

The benefits of chlorine dioxide application In mold-prone maritime environments

A white paper by:
Controlled Performance with Gases
Featuring *Klean Bio-Zone* technology

The dangers of breathing mold-contaminated air are well documented and firmly established – and ongoing decontamination is a vital health practice in any mold-prone environment.

But a further complication of mold in the luxury boating industry is the offensive odors generated by airborne mold fungus. These rank odors are easily drawn into HVAC systems and distributed throughout closed-system environments.

The risks of harboring patches of mold that generate contaminated and foul-smelling air are multiplied in warm and humid environments that are close to water. And mold doesn't limit itself to dank, old harbor scows. Yachts and other high-end watercraft that travel the high seas and visit exotic island ports are especially vulnerable to accruing spores that even when can leave behind a malodorous reminder that belies the cleaning attempts that have occurred.

Even the most immaculate and well-maintained vessels are capable of placing passengers and crews in a highly undesirable atmosphere of noxious odors. And maybe also leave them apprehensive about what toxins they may be breathing.

This white paper focuses on advances in the application of chlorine dioxide, a supremely effective chemical for killing mold spores – *AND* a supremely effective deodorizer that doesn't just perfume the air, but kills dead the spores in the air that cause odor.

Going further with decontamination

The science of decontamination has taken a giant step forward in recent years with the introduction of chlorine dioxide gas as a highly effective destroyer of dangerous mold, bacteria and virus microbes. The chemical is a derivative of chlorine that has long been used in water purification. Chlorine dioxide has been proven powerful enough to purify the water in huge municipal reservoirs, yet safe enough to be used in toothpaste.

It's also a routine sanitizer for fruits and vegetables – approved safe for human consumption by the United States Food and Drug Administration (FDA).

And the methods and safety protocols for applying chlorine dioxide gas are also well understood, with guidelines established by the Occupational Safety and Health Administration (OSHA).

Beyond those safety approvals is the fact that chlorine dioxide is by far the most environmentally safe high-powered decontaminator. Because it is a gas, chlorine dioxide quickly dissipates. It does not leave behind toxic residues that must be washed off areas that have been treated – and does not run off or leech away to contaminate soil and water.

That means chlorine dioxide is a highly effective decontaminant that doesn't linger to cause residual environmental concerns.

A new company called Controlled Performance with Gases (CPG) has developed a system it calls *Klean Bio-Zones* to effectively deliver chlorine dioxide gas. And engineers have worked out special, adaptable techniques to tackle widely varying commercial cleaning challenges.

CPG has implemented specialized solutions for applications as diverse as maintaining clean environments for children with critical care needs, and providing healthy stabling and shipping environments for million-dollar thoroughbred racehorses.

The common denominator of those applications is the absolute need for clean environments – and that's exactly the standard of health safety desired in maintaining passenger safety and providing a pleasant experience aboard yachts and cruise lines.

A little history

There's nothing new about chlorine dioxide. The simple derivative of chlorine was first produced in the laboratory of British chemist Sir Humphrey Davy in 1814. Davy noted the useful cleansing and purification properties of chlorine dioxide, and the chemical became a scientifically accepted disinfectant. In the 20th Century municipal water companies began using the chemical to purify drinking water, and chlorine dioxide remains the preferred treatment for clean water today.

But in the past 50 years a whole new world of possibilities has opened for chlorine dioxide – especially as a gas, which increases its reach and potency in fighting viruses, bacteria and mold.

A series of high-profile events brought attention to the power and possibilities of chlorine dioxide gas.

Notably, in 2001, chlorine dioxide gas was used to decontaminate buildings and equipment after anthrax bio-terrorism attacks in Washington, D.C.

Then in the wake of destruction and flooding caused by Hurricane Katrina 2005, FEMA, the Federal Emergency Management Agency, used chlorine dioxide gas to disinfect and decontaminate homes inundated by catastrophic flooding. The mold-stopping power of chlorine dioxide, and the big-scale capabilities of the chemical as a gas, enabled the rehabilitation of homes and rebuilding of neighborhoods in New Orleans.

