Odorox® Independent Toxicology and Physical Chemistry Testing

Odorox® hydroxyl generators use multiple wavelength ultraviolet irradiation to generate hydroxyl radicals from water vapor in ambient air. The Odorox® system is designed to produce a concentration of hydroxyls comparable to that found in nature to destroy malodors, microorganisms, and volatile organic compounds (VOCs) in the air, on surfaces, and within porous materials like fabric, paper, etc.

HGI Industries, the manufacturer of Odorox® products, recently completed a series of toxicology and physical chemistry tests on its Odorox® Boss™ hydroxyl generator. The tests were commissioned by HGI using industry leading third party laboratories and experts, and are by far the most comprehensive on record with respect to this new technology. The results of these tests further confirm the overall safety and effectiveness of the Odorox® technology

Toxicology Study

The toxicology study was conducted by Comparative Biosciences, a preclinical contract research organization renowned for their leadership in the area of Food and Drug Administration (FDA) testing and Good Laboratory Practices (GLP). The thirteen week study involved the testing of sixty rats and was conducted under strict FDA GLP guidelines. Forty of the rats were exposed to two Odorox ® Boss™ machines running twenty-four hours per day, seven days a week, in a 200 sq. ft. (1,647 cu. ft.) room, while twenty of the rats were used as a control group and not exposed to any Odorox® equipment. It should be noted that this is a very heavy concentration of hydroxyls, and atypical of normal operating conditions. The study was an absolute success. **There were no adverse effects** in the exposed group and no detectable differences either pre mortem or upon post mortem studies of tissues at the gross and cellular levels.

Lovelace Respiratory Research Institute - Physical Chemistry Testing

The Lovelace Respiratory Research Institute (LRRI), founded in 1947 and located in Albuquerque, New Mexico, is a not-for-profit biomedical research organization well known for its technical expertise and research capabilities, particularly in the area of physical chemistry testing. LRRI conducted a series of physical chemistry tests using the Odorox® Boss™ machine. These tests were analyzed and validated by a leading physical chemist, Dr. David Crosley, with special expertise in hydroxyl radical chemistry and spectroscopic analysis. These tests are summarized as follows:

Hydroxyl output - The hydroxyl output of the Odorox® Boss™ machine was determined in an ultra-clean room by measuring the rate of reaction with n-heptane, a well-characterized VOC known to react selectively with hydroxyls, and not with ozone. The Boss™ unit produced a concentration of hydroxyls outside the chamber of the machine equal to approximately 2,000,000 hydroxyls per cubic centimeter. This concentration generally matches the average steady state concentration of hydroxyls found in a typical outdoor environment. Inside the chamber of the machine, the Boss™ unit produced a quantity of hydroxyls that is exponentially greater than concentrations generally found in nature. The combination of the internal and external hydroxyl production is significant to the overall effectiveness of the Odorox® technology.

Remediation effectiveness - The effectiveness of using the Odorox® Boss™ machine in a remediation application was determined by measuring how fast the hydroxyls reacted with the test VOC, whose concentration was typical of levels found in remediation conditions. The Odorox® Boss™ unit consumed over eighteen percent of the volatile organic test compound in the two hour test period. This is a very high rate of reaction and is consistent with published kinetics.

Titan comparison - For comparison purposes, the hydroxyl output of the Titan system, manufactured by International Ozone Technologies, Inc., was also tested under conditions identical to those used for the Odorox® Boss™ unit. The Titan uses a very different technology, known as photo catalytic oxidation (PCO), which involves the irradiation of a catalyst coated surface. The catalyst, titanium dioxide, binds the volatile organic compounds to be oxidized. When irradiated, the catalyst produces oxidants at the catalyst surface which react with bound compounds and microorganisms. **There is no mechanism for producing hydroxyls that exit the machine to treat the external environment. In other words, only air passing over the catalyst surface can be treated.** The Titan results are summarized below.

- In the two hour test period no measurable reduction in the n-heptane concentration was observed, although the measurement device (GC-Mass Spectrometer) is sensitive to 5-10 parts per billion (ppb).
- The experiment was repeated using 2-methyl furan which is known to react with hydroxyls twice as fast as n-heptane. Again, no measureable reduction in the 2-methyl furan was observed.
- **If any hydroxyls are being produced by the Titan product, they are too few for measurement**.

Ozone output - The Odorox® Boss™ machine was also tested for ozone output. Testing of residual ozone emissions is difficult due to the fact that standard measuring instruments cannot distinguish between hydroxyls and other oxidants such as ozone. The ozone testing was conducted in an ultra-clean room and included the use of more sophisticated physical chemistry to screen or quench hydroxyl output in order to measure remaining oxidant levels. The room measured 530 sq. ft. (4,238 cu. ft.). The results indicated that the Boss™ unit produces residual amounts of oxidants (assumed to be all ozone) measuring 0.04 parts per million (ppm). Just as in nature, the Odorox® technology produces negligible levels of ozone as a by-product of making hydroxyls. Odorox® systems are designed to minimize the residual ozone principally by irradiating and decomposing it as it is formed within the Odorox® UV processing chamber.

Ozone is non-accumulative under these conditions and remains at a steady state concentration similar to ambient levels in the outside air. Ozone is also lost to a variety of chemical reactions, including its reaction with hydroxyls. Under normal use conditions with average levels of ventilation and air movement, the ozone levels are far below the Occupational Safety and Health Administration (OSHA) guidelines for permissible exposure limit (PEL) of 0.1 ppm time-weighted average over an eight hour period.

Safety has always been a top priority. It is important to note that certain operating conditions should be avoided, such as the use of our commercial or industrial units in small confined spaces with no air exchange or without proper monitoring. As such, we do provide operational guidelines for each of our hydroxyl products, which are available on our website at www.odoroxhg.com.

