UV Validation and Certification

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Ultraviolet (UV) technology has many advantages such as being effective against a wide variety of microorganisms (bacteria, viruses and protozoa such as Cryptosporidium and Giardia), chemical free, environmentally friendly, free of harmful disinfection by-products (DBPs), safe, compact, and cost-effective. The technology is used around the world in municipal drinking water and wastewater applications as well as for various industrial, commercial, aquatics/leisure and residential/consumer water treatment applications.

One of UV's few limitations is the difficulty in monitoring its efficacy during operation. To successfully do so, systems must be validated and subsequently certified for various applications. Validation testing certifies UV reactors for performance, specifically dose delivery by and monitoring of the UV system. In addition, testing also determines a set of operating conditions that can be monitored by a utility to ensure that the UV dose required for a given pathogen inactivation credit is delivered at all times. An independent and recognized third party conducts testing either off-site at a dedicated test facility or on-site at the facility actually interested in installing UV.

The Need for Validation Testing

Most countries have established regulations and guidelines on UV usage for water and wastewater treatment. For the U.S. drinking water market, for instance, the USEPA's Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) requires the use of validated UV reactors for receiving Cryptosporidium, Giardia or virus inactivation credit. In the U.S. and elsewhere, UV systems used in the municipal drinking water market must meet stringent protocols such as DVGW W294 (Germany) and ÖNORM M5873-1 (Austria). In the U.S., they might also need to comply with guidelines specified in the USEPA's UV Disinfection Guidance Manual (UVDGM) or by the National Water Research Institute (NWRI). For small-flow applications, such as residential and commercial, UV systems must be certified according to the NSF/ANSI Standard 55 (National Sanitation Foundation) Protocol. For swimming pool applications, UV systems must be certified according to the NSF/ANSI Standard 50 Protocol.

In the wastewater market, UV systems must comply with the Title 22 guidelines specified by the NWRI and the American Water Works Association Research Foundation (AwwaRF) for water reuse applications. For conventional wastewater discharge applications, UV systems that have undergone bioassay testing are more frequently specified due to the uncertainty associated with existing mathematical models.

Alternate Testing Methods

Many consider such mathematical models complex and unreliable. Ambiguity arises when critical input parameters are incorrectly entered, which negatively affects the quality and accuracy of the output data. And as the results are not based on actual microbiological data, they must be validated.

Actinometry is another testing method that involves a photochemical reaction for which the quantum yield is very well known. Ferrioxalate, persulfate, iodide/iodate, uridine, and dyed microspheres are examples of actinometers. The problem with using this testing method is that it is still being developed, although the dyed microspheres technology is showing promise.

Yet another testing method is radiometry that uses a sensor or radiometer device to sense the total irradiance incident on a sensor element. Using sensors has several shortfalls, including their consistent reliability and accuracy. Also, while a UV reactor consists of a variable intensity field, sensors can only measure light at one given position within the reactor. Accordingly, the devices are used to only monitor the UV system's performance and not to measure the UV dose.

Bioassay Testing

Biodosimetry is the preferred method of testing. Also known as bioassay testing, this testing method involves using a microorganism for which the response to UV is very well known. First, a challenge (surrogate) microorganism is selected. In Europe, *B. subtilis* spores tend to be the microorganism of choice; in the U.S., MS2 bacteriophage is commonly used. New microorganisms such as T1 and QBeta are showing promise as they more closely match the sensitivity of waterborne pathogens like Cryptosporidium. To yield the best results, the ideal surrogate should be non-pathogenic, easily cultured to high titers, and easily enumerated. Moreover, the microorganism's UV sensitivity should be similar to that of the target pathogen.

Validation testing begins by generating a UV dose response curve, which expresses log inactivation versus UV dose for the challenge microorganism in the testing water. While testing the actual UV system, the reactor is subjected to various flow rates and different water quality conditions. The influent water is seeded with the same type of microorganism for which the dose response curve is generated. The water transmittance, which measures the ability of UV light to penetrate the water, is adjusted to simulate different and worst-case operating scenarios. The UV system is turned on, and multiple sample counts are taken before and after the reactor. The inactivation of the microorganism is measured for each test condition; the measured inactivation is then related to a dose value using the dose response generated by the collimated beam apparatus. This dose value is noted as the reactor's delivered Reduction Equivalent Dose (RED).

The desired RED is highly dependent on the application. For municipal drinking water treatment applications, the most common target RED is 40 mJ/cm^2. For municipal wastewater discharge applications, a common target RED is either 15 or 30 mJ/cm^2. For water reuse applications, depending on the treatment scheme, the target RED can be as high as 100 mJ/cm^2. For residential applications, based on the intended use, the target RED is either 16 or 40 mJ/cm^2.

Criteria for testing standards do slightly vary. The DVGW W294 protocol, for instance, requires a minimum number of monitoring ports containing UV irradiance sensors. How many depends on the number and power of the UV lamps. The individual sensors, windows and reference sensors (radiometers) must also be standardized to the W294 protocol. Throughout the life of the validated UV reactor, each sensor will need to be checked with a radiometer to ensure proper operation. By testing the various UV sensors, regulators can ensure that the system is operating properly.

Conclusion

To receive DVGW, ÖNORM, USEPA's UVDGM, NWRI (Title 22) or NSF55 validation/certification, UV systems must successfully pass rigorous validation testing from a trusted and respected third-party source. Today, bioassay testing is the only used and accepted testing method. Testing occurs either on- or off-site. Off-site test centers for municipal water applications are located in Austria (ÖNORM M5873-1), Germany (DVGW W294), Johnstown, N.Y., USA, and Portland, Ore., USA. The last two are used to validate reactors according to the USEPA's UVDGM as well as for water reuse and municipal wastewater applications. The NSF facility can be used for Standards 50 and 55.

For a UV system to receive validation/certification from one of the above-named organizations speaks highly of its operational efficiency for particular water and wastewater treatment applications. For example, UV disinfection technical specifications often require that UV systems meet the DVGW W294 standard for drinking water applications. Likewise, facilities wishing to install a UV system frequently seek a validated/certified product for their municipal or industrial water/wastewater application.

About the Author

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