Meanwhile, the United States government was funding chlorine dioxide research at the Pacific Northwest National Laboratory, in Richland, Washington, to develop possible large-scale disinfecting systems to combat the Ebola virus in Africa ~ and as a national security measure if the Ebola virus should reach the United States. Systems developed at the national laboratory continue to be used successfully.

A hoped-for side effect of the national security research was that the science discovered would stimulate private business investment in commercial applications for chlorine dioxide. And it has.

Proactive, rather than reactive

A new company in Louisville, Kentucky, called Control Performance with Gases (CPG) has tested and deployed chlorine dioxide in a variety of ways geared more toward prevention than reaction to disaster.

“CPG wants to be proactive, rather than reactive,” says the company’s science principle James Knoer. “This is the powerful disinfectant that’s been used in horrible disasters, and even in the anthrax bio-terrorism attacks – and that’s a wonderful thing for the country. But why not use this breakthrough science when there’s *not* a disaster? To prevent the growth of viruses and bacteria before they gain a foothold in everyday life?”

Knoer says the science is already in place.

“What CPG offers is the knowledge and experience to apply the science of chlorine dioxide in a preventative way.”

The company calls its process Klean Bio-Zone.

That's not a chemical formula, says CPG's industrial designer Larry Bender.

"Klean Bio-Zone is a complete system of high performance standards in testing and application," says Bender, who has developed the techniques and specified the equipment to meet rigorous application procedures that are exactly tailored to each situation.

No one-size-fits-all, Knoer and Bender agree.

"And it begins and ends with testing," says Knoer. "We test at the site to help assess the situation, to find out what's needed. Then we test again to be certain the problem is solved."

From children to racehorses to yachts

One of the preventative applications CPG has implemented is in the critical care of children with compromised immune systems.

The Kidz Club operates specialized day care centers - Prescribed Pediatric Extended Care - for children who are medically fragile. It offers parents a chance for normal employment while critical care children enjoy a safe day care environment, with on-duty nursing.

"Our clients are parents with children who can't be left at a normal day care center," says Kidz Club president Lee Zimmerman. "These children require special attention, and they especially need an environment that is virus- and bacteria-free because most don't have strong immune systems."

CPG worked out an environmental treatment schedule for Kidz Club facilities that is non-disruptive. Internal studies show a remarkable standard of cleanliness has been achieved. "That gives the parents, and our staff, a special level of reassurance," says Zimmerman.

In working with the Kidz Club, CPG addressed the problem of cross contamination - children going home at night to different homes, with different sets of parents and siblings, who themselves have wide ranges of exposures in their daily lives.

"That got us to thoroughbred horses," says Knoer. "It's the signature industry in Kentucky, and you can't drive a mile without seeing horses in pastures. But we realize those horses move constantly, shipping from farms to tracks and all over the world - all the time. That's the ultimate risk of cross contamination."

Now the company is focused on the science of chlorine dioxide decontamination in the yachting and luxury boating industry – where cross-contamination is also a serious issue.

Operating at sea, mold, and other microbial spores thrive in the warm and moisture-rich environment. The problem is multiplied with the constant introduction of new spores as boats call on multiple ports. New passengers coming aboard unwittingly introduce new threats to which fellow passengers and crew have not become naturally immunized.

“Once again, the problem of cross-contamination complicates the maintenance of a healthy environment,” says Knoer. “It’s a problem that requires vigilance and best practices of sanitation. But it’s also a problem that chlorine dioxide is perfectly suited to address.

“We can do something about it.”

Close confines aboard ships at sea

Luxury boat owners and operators also know that a sleek, custom-built vessel is a marvel of built-in compactness. Space is at a premium, and the boat’s electrical and HVAC are usually stowed away in the tightest possible way.

But that *out-of-sightness* has a downside: things are hard to get to. Tucked away. HVAC air carriers that might be easy to maintain in a commercial building, are extremely difficult to reach on a yacht.

