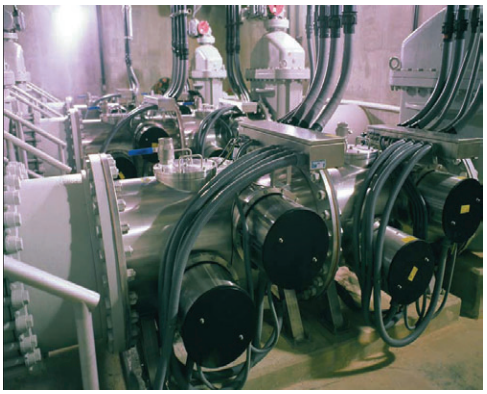
U.S. Environmental Protection Agency
Environmental Technology Verification Program

Ultraviolet (UV) Disinfection Systems for Secondary Wastewater Effluent and Water Reuse

The U.S. EPA Environmental Technology Verification (ETV) Program's Water Quality Protection (WQP) Center, operated by NSF International under a cooperative agreement with EPA, has verified the performance of three ultraviolet (UV) disinfection systems[1], one for secondary effluent and two for water reuse applications. These technologies can be used in place of chemical disinfection to inactivate or destroy infectious organisms, such as *E. coli* and *enterrococci*, in wastewater treatment plant effluent prior to release or reuse. Wastewater treatment facilities can use these technologies to install or upgrade disinfection systems, thus helping them to comply with discharge standards, including those under Total Maximum Daily Load (TMDL) requirements.



One of the verified UV technologies

Technology Description and Verification Testing

The ETV-verified UV technologies utilize either "low-pressure" or "medium-pressure" mercury lamps to generate electromagnetic radiation that can penetrate the cell walls of microbial organisms, eliminating their capacity to reproduce. All three technologies utilize contact reactors with lamps that are enclosed in quartz sleeves. **Table 1** lists the three ETV-verified UV technologies.

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Table 1. Verified UV Disinfection Technologies for Water Effluent and Water Reuse

Technology	Description
Aquionics, Inc. bersonInLine® 4250 UV System	Uses high-output, medium-pressure mercury lamps in quartz sleeves that are oriented horizontally and perpendicular to the direction of flow
Ondeo Degremont, Inc. Aquaray® 40 HO VLS Disinfection System	Uses high-output, low-pressure mercury discharge lamps in quartz sleeves oriented vertically and perpendicular to the direction of flow
SUNTEC *environmental*, Inc.[a] LPX200 UV Disinfection System	Uses high-output, low-pressure UV lamps in quartz sleeves oriented horizontally and parallel to the direction of flow

[a] Company no longer in business

Wastewater Effluent and Water Reuse Efforts at a Glance

Pathogenic organisms present in wastewater effluents can cause a variety of diseases in humans. Pathogen-containing discharges can limit public use of valuable natural resources such as beaches, lakes, and rivers. For example, in 2005, more than 1,100 U.S. beaches, or 28% of those monitored, were issued warnings or closed for at least one day because of water contamination.

To help address the human health effects of the presence of various pathogens in water, the EPA sets water quality criteria under the authority of the Clean Water Act. The EPA recently established health-based federal bacteria standards for a number of states and territories bordering the Great Lakes or ocean waters. These criteria limit the geometric mean for *enterrococci* in marine coastal recreation waters to 35 colonies per 100 millimeters (35/100 mL), and for fresh waters, 33/100 mL. For fresh coastal recreation waters, the criteria limit the geometric mean of *E. coli* to 126/100 mL. Under the Clean Water Act, states are also required to identify impaired waters that do not meet water quality standards even after installation of pollution control technology.

Removal of pathogens is also a primary concern for a number of states promoting water reuse projects aimed at conserving water. EPA and the U.S. Agency for International Development have jointly developed a technical document with guidelines for water reuse. These guidelines recommend a higher degree of treatment wherever public exposure to reused water is expected. UV disinfection is one of the disinfection processes proposed in the guidelines. Reuse efforts are necessary in areas where water scarcity is experienced because of growing water demands, as well as in areas subject to drought. In 2005, the National Drought Mitigation Center identified 41 states experiencing water-related drought impacts. Among the advantages of water reuse are that it decreases the diversion of water from sensitive ecosystems, reduces and prevents pollution, and creates, restores or enhances wetlands and wildlife habitats.

