Understanding Evaluation, Testing and Certification of UV Systems for Drinking Water and Recreational Water Treatment

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ABSTRACT

NSF International (NSF) has several standards and programs involving the testing and certification of performance and health effects of water treatment and distribution products for many end uses such as residential drinking water treatment, industrial and waste water, ballast water treatment, public or municipal drinking water treatment as well as the pool, spa, and recreational water treatment. NSF/ANSI Standard 50: Equipment for Pool, Spa, Hot Tub and Other Recreational Water Facilities provides the all encompassing product and system evaluation criteria for evaluation of products and materials used at recreational water facilities. This presentation will discuss harmonized testing and certification requirements, new developments and criteria that have been developed for the Drinking Water and Recreational Water and Aquatics Markets, specifically evaluation, testing and certification of ultraviolet (UV) light systems.

Keywords: Ultraviolet Disinfection, Cryptosporidium, MS2 phage, Testing, Certification, Validation, Water Quality, RED-Reduction Equivalent Dose, LTSESWTR Long Term 2 Enhanced Surface Water Treatment Rules, USEPAUVDGM United States Environmental Protection Agency Ultra Violet Disinfection Guidance Manual

INTRODUCTION

UV water treatment systems help to assure excellent water quality for swimmers. The presentation taught attendees how these products are functionally evaluated, tested and certified and how the testing and certification work can aid manufacturers in multiple product use markets.

As a result of the 1993 Milwaukee outbreak of *Cryptosporidium*, the EPA began a series of regulatory endeavors. The most significant promulgated and proposed rules addressing *Cryptosporidium* since 1994 were the Information Collection Rule, the Interim Enhanced Surface Water Treatment Rule, the Long Term I Enhanced Surface Water Treatment, Filter Backwash Rule and the Long Term 2 Enhanced Surface Water treatment Rule (LT2ESWTR).

In 1998, the EPA's Environmental Technology Verification (ETV) began a study to determine how well UV treatment would inactivate *Cryptosporidium* using new methods of animal infectivity to detect the kill of *Cryptosporidium*. A final ETV report was published May 1999 that supported other research on UV effectiveness in inactivating *Cryptosporidium*. In the LT2ESWTR the effectiveness of UV for the treatment of *Cryptosporidium* was recognized by including UV as part of the rule's "tool box" of treatment options.

After many water-park cryptosporidiosis outbreaks, regulations for *Cryptosporidium* inactivation were drafted in some states in the U.S. To address the need for consistency, in 2005 NSF initiated development of *Cryptosporidium* treatment requirements for recreational water UV systems. For the next few years, the NSF Joint Committee on Recreational Water Facilities worked with drinking water and recreational water stakeholders to create harmonized *Cryptosporidium* criteria. In 2010, the testing and certification requirements were added to NSF/ANSI Standard 50 for Recreational Water Equipment. NSF-50 Section 13.18 specifically cites testing and evaluation in accordance with EPA Protocol for the validation of UV reactors for use in drinking water. In this way, the same validation protocol is used for recreational water treatment equipment as for drinking water treatment equipment. This produced a harmonized protocol for the validation of UV reactors.

Regulations and legislation have since been passed in California, New York, Florida, Texas, and Utah and other sites to require UV products which treat certain types of recreational waters (typically spray pads or spray grounds) to be tested and certified to NSF/ANSI Standard 50 and to inactivate 3 log or 99.9% of *Cryptosporidium* and achieve the desired reduction equivalent dose at a given set of conditions. Some states require that UV systems meet a UV dose of 40mJ/cm2. This is also the requirement in international standards like DVGW and ONORM.

NSF, as the ETV Drinking Water Systems Center (DWSC) manager, published the NSF and EPA ETV *Generic Protocol for the Development of Test/Quality Assurance Plans for Validation of UV Reactors – 2010*. The ETV UV Protocol is based on and consistent with the EPA's Ultraviolet Disinfection Guidance Manual (UVDGM).

In addition, NSF issued the final harmonized specific testing methods and evaluation criteria for third-party testing and certification of UV systems as part of its NSF Standard 50 revision. These requirements were added to the existing UV evaluation and testing requirements already within NSF/

ANSI Standard 50. NSF/ANSI Standard 50 also cited the EPA ETV UV Protocol. Thus the NSF/ANSI Standard 50-2010 incorporated new requirements that include a more specific and repeatable derivative of the LT2ESWTR and UVDGM, as well as requirements from DVGW W-294 and ONORM 5873 for UV drinking water system evaluation. The presentation explained the process by which UV systems are evaluated for both drinking water and recreational market uses and how the combined evaluation, testing or validation and ultimately certification can provide officials, facility operators, and manufacturers the greatest benefit