“That’s the beauty of a gas,” says Bender. “It can get into and treat the tiniest recesses.”

The engineer says that the HVAC system actually becomes a distribution partner for chlorine dioxide gas, if applied through the exclusive *Klean Bio-Zone* process.

“Liquid sprays have a built-in problem of reaching distant trouble spots in narrow, bending HVAC systems,” explains Bender. “But the air-movement integrity of a boat’s HVAC system means chlorine dioxide gas may actually be evenly and effectively distributed through every inch of the HVAC ductwork.”

***Klean Bio-Zone* technology**

At the center of the *Klean Bio-Zone* application process for boats is a specially calibrated electrostatic sprayer that delivers chlorine dioxide as a gas.

Larry Bender, CPG's industrial designer, drew from an extensive background in ultra-high standard air filtration to develop an electrostatic gas sprayer that is a unique element of the Klean Bio-Zone system. The electrical charge in the gas is what enables the chlorine dioxide to get down to the real nitty-gritty of decontamination problems – the dangers lurking out of sight.

“Imagine a chair in a room,” Bender explains. “You spray the front of the chair, but the chlorine dioxide gas finds its way around to the backside, and underneath the chair, because it's a gas. It will get into invisible crevices in a paneled wood wall, but also find microscopic recesses in flat surfaces.”

“And,” Bender continues, “because we've given the gas an electrostatic positive charge, the chlorine dioxide attaches itself to the object.”

A big plus of using chlorine dioxide is its safety.

Approved safe by the FDA and EPA, chlorine dioxide gas is far superior to highly toxic chemical cleaners such as phenol and hydrogen peroxide, which linger and run off in the application area. CPG technicians wear OSHA-approved safety masks and protective gear while applying the gas, and a few minutes after application, the area is safe for re-habitation by humans.

Leave your cup on the bridge

A further benefit of decontaminating with chlorine dioxide is everyday items do not have to be removed for decontamination. In fact, it's a good thing if computers, papers, appliances, tools, clothes and dishware are exposed to chlorine dioxide. ClO₂ will not cause rust or corrode of steel and sensitive metals in appliances and computers.

In tests in which “spores strips” were placed in various locations, chlorine dioxide gas was shown to readily penetrate cloth, fabrics, paper, etc. – effectively deactivating high concentrations of spores. This means facilities may be decontaminated without first removing all porous materials.

There's also a simple cost savings simply in not tasking skilled workers with the chore of removing, storing and bringing furnishings back aboard. “Just leave your coffee cup on the bridge,” says Knoer.

A bigger cost savings is realized in the application process.

Delivering chlorine dioxide as a gas demands much less of the chemical than spraying with hoses and nozzles and run-for-cover foggers. That includes sprays often labeled as “dry gas” or “dry fog,” which actually are misting devices ~ similar to what one might see used along the sidelines at a football game on a hot day. Of course, players closest to the mist are cooled the most, and those farther away not so much.

“In other words,” says Bender, “those in-place sprayers work OK right here, but what are you going to do about that corner at the end of the stateroom?”

Bender says because CPG’s custom-designed electrostatic gas sprayers are portable, the company’s technicians are able to treat every part of the ship.

Which is the beginning of significant cost savings, says Bender.

“Taking a large 10,000 square foot yacht as an example, it takes 28 gallons of a *liquid* decontaminant to sterilize the space. But using our electrostatic gas sprayer, it only takes three gallons.”

Quite a difference. But Bender says the *real* benefit isn’t in the cost savings of three gallons compared to 28 gallons. Chlorine dioxide is not an extremely expensive chemical.

“It’s the effectiveness,” Bender explains. “It simply requires less chemical to do the job. How do we know? Through our testing – before and after – we can determine how well our product has performed. How uniformly it is working.

“Above all,” adds Bender. “The client has the reassurance that what they are paying for is working.”

**Size doesn’t matter,
Except in the destruction of microbes!**

(And smaller is better)

Knoer notes that a unique benefit of gas is its microscopic ~ or *nano*-microscopic ~ droplet size.

