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Utah Gas

Biocide Testing and Recommendation

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Purpose:	Identify a product for microbial treatment
Key Words:	Biocide, Microbes, ATP, Dilution Cultures

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Related Reports:			

Rev	Date	Description	By	Approved
1	2/20/19	Draft	Tech Team	Curtis Nelson

Summary:

Microbial contamination can lead to adverse conditions. Biogenic H_2S generation poses not only a safety risk but results in failed compliance for sales and transport, corrosion risk, and precipitation of iron sulfide. Microbially influenced corrosion (MIC) has been observed in SWD injection lines at the Utah Gas Water Facility. BHGE performed biocide kill study to identify products to affectively treat microbes in the Utah Gas water tank DCU-1, using produced water and microbes indigenous to this tank. A selection of products was chosen based on winter weather suitability, different chemistries of the products themselves, and previous successful applications in other areas. Biocide testing identified three products, AL133, XC320 and XC370, as products that could effectively treat the microbes. The three products showed good percent kill results for total microbes and total kill using APB/SRB serial dilution.

Evaluation of Microbial Risk:

In evaluating the biocides to best treat the Utah Gas DCU-1 water, two types of data were utilized, serial dilution cultures and ATP luminescence. The culture bottles represent recovery of live and culturable bacteria from the system which are serially diluted 10-fold to extinction. The data is expressed as number of positive bottles, where each positive bottle represents a 10-fold increase in the number of bacteria per ml (NACE TMO 194-2014, ***Field Monitoring of Bacterial Growth in Oil and Gas Systems***). For our purposes, the most relevant types of media are for sulfate reducing bacteria (SRB) and acid producing bacteria (APB). Both of these groups of organisms are problematic in the oilfield:

- ***SRB*** generate biogenic sulfide which yields H_2S and iron sulfide when soluble iron is present. They also cause microbiologically influenced corrosion (MIC) by cathodic depolarization. ***SRB are key agents of biogenic H_2S in the Utah Gas field.***
- ***APB*** generate small chain organic acids or even mineral acids which are extremely corrosive. Many are facultative anaerobes and can exist with or without oxygen. They are fast growing and aggressive colonizers to form biofilms, laying down the polymeric matrix which then harbors multiple organisms including SRB.
- In a ***biofilm***, APB and SRB form a synergism. SRB utilize small chain organic acids from APB as a carbon source. Since both of these organisms cause MIC, such biofilms are very deleterious to metal surfaces where corrosion pits can be formed and lead to failures. The biofilm is a protected environment where H_2S can be generated in well bores, treaters, tanks, flowlines, and injection lines. Biofilm microbes act synergistically to form barriers to and degrade biocides. Resistance can be up to 1000 times that of individual free-floating bacteria.

In addition to APB and SRB monitoring, total microbes were determined in samples using ATP analysis. This compound is present in all living cells and can be detected rapidly without culture techniques. Baker Hughes chose to use the term microbes to be all inclusive because microbes include the domain that is bacteria and a second domain that is archaea. Archaea are similar in size and behavior to bacteria and many species cause corrosion or generate H_2S. They cannot be cultured, but their presence is included in the total number determined by ATP analysis (hence, total microbes).

Selection Testing for Microbial Control:

To examine biocide cost-efficacy, time kill studies were conducted per NACE TMO 194-2014 to select for the best performing biocide against microbial populations in produced water sampled from the DCU-1 tank. The tests used a 1 and 4-hr contact time and biocide concentration range of 100-200 ppm. Biocides will differentially perform against microbes due to 1) water chemistry, 2) differences in microbial cell wall and extracellular matrix among species and strains within a population, and 3) strain differences in ability to block biocide penetration or to degrade biocide.

The results shown in Figure 1(1 hr contact) are data using ATP analysis to quantify the number of surviving microbes for each treatment. **The biocides AL133, XC320 and XC370 were the best**

performing biocides for microbial control, showing greater than or equal to 92% reduction in all microbes for 200 ppm and > 85% reduction at 100 ppm in the 1 hour kill study (Table 1).

