**CHLORINE DIOXIDE (ClO₂)**

**OIL AND GAS APPLICATIONS: THE FACTS**

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**Introduction**

Chlorine dioxide (ClO₂) has been used in oil and gas applications and in refineries for decades with overwhelming success. It has been shown to be an effective environmentally preferred method to treat water in tanks, reserve pits, impoundments, and ponds, while consuming less energy and reducing manpower needs compared to alternative solutions. The application of an aqueous solution of ClO₂ efficiently neutralizes APB and SRB bacteria, hydrogen sulfide, iron sulfide, phenols, and mercaptans in source, flowback, and produced waters.

As an example, Baker Hughes’ H2prO™ HD water management units are mobile self-sustaining ClO₂ treatment units. In 2013 these units successfully treated more than 500 wells across most major shale plays in the U.S. This success equates to more than 50 mm bbls of water treated in the last 18 months for use and reuse. Locally, these units have been mobilized in both the Marcellus and Utica shale formations for multiple clients with continual water treatment success.

Even with extensive field success and a demonstrated safety record, there is still confusion about using ClO₂ for oil and gas applications. With that in mind, here are a few facts to clarify key information about this technology.

**Fact #1: ClO₂ is safe**

Much of the safety concerns with ClO₂ center upon the perception that it is flammable. While ClO₂ gas at concentrations above 10% in air is mildly volatile (i.e. it “puffs”), today’s modern equipment generates ClO₂ in an aqueous solution (liquid) at a maximum concentration level of 3000ppm (0.3%), eliminating the hazard. As an additional safety feature, Baker Hughes’ H2prO HD unit uses a 3-precursor vacuum-based eductor system that generates ClO₂ in-situ with any water source. Water passing through an eductor creates a vacuum that causes the precursors to flow. When no water flows, no chemicals flow and no ClO₂ is created. When water flows, chemicals flow and a ClO₂ solution in water is created. This process ensures safe and efficient generation of the ClO₂.

**Fact #2: ClO₂ does not affect pH or performance of hydraulic fracturing fluids**

While a 3000ppm ClO₂ solution is slightly acidic, the dosage levels used have a negligible effect on water pH. As an example, more than 228 stages have been completed in the Eagle Ford with an average pH of 8.0. With more than 500 wells completed to-date (with many Marcellus and Utica wells) using the H2prO HD units, no problems have been exhibited with any hydraulic fracturing fluid system.

A much more in-depth evaluation on the non-effect of ClO₂ on the performance of the slick water friction reducers is discussed in a white paper by Baker Hughes. This paper is available upon request.

**Fact #3: ClO₂ is not corrosive**

For the application concentrations used in the field, ClO₂ is less corrosive than...
almost any acid used in hydraulic fracturing. To better understand the concerns, however, Baker Hughes examined 12 common oilfield metals in our laboratory and exposed them to 3000 ppm ClO2 solution for 24 hours at 150°F and measured the corrosion index. Results were well within acceptable standards for corrosion. Specifically, a 0.03 index (lbs/ft²) was observed, which is well below an industry accepted standard of 0.05.

Fact #4: ClO2 does not create THMs in water
Trihalomethanes (THMs) are carcinogenic and thus the avoidance of their formation is essential. THMs are formed in the presence of an active halogen. However, in the case of ClO2, it is oxygen, and not the chlorine halogen, which is the reactive species. Therefore, ClO2 has no effect on the formation of THMs.

Fact #5: ClO2 does not chlorinate water
Chlorine is not introduced into the water by ClO2 creation. As dictated by the chemical reaction, the only by-product of the ClO2 generation is sodium chloride (NaCl). Note that three precursor systems are more efficient and introduce less NaCl into the water than two precursor systems.

Fact #6: ClO2 is environmentally preferred
ClO2 is used widely in the U.S. food preparation industry; in Europe for drinking water treatment; and is gaining use in the United States for drinking water treatment. It is approved by both the EPA and FDA. ClO2 could be considered one of the most environmentally preferred products available for the industry for bacterial control.

Conclusion
Locally, adoption of this technology and process has enabled local clients to successfully treat 4.1 MM bbls of water in the Marcellus and 4.2 MM bbls of water in the Utica for use and reuse in their operations.

In summary, ClO2 is a safe, effective, and economic solution for treating any water source for use in hydraulic fracturing. Knowing the facts will help everyone in capitalizing on its numerous benefits.

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