That contrasts with the larger molecules of liquid sprays.

“With liquid sprays, the so-called dry fogs, after a few feet the droplets clump together, like raindrops forming, and gravity takes over,” says Knoer. “It goes straight to the deck.

“A gas, though,” says Knoer, “goes in all directions ~ meaning it can go up and over the edge of a light fixture in the ceiling, or behind a cabinet. If a sample size is 500 parts per million, 100 parts attach to the surface where the spray is directed, with 400 dispersed in the air to travel to hard-to-reach places.

With a liquid spray, after 100 hit the target, 400 hit the floor.”

Fighting viruses, bacteria and mold means going small ~ getting a true sterilant down to the nitty gritty to get next to, and kill, dangerous microbes.

Keeping interior spaces tidy and clean is important. Bleach and other household chemicals are certainly valuable cleaning tools. But the war against the most virulent viruses is fought beyond the reach of everyday cleaners and disinfectants. Dangerous viral microbes are so infinitesimally small they can't be seen with the human eye. Or even conventional microscopes. But they can be reached – and killed ~ with chlorine dioxide gas.

Sick Yacht Syndrome

Thermal envelopes have gained a great deal of attention in the building industry as a means of reducing the exchange of indoor air with outdoors air. Sealing a house – creating a “thermal envelope” around it – is obviously a terrific way to cut energy costs.

But there's a downside. Newer homes no longer “breathe” as well as older homes. Meaning interior air quality deteriorates. Indoor air accumulates toxins from routine chemicals (such as cleaning products) that in the old days would have been “aired out” by homeowners by simply opening a window or two. Let in some fresh air!

Instead, harmful, or simply, malodorous elements are retained, and constantly added to. Even with efforts to clean the toxin air, the build-up over time is calamitous, and often almost irreversible. Home construction experts have a name for the bad air problem. They call it “Sick Building Syndrome.”

The same undesirable effect plagues the luxury boating industry, with its own onboard accumulations of toxins from cleaning products, cooking, heating, even breathing. And a similar name, “Sick Boat Syndrome.”

Increasingly, the luxury boating community is learning about Sick Yacht Syndrome.

Sources typically harmful for boats include:

Stale air
Diesel fumes
VOC presence (volatile organic compounds)

Bilge odors
Holding tank odors
Norwalk virus
Staph virus
Mold

On that list, one of the most pernicious and hard-to-tame sources is mold.

As mold spores mature through their life cycle, they off-gas various chemicals that are part of a group known as Microbial Volatile Organic Compounds. Each mold spore has a particular accompanying odor.

Common mold spores associated with shipboard odors:

1-octen-3-ol
1-butanol
Borneo
3-octenone
2-hexanone
Meaty
Alcohol fermentation
Camphor
Herbaceous, nutty, fruity
Acetone

The resulting broth of smells can be off-putting in any environment ~ but especially so in the luxury confines of a yacht.

Ordinary disinfectants may destroy some mold spores at their source, but spores that have been inhaled by the yacht's HVAC system from any source can re-circulate and set up new spots of incubation. All the while, the odors from previous and current growths can linger in any absorbent material such as bedding, cloth upholstery, table linens and more. Inside the thermal envelope, Sick Boat Syndrome grows, and the quality of life aboard spirals downward. And its tough to reverse.

CPG believes this is an obvious port of entry point for **Klean Bio-Zone** chlorine dioxide treatments. BEFORE the problem begins, or gets worse. It's the emphasis on being proactive rather than reactive. Preventing disaster, rather than reacting to a catastrophe.

It needs no elaboration to say that maintaining shipboard air that smells clean and healthful is a necessary component of providing a yachting experience owners and passengers expect. Until recently, however, most anti-mold treatments have proven inadequate to fully address the matter. Many treatments merely mask odors without eliminating their underlying causes. (Be especially suspicious, for example, of the smell of pineapple, a telltale sign of corners being cut.)