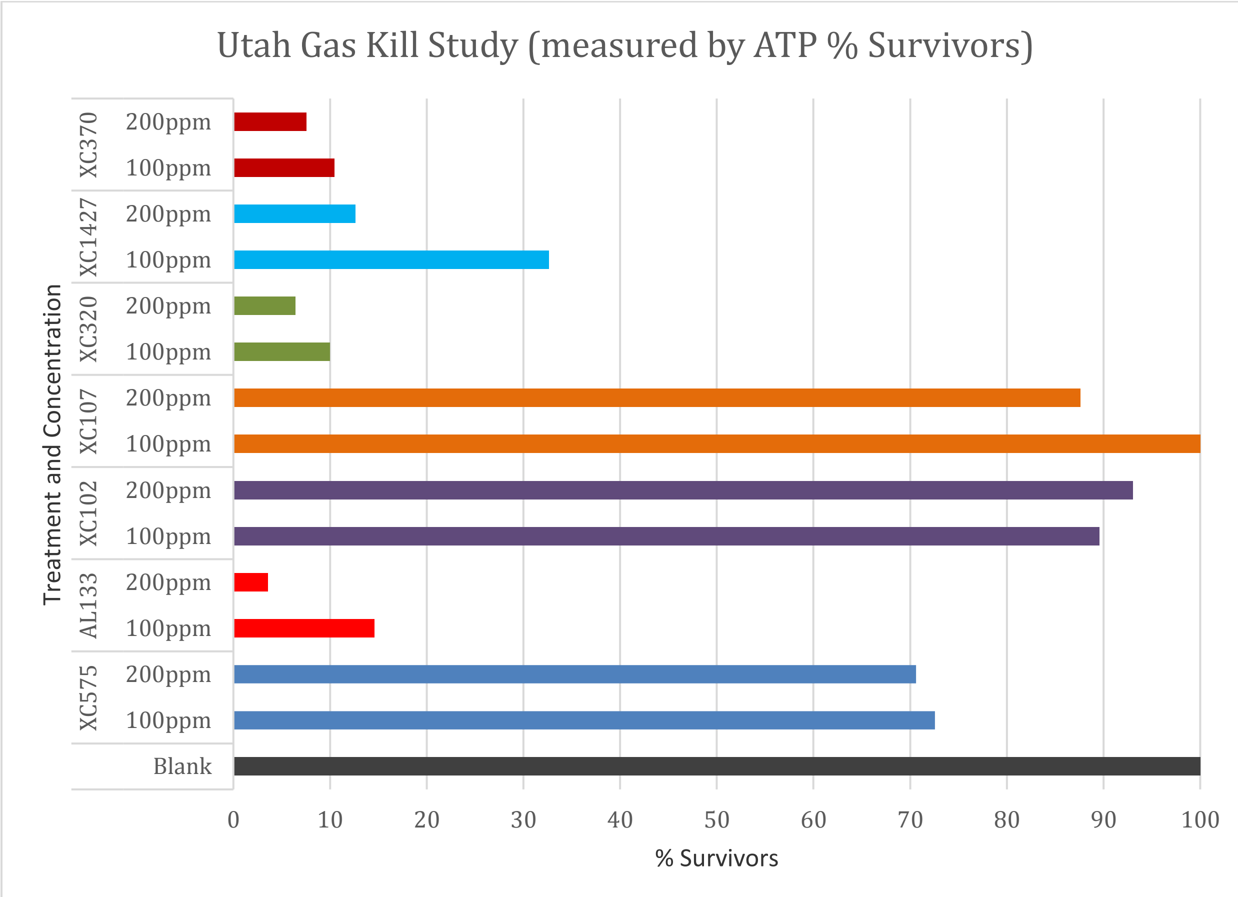

Figure 1: Biocide Performance Testing Results: 1 Hr Contact Time

Table 1: Microbial Reduction by Top Biocides in Kill Study

Biocide (ppm)	AL133	XC320	XC370
100	85%	90%	90%
200	96%	93%	92%

These biocides have surfactant properties and are good biofilm penetrants. This is an advantage because biofilms are the key target of a biocide program and these attached communities are responsible for MIC and sulfide production. The surfactant properties also provide some corrosion protection and help penetrate and move solids. They have proven utility in addressing problems with biogenic H_2S in production wells and in maintaining microbial control in water facilities.

Simultaneous to the ATP sampling, serial dilution bottles were inoculated to test kill performance specific to SRB and APB. AL133, XC320 and XC370 outperformed all other screened products at 100 and 200 ppm (see Table 2).

Table 2: APB SRB Kill Study Results

APB SRB Kill Study		1 hr		4 hr	
Product	Concentration	APB	SRB	APB	SRB
Blank	0 ppm	3	1	3	1
XC370	**100 ppm**	**0**	**0**	**0**	**0**
XC370	**200 ppm**	**0**	**0**	**0**	**0**
XC575	100 ppm	2	1	1	1
XC575	200 ppm	1	1	1	1
XC320	**100 ppm**	**0**	**0**	**0**	**0**
XC320	**200 ppm**	**0**	**0**	**0**	**0**
XC102	100 ppm	2	1	2	1
XC102	200 ppm	2	1	2	1
AL133	**100 ppm**	**0**	**0**	**0**	**0**
AL133	**200 ppm**	**0**	**0**	**0**	**0**
XC1427	100 ppm	0	0	0	0
XC1427	200 ppm	0	0	0	0
XC107	100 ppm	3	1	1	1
XC107	200 ppm	3	1	1	0

Table above reflects number of bottles turned, see* Table 3 *below for interpretation.

Table 3: Bacteria Interpretation Legend

Bottles Turned	Bacteria/mL
0	≤1
1	10
2	100
3	1000
4	10000
5	100000
6	1000000
7	10000000

Table 4: initial bacteria samples

Location	Date	SRB	APB
G 15	12/13/2018	4	6
DCU 1121	12/13/2018	1	6
DCU 1	12/13/2018	5	6

Conclusion:

- AL133 was the best performing product with over 96% kill at 200 ppm measured by ATP. Although a complete kill measured by serial dilution method was observed with 100 ppm, archaea cannot be measured in this way and a larger than 10% increase in kill was observed at 200 ppm measured by ATP.
- Initial bacterial enumeration performed with bug bottles showed up to 6 APB and 5 SRB positive bottle turns (Table 4), a severe amount of bacteria showing the need for biocide treatment.

Recommendations:

- Treat water tanks initially with 350 ppm AL133 biocide in batch treatment to shock the established microbial population and bring them under control. Then treat bimonthly with 200 ppm, based on tank capacity.
- The success of the microbial control program is best monitored with SRB and APB enumeration performed with bug bottles. Results can be used to optimize treatment dose and frequency.