

AIRPHX Technology Overview

AIRPHX uses a proprietary non-thermal plasma generator to create a number of oxidizing molecules that are excellent disinfecting agents. The technology was evaluated in two peer reviewed white papers: 1) Evaluation of the AIRPHX Advance Oxidation System in Controlling Healthcare-Associated Infections on Various Surfaces by Rick Falkenberg, Ph.D., September 13, 2017 (“White Paper #1”); and 2) Evaluation of an Advanced Oxidation System in Controlling Healthcare-Associated Infections in Active Patient Environments by Rick Falkenberg, Ph.D, September 25, 2018 (“White Paper #2”).

Please note: As further explained below, the ozone generated by AIRPHX units referenced in White Papers #1 and #2 is no longer released into treatment spaces.

AIRPHX Oxidizing Molecules

White Paper #1 describes what types of oxidizing molecules are generated by the AIRPHX technology:

“These [oxidizing molecules] include oxygen ions, free radicals and peroxides that are highly reactive due to the presence of an unpaired valence shell electron. It is important to note that the amount of energy present in the AIRPHX plasma is not strong enough to alter the nitrogen in the air.

Measurable levels of gas-phase hydrogen peroxide, other [oxidizing molecules], and ozone are produced within the chamber and, given their half-lives, can be allowed to enter the surrounding environment when this is desired. The hydrogen peroxide produced is different than vaporized or aerosolized hydrogen peroxide. Gas-phase hydrogen peroxide has a more acute bond angle and is shorter lived than the more stable liquid or vaporized forms. In addition, the ozone produced is shorter lived with an approximate 20 minute half life. When ozone is released from an AIRPHX unit based on the intended use, it interacts with airborne contamination and is consequently at very low dissolved levels.

It is reasonable to assume that a number of other [oxidizing molecules] are created within the chamber but do not leave it due their short half-lives:

Species	Half Life
Atomic Oxygen (O)	Microseconds
Singlet Oxygen (O ₂ with displaced electron)	Microseconds
Hydroxyl Radicals (OH ⁻)	Microseconds
Superoxide (O ²⁻)	< 1 sec
Hydrogen Peroxide (H ₂ O ₂)	Variable
Ozone (O ₃)	20 minutes max-carbon load dependent

Regulation of AIRPHX Oxidizing Molecules

At the time the White Papers were published, AIRPHX technology emitted both hydrogen peroxide and ozone into the treatment space. Both occur naturally in air.¹ Ozone's primary purpose was as a marker to determine the level of oxidizing molecules in the treatment space. The levels of ozone produced by AIRPHX provided little, if any, disinfection in the treatment space. Hydrogen peroxide is an excellent disinfecting agent with a very long half life. The National Institute of Health confirms the efficacy of hydrogen peroxide: "Although nonflammable, [hydrogen peroxide] is a powerful oxidizing agent that can cause spontaneous combustion when it comes in contact with organic material." <https://pubchem.ncbi.nlm.nih.gov/compound/Hydrogen-peroxide>

Both ozone and hydrogen peroxide are regulated by Occupational Safety and Health Administration ("OSHA") and, at elevated levels, they can become irritants.

Ozone. White Paper #2 addresses safety issues with respect to ozone that is created by AIRPHX technology:

"The AIRPHX technology is equipped and regulated through the use of an integrated Aeroqual sensor (Aeroqual Limited, Auckland, New Zealand) monitoring ozone (O₃) as an indicator of [oxidizing molecule] production. The low level O₃ byproduct of the clean process that takes place within an AIRPHX unit is safe according to the OSHA Hazard Communication Standard 29 CFR 1910.1200. The AIRPHX technology relies on electricity and the oxygen present in ambient air to produce marginal levels of [oxidizing molecules] where O₃ is stabilized (average less than 0.03 ppm) within a treated area or space. This level is lower than limits established by the Occupational Safety and Health Administration of 0.10 ppm and the Center for Disease Control through The National Institute for Occupational Safety and Health (NIOSH) of 0.10 ppm."

Hydrogen Peroxide. White Paper #2 addresses safety issues with respect to the hydrogen peroxide that is released into the treatment space:

The hydrogen peroxide produced (previously discussed) is different from vaporized or aerosolized hydrogen peroxide (H₂O₂). This by-product is from the clean process that takes place within an AIRPHX unit is not hazardous according to the OSHA Hazard Communication Standard 29 CFR 1910.1200. The AIRPHX technology relies on electricity and the oxygen present in ambient air to produce marginal levels of H₂O₂ where it is stabilized (average less than 0.07 ppm) within a treated area or space. Such treated area(s) should have consistent/constant airflow to provide a uniform distribution of the sanitizer. This level is lower than limits established by the Occupational Safety and Health Administration for General Industry: 29 CFR 1910.1000 1 ppm and the Center for Disease Control through The National Institute for Occupational Safety and Health (NIOSH) of 1 ppm."

¹ AIRPHX units have been verified by the Washington State Department of Agriculture to comply with USDA National Organic Standards (7 CFR Part 205).

Removal of Ozone

In response to general market concerns about ozone (as opposed to complaints from AIRPHX customers about irritation from ozone), AIRPHX developed a catalyst that removes virtually all ozone produced by the AIRPHX unit through a thermal conversion process. AIRPHX is in the process of seeking California Air Regulatory Board (CARB) certification for the ozone stripping technology. In the meantime, AIRPHX has conducted its own testing using the testing methodology mandated by CARB. AIRPHX internal results show ozone levels of 0.0005 parts per million (CARB standards are 0.050 ppm and OSHA standards are 0.1 ppm). Ozone occurs naturally in ambient air at levels generally substantially in excess of 0.0005 ppm. AIRPHX has filed a patent on the plasma cell incorporating this ozone removing technology that is currently being reviewed by the US Patent and Trademark Office.

Summary

AIRPHX units are safe when operated in accordance with the user guide, including deploying the units in appropriately sized treatment spaces with reasonable airflow. AIRPHX technology is operating safely in hundreds of installations such as commercial gyms, college athletic programs, hospitals (including wards of hospitals with immune-challenged patient populations), military bases, food processing facilities, commercial buildings, residences, dental offices and country clubs.

AIRPHX received no complaints from customers about irritation during the period when AIRPHX units deployed ozone into treatment spaces, although some customers commented on the ozone “smell”. Since deploying its ozone stripping technology, AIRPHX is not aware of any complaints related to operation of its technology in accordance with the user guide.

As noted in White Paper #2, in the event the Aeroqual sensor was triggered, the level of hydrogen peroxide in the treatment space would be less than 0.07 ppm (1/14 the OSHA standard). Since removing the Aeroqual sensor, AIRPHX has tested for hydrogen peroxide levels in dozens of installations without ever registering even 0.1 ppm, consistent with the hydrogen peroxide levels noted in White Paper #2 as not exceeding 0.07 ppm when AIRPHX units are operated in accordance with the user guide.