Bleach, ammonia and other basic cleaners are not sufficiently powerful. And because these leave a residue on treated surfaces, they require a subsequent clean up of their own.

But recent improvements in the application of chlorine dioxide have enabled yacht owners and management companies to employ this potent disinfectant and deodorizer to obtain a level of cleanliness and air quality that sets a new benchmark.

Chlorine dioxide: Properties and Uses

Chlorine dioxide (ClO₂) is a yellow-green gas with an odor similar to chlorine with excellent distribution, penetration and sterilization abilities ~ due to its gaseous nature.

Chlorine dioxide has been recognized as a disinfectant since the early 1900s and has been approved by the Environmental Protection Agency (EPA) and the Food and Drug Administration (FDA) for many applications. It has been demonstrated effective as a broad spectrum, anti-inflammatory, bactericidal, fungicidal, and virucidal agent, as well as a deodorizer.

Chlorine dioxide is also able to inactivate beta-lactams and destroy both pinworms and their eggs. It is widely used as an anti-microbial and as an oxidizing agent in drinking water, poultry process water, swimming pools, and mouthwash preparations. It is used to sanitize fruit and vegetables and also equipment for food and beverage processing. It is widely used in life science research laboratories. It is also employed in the health care industry to decontaminate rooms, pass-throughs, isolators and also as a sterilant for product and component sterilization. Approximately 4 to 5 million pounds are used daily.

Chemical Properties

Although chlorine dioxide has "chlorine" in its name, its chemistry is radically different from that of chlorine. When reacting with other substances, it is more selective, allowing it to be a more efficient and effective sterilizer. For example, it does not react with ammonia or inorganic compounds. Chlorine dioxide oxidizes products rather than chlorinating them, so unlike chlorine, chlorine dioxide will not produce environmentally undesirable organic compounds containing chlorine. Its selectivity to organic compounds makes it more economical.

Antimicrobial Properties/Mode of Action

Chlorine dioxide acts as an oxidizing agent and reacts with several cellular constituents, including the cell membrane of microbes. By "stealing" electrons from them (oxidation), it breaks their molecular bonds, resulting in the death of the organism by the breakup of the cell.

The ClO₂ chemical is small enough to enter the cell and disrupt protein synthesis.

Inactivation of Spores vs. Bacteria

The difference between spore and bacterial inactivation is the same as the difference between sterilization and disinfection. For a chemical agent to be classified as a sterilant, it must be demonstrated to be effective at inactivating spores. Spores are among the hardest organisms to kill, and for this reason sterilizing agents are considered the most rigorous decontaminating agents. These agents offer complete kill of all microbial life.

Disinfection, on the other hand, does not require the complete inactivation of spores or all microbial life and is normally validated against a few vegetative bacteria species. For this reason, disinfecting agents are less rigorous, and are not so effective as sterilizing agents.

Environmental Impact: Chlorine dioxide vs. chlorine

Chlorine dioxide's special properties make it an ideal choice to meet the challenges of today's environmentally concerned world and is an environmentally preferred alternative to elemental chlorine. When chlorine reacts with organic matter, undesirable pollutants such as dioxins and bio-accumulative toxic substances are produced. Thus, the EPA supports the

replacement of chlorine with chlorine dioxide because it eliminates the production of these pollutants.

Chlorine dioxide has proven to be a perfect replacement for chlorine – the long-held popular standard for cleanliness. Chlorine dioxide provides all of chlorine's benefits without any of its weaknesses and detriments.

Most importantly, chlorine dioxide does not chlorinate organic material, eliminating the formation of trihalomethanes (THMs), haloacetic acids (HAAs) and other chlorinated organic compounds, which are known carcinogens. This is particularly important in the primary use for chlorine dioxide, which is water disinfection. Other properties of chlorine dioxide make it more effective than chlorine, requiring a lower dose and resulting in a lower environmental impact.

