reservoir conditions for months, and is winterised to minimise freezing at temperatures that reach as low as -40 °C.

**Downward doses and efficacy**

TTPC and other chemistries have gained popularity in recent years due to their lower cost per unit. At the same time, biocide doses have decreased onsite. This ‘less-is-more’ trend suggests that many operators do not fully recognise the value of an integrated biocides programme that goes beyond topside quick-kill treatments.

Take ClO₂ as an example. The compound is highly reactive, which means that it is quickly consumed through chemical interactions with other frac fluid additives, leaving less to kill bacteria in the wake of its initial use. And, if ClO₂ residuals remain, they quickly lose efficacy downhole because the biocide is prone to degrading at high temperatures.

Short-sighted decisions to cut costs without understanding the impact on operational efficiency can cost operators more in the long-run. It is important to distinguish between cost per unit and cost to treat when evaluating the cost of a microbial control programme. Despite the perceived low cost of ClO₂, glut-quat blends can provide a 10 - 50% lower cost to treat.

**Longer-term state of mind**

Another more promising trend in microbial control is the growing interest in solutions that offer long-term protection in the downhole environment. This includes a mental shift from focusing on the lowest unit cost to the total cost to treat. Whether it be more stages per frac, lower quality proppant or the recycling of produced water, changes in well construction today require solutions that offer downhole protection for extended periods of time. Solutions that last for weeks or months – as opposed to just seconds or minutes – are now a necessity.

The oil and gas industry is both changing and growing at an unprecedented rate. As a result, biocide efficacy is critical to make hydraulic fracturing operations efficient and profitable. Confidence in one’s microbial control programme is necessary to thrive in today’s competitive landscape, and only by taking the time to understand and implement an integrated approach can that confidence be achieved. An effective biocide programme – one that accounts for duration, temperature and higher efficacy – is a relatively small upfront investment that can enhance production and hydrocarbon quality over the entire lifecycle of a well.