



### *Benefits of Mixed Oxidant Chemistry.*

Beyond the economic and operational benefits onsite generation, MIOX provides the following description about the benefits its unique chemistry can drive for RCL. MIOX's mixed-oxidant onsite generation systems produce a more active chlor-oxygenated chemistry than its traditional sodium hypochlorite systems. Although the MIOX mixed-oxidant and hypochlorite systems are both sized and dosed based on free available chlorine (FAC) concentration, the mixed-oxidant solution offers advanced oxidation ability over the hypochlorite solution. The mixed-oxidant solution not only achieves approximately two log better kill of microorganisms than does hypochlorite; it also achieves inactivation much more rapidly and across a broader range of microorganisms.

MIOX recommends the use of its mixed-oxidant chemistry for Celebrity and Royal Caribbean fleets. The superior chemical properties will provide measurable benefits, including superior biological control and elimination of biologically-induced operational efficiencies. This can enhance guest safety, thereby increasing brand value and further decreasing liability exposures. Mixed oxidant chemistry can also help to avoid ship quarantines and associated revenue loss.

1). *Superior Pathogen Control.* MIOX inactivates even chlorine-resistant pathogens such as Cryptosporidium. Water is a common method of transmission. High profile incidents, such as those faced in Idaho and Utah last year, is causing greater consumer awareness. A Cryptosporidium outbreak was responsible for the ban of all children under the age of five from public pools last summer in the State of Utah. Research by CDC is leading to increasing levels of scrutiny and regulation.

2). *Limit Expense from Positive Legionella Counts.* Legionella resides in a ships' water distribution system where biofilm exists. Resistant to chlorine alone, this biofilm matte gives Legionella a medium with which Legionella resides and grows. MIOX prevents the growth of biofilm, by eliminating the polysaccharide substrate that chlorine alone cannot remove. Eliminating biofilm also reduces any labor requirements for mechanical cleaning ("scrubbing") of pipes. Once oxidant-demanding biofilm has been eliminated, chlorine use for a typical water distribution system can drop, at times as much as 30%.

3). *Avoid Ship Quarantines.* When Legionnaire outbreaks are experienced, vessels may be quarantined for an indeterminable time until Superchlorination and testing confirms all trace counts have been eliminated. This creates revenue loss when scheduled trips are missed, guest reservations are canceled, linens and furniture are damaged, including guest property, and large volumes of emergency service is required.

4). *Increase Brand Value.* From a public health point of view, improved control of viruses and bacteria can lead to improved guest satisfaction. Guests should be encourage to understand what measures the Celebrity and Royal Caribbean fleets are taking to ensure a satisfying and safe experience. This can lead to a rise in demand for cruise vacations compared to peers, improving market share.

5). *Reduce formation of disinfection by-products (DBPs).* Total Trihalomethanes (TTHMs) are formed by a reaction between organic matter and chlorine in the water. Since they are known carcinogens and dangerous to human health, the U.S. EPA regulates TTHMs in drinking water. To reduce the formation of TTHMs, either the organic precursors or the free chlorine must be reduced. Mixed oxidants achieve both of these objectives by reducing organic biofilm as well as reducing the required chlorine dose, typically ranging from 30% to 50%.