Water Solubility

Unlike many decontaminating agents, chlorine dioxide has the unique ability to retain its sterilization capacity in water. In order to maximize process reproducibility and minimize materials effects when using the chlorine dioxide gas, it is best to avoid pools or puddles of water. However, if small amounts of water are present the efficacy of chlorine dioxide is not affected.

Overcoming Barriers to Usage

Since chlorine dioxide has been around for a while, why isn't it more widely used?

The answer is in how the gas is made – and often incorrectly made. It's not easy to do it right.

It turns out there is more than one way to make chlorine dioxide gas. If the result isn't pure, it cannot be used on computers and other sensitive electronics.

Furthermore, in the past, methods of making chlorine dioxide required huge machines that produce huge volumes of the gas. And the costs were prohibitive in business applications.

CPG also has innovated a process as part of its Klean Bio-Zone system that delivers chlorine dioxide to any size closed space, regardless of how small that might be. One no longer has to make a Hinesburg full to treat a home or a boat.

That makes it ideal for real-world, everyday applications. With CPG's patented system, reaction by-products are held in a pouch where they are neutralized and able to be discarded.

Onboard Cleaning Techniques

Most commercial cleaners instruct the user to spray their product and allow it to sit for 30 seconds to 1 minute before wiping off. The wipe (or rinse) is important because those products are chemicals that are as poisonous to humans as they are to the microbes – and thus need to be removed.

Moreover, if the wiping cloth or rinsing water isn't pure, the user may inadvertently *re-contaminate* surfaces that are intended to be decontaminated.

Many applications use chlorine as the antibacterial agent ~ which irritates the eyes and mucous lining of the airways in humans. Other applications use ammonia or alcohol-based solutions (which are also irritants) ~ again with the spray on wipe-off technique.

CPG has perfected a method to produce chlorine dioxide that remains neutral with less than one part per million in by-products.

With other application clean-up techniques, the act of wiping off may not allow enough time for the chemicals to get to bacteria and molds at the bottom of the “haystack” of microbes or the middle of the cluster.

The rag or sponge itself can pick up the bacteria, molds or spores, and become the agent that causes cross-contamination and spreads microbe infestation. Spraying and wiping of spores will do little to these resistant forms of the microbes. Plus, several of these cleaners with chlorine, alcohol, etc., can cause corrosion, discoloring and failure of electronic devices if sprayed on and not removed. In some cases, just spraying them on will cause those problems.

Commercial cleaners tackle the odor problem by including a fragrance that masks the smell of microbes instead of addressing the root problem.

Many of the chlorine-based products claim to disinfect with 99.9 percent efficiency. While that sounds good, it isn't good enough to be considered high-level decontamination, let alone sterile.

This again is using the spray and wipe method that doesn't attack the spore form of the microbes. Most surfaces have tiny scratches, cracks, nooks and crannies in which their spores will remain. Using these cleaning methods many of the microbes are missed completely and the 99.9 percent threshold is questionable at best.

Chlorine dioxide in Gas Form Provides Superior Results

To get an area truly sterile, the gas properties of Chlorine dioxide are key. Pure Chlorine dioxide from CPG, coupled with the new patent pending equipment for its gas phase application, is a breakthrough in this chemical's use. Yet the cost of our technology is much less than with rival methods.

Decontamination will work if the application of the agent satisfies these criteria:

1. Complete distribution
2. Total penetration
3. Sufficient contact time at specified concentration

CPG's method is an eight-hour process that entails an initial visual inspection to develop the most effect plan of applications.

Then, the Klean Bio-Zone system is deployed. The craft is then ventilated and ready to be used, with greatly improved indoor air quality.

CPG also applies a product that retains anti-microbial properties for four to six weeks. Other products leave treated surface immediately vulnerable to full re-contamination.

'Quats' add weeks of protection

In many applications, CPG adds an additional chemical treatment called a Quaternary, also applied as a gas.

If chlorine dioxide has been around for ages, Quaternary is the smart new kid on the block. The chemical's big plus is it can add up to 4-6 weeks of protection against contamination.