[1] The ETV Program operates largely as a public-private partnership through competitive cooperative agreements with non-profit research institutes. The program provides objective quality-assured data on the performance of commercial-ready technologies. Verification does not imply product approval or effectiveness. ETV does not endorse the purchase or sale of any products or services mentioned in this document.

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All of the verification tests were conducted at the Parsippany-Troy Hills Wastewater Treatment Plant in Parsippany, New Jersey. The testing used MS2 bacteriophage as the target organism because of its high tolerance to UV light. The tests were conducted on water with UV transmittances of 55% and 65%. All of the verifications measured power consumption and headloss results, developed dose delivery-flow curves, and obtained reactor design data for use in scaling system design for applications larger than those tested. The technical objective of the tests was to verify the effective delivered dose for each UV system's reactor under varying flow and water transmittance conditions. Each of the verifications met this objective, developing dose delivery curves based on the MS2 bacteriophage survival rates observed during testing. Additional information on the verification of these UV systems can be found at http://www.epa.gov/etv/verifications/vcenter9-5.html

Selected Outcomes of Verified UV Disinfection Technologies

- Based on a 25% penetration of the market for these technologies, the ETV-verified technologies would be installed at 77 wastewater treatment facilities (out of 309 facilities), and would assist 23 wastewater treatment facilities (out of 90 facilities) in complying with EPA's new water quality standards for coastal and Great Lakes recreation waters. The technologies would also enable water reuse at 29 facilities (out of 114 facilities) in Florida and California, resulting in the capacity to recycle at least 140 million gallons per day of water.

- The technologies would replace conventional chemical disinfection at many of the facilities mentioned above and, in the process, eliminate the need to manage hazardous chemicals and potentially reduce operating costs. Adverse health effects have been associated with the conventional method of chemical disinfection since harmful disinfection by-products, such as trihalomethanes, may be formed when using chemical disinfection. **Table 2** summarizes the advantages and disadvantages of UV disinfection systems over chemical disinfection (such as chlorination).

Table 2. Advantages and Disadvantages of UV Disinfection Over Chemical Disinfection

Advantages	Disadvantages
• Effective at inactivating most bacteria, viruses, spores, and cysts • Eliminates the need to manage toxic, hazardous, or corrosive chemicals • Might not generate harmful residuals (e.g. trihalomethanes) • Can be less labor intensive to operate • Uses shorter contact times • Requires less space for equipment and process	• Dosage must be sufficient to deactivate certain organisms • Organisms sometimes are able to reverse the destructive effects • Preventive maintenance is more intensive • Must be designed to account for turbidity and suspended solids in wastewater that can reduce the transmittance of the UV radiation • Does not provide a disinfectant residual, which may be a disadvantage where a residual is desirable

- Use of the ETV-verified technologies in the treatment of secondary wastewater effluent ultimately will reduce exposure of downstream users to infectious organisms, reducing the incidence of disease and protecting the public's ability to use natural resources such as beaches and rivers.

- Although UV technologies have higher capital costs than chemical disinfection, they generally require a smaller footprint than chemical disinfection processes. The use of UV disinfection can avoid additional land costs associated with expanding a treatment facility and can reduce labor cost, as they can be less-labor intensive to operate.

- The ETV verification protocol for validating UV technologies has been acknowledged by the State of California as meeting the minimum requirement for acceptance of a technology under the State's regulations for UV disinfection. This provides an advantage for ETV-verified vendors in gaining acceptance from the State regulatory agency and in marketing their technology in California. Several states and agencies also have started using the technologies, such as the Flat Creek Water Reclamation Facility in Gainesville, Georgia, the City of Fairfield, Ohio, and the Laguna County Sanitation District in California.

References

U.S. EPA, ETV Case Studies: Demonstrating Program Outcomes, Volume II. EPA/600/R-06/082. September 2006. (primary source). http://www.epa.gov/etv/pdfs/publications/600r06082/600r06082.pdf

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