That gives the entire treatment a longer life cycle, which can be a big decontamination plus for ships away from port for extended periods of time.

Quats, as they are known, work differently than chlorine dioxide. Quats are positively charged polyatomic ions of the structure NR_4^+ . Working at the nano level, Quats have stickers that are electrically charged, capturing microbes on their spears. Kind of like a shish-ka-bob. The result is the cell membrane of a dangerous microbe is disrupted ~ so that it can't reproduce (multiply). The microbe is left dead in its tracks.

And it is not a highly-toxic chemical. Quats are routinely used in the food processing industry, preventing contamination of work clothing.

Safety Should Always Take Precedence

How chlorine dioxide is generated and used dictates what precautions need to be taken.

Like all biocides or fumigants, if it kills microbes, it can be harmful to humans. Chlorine dioxide dissolved in water can be an irritant similar to bleach or ammonia. In its gas phase, over-exposure to chlorine dioxide can cause pulmonary discomfort and distress. It will also penetrate into the blood stream reacting with iron compounds ~ effectively doing the same thing as carbon monoxide. This is why trained professionals should use OSHA-approved personal protective equipment during application.

An important note: If such products are not used with the utmost care, they are hazardous. They leave virtually no room for error when it comes to application. Recognizing this, CPG has developed a system that controls the gas as part of the process itself, meaning that potential negative consequences are addressed before the application process is begun.

Of course, once the application has been made, the gas disappates quickly and humans and animals may safely return that day.

The Proof Is in The Test

Air Filter Testing Labs, a third-party testing facility in operation since 1970, ran a decontamination/sterilization test with the Controlled Performance *Klean Bio-Zone* gas-phase equipment and chlorine dioxide from CPG. They used biological indicators in a 36 cubic ft. stainless steel chamber. A biological indicator (BI) is used to challenge the efficacy of a decontamination/sterilization cycle. BI's consist of bacterial spores, which are considered among the hardest microorganisms to kill. Sterilization is generally referred to as a 6-log (99.9999%) reduction of an organism. BI's consist of over 1 million bacterial spores.

To challenge the sterilization cycle, BI's were placed in hard to reach regions of the area being sterilized. After the sterilization cycle has been completed, the BI's are cultured in microbiological media using the aseptic technique. After an incubation period of 48-72 hours, if the biological indicator did not produce growth within the media the sterilization cycle is deemed to be valid.

Results of testing of the Klean Bio-Zone process show a 6-log reduction of spores, proving Chlorine dioxide gas, with CPG equipment, achieves true sterilization.

This opens the door to a wide range of applications and is a major improvement over the spray-and-wipe techniques for eliminating cross contamination concerns.

What Makes It So Special?

During the applications and testing of chlorine dioxide from CPG, chlorine dioxide was shown to be a disinfectant, tuberculocide, virucide, fungicide, algacide, slimicide, deodorizer, all rolled into one. Ultra-pure chlorine dioxide from CPG has many advantages over other disinfectants:

- * Very low toxicity profile
- * Extremely effective against all microbe threats
- * Non-corrosive
- * Compatible with the widest range of materials
- * Highly effective at very low concentrations
- * Safe, even approved for use directly on food
- * EPA-registered
- * FDA-approved
- * Registered by the Organic Materials Review Institute
- * Compliant with protocol for chain of custody application
- * Applied via gas-phase equipment
- * Complete with training
- * Tested in independent certified third laboratories and real-world applications
- * Made from patented technology

Conclusion

Managers of yachts face a unique set of environmental challenges while serving an exacting clientele. From the aesthetics of the vessel, to the level of hospitality, to the the cleanliness of onboard conditions, much is expected.

CPG's *Klean Bio-Zone* gas-phase chlorine dioxide application can be an excellent solution for decontamination and deodorization of mold spores and other onboard organic dangers.

For more information on how to add CPG to your arsenal in the battle for the ultimate yachting experience, call Ken Bourgeois at 844-242-7669 or email ken@iaqmoldtest.com.