DISCUSSION

Ultraviolet Systems

Certification of UV Systems is conducted to the NSF/ANSI Standard 50 – 2011 and the EPA's Environmental Technology Verification (ETV) *Generic Protocol for the development of Test/Quality Assurance Plans for Validation of UV Reactors - 2010*. The presentation provided core elements of the technical evaluation and testing of UV systems for performance and functionality via alarms, use of challenge organisms such as MS2 phage for target organism such as *Cryptosporidium*, generation of single sensor set-point and/or set-line data for operational control, in the process of validation of UV reactor system performance. The NSF/ANSI 50 testing and certification enables validation of UV systems of any flow rate as it does not set any maximum or minimum functional flow rate for systems. The NSF/ANSI Standard 50 references the ETV protocol which also allows for the validation to a RED of 40mJ/cm2 which some States now require and is also specified in certain international regulatory agencies. Together NSF 50 and ETV UV Protocol represent harmonized criteria.

EPA ETV UV Protocol:

The EPA in its ETV DWSC completed the development of a generic protocol designed to validate the performance of small flow (<1000 GPM) UV reactor equipment. NSF held calls with stake-holders especially State drinking water regulators to develop a simple, direct and clear UV validation protocol. Drinking water regulators perceived that the present UVDGM-2006 offered flexibility but not clarity in validations. An EPA ETV technical panel of experts including well informed State regulators was formed to work with NSF to develop a simple and clear UV validation protocol. The result was published in 2010 followed by a revised 2011 based upon additional stakeholder comments (August 2011).

The EPA ETV UV protocol was designed to validate UV reactors using a single sensor set point control strategy as this was most likely the control strategy best used for small systems. In addition, the ETV Protocol is also used to address the requirements by international organizations. The protocol also addresses the Norwegian Institute of Public Health requirements for UV reactor testing and design.

The presentation discussed 1) a summary the ETV Protocol requirements, 2) how the ETV Protocol clarifies certain vague aspects of the UVDGM, 3) the process by which recent advances in validation may be included via protocol modification process and 4) a description of how certain non-testing aspects of the EPA's UVDGM are handled under a certification program.

The EPA ETV Protocol includes these UV reactor validation steps:

1. Obtained the technical specifications for the system from the manufacture;
2. Assessment of the UV sensors,
3. Collimated beam laboratory bench scale testing,
4. Full scale reactor testing, and
5. Calculations to determine the RED, and adjust the RED for uncertainty in UV dose and calculate a validated dose for *Cryptosporidium* to show a minimum 3 log reduction.

Some examples of the UVDGM that the ETV protocol made specific were: mandating the use of germicidal only sensors, allowing DVGW or OONORM certified sensors, rejecting duty sensors not within 5% of reference sensors, mandating radiometer agreement within 5%, requiring pipe configuration with 90 degree bend for testing as the most conservative, specifying conditions for performing stability testing, specifying the minimum number of sensors for monochromatic lamps and also for polychromatic lamps. Other details of the protocol are summarized in the attached presentation and more detail can be found at this web site:
http://www.nsf.org/business/drinking_water_systems_center/pdf/Final_ETV_UV_Validation_Protocol.pdf.

The ETV protocols are continuously improved. ETV protocols can be modified to address recent scientific advances and lessons learned by all stakeholders including State regulatory agencies. The ETV protocol review process involves a once a year announcement (http://www.nsf.org/

business/drinking_water_systems_center/pdf/uv_stakeholder_etv_announcement_2012.pdf). Suggestions can be made at any time of the year however; they will be posted for all to see and addressed once a year typically during the January through March period.

Some recent improvements from this process of stakeholder reviews included precise timing of influent and effluent sample collection, stakeholder procedure for allowing test organism other than MS2, frequency of flow meter calibration, and frequency of reactor blanks. Some comments / improvement presently under consideration include validation to dose only with various test microorganisms.

NSF / ANSI Standard 50

In 2009, the NSF Standard 50 Joint Committee decided to include in the standard requirements for validation of UV reactors consistent with the UVDGM-2006 for *Cryptosporidium* log inactivation.

The NSF/ANSI 50 testing and certification enables validation of UV systems of any flow rate as it does not set any maximum or minimum functional flow rate for systems. A critical goal was the development of a clear and direct generic protocol based on the EPA's UVDGM-2006 and validation of UV dose of the reactors. The protocol was designed to validate UV reactors using a single sensor set point control strategy.

In 2010 the NSF International Recreational Water Facility Joint Committee agreed to cite the ETV protocol within the NSF/ANSI Standard 50 Section 13. The NSF 50-Section 13 now requires a **minimum** of 3-log *Cryptosporidium* inactivation performance (greater performance is also accepted). As improvements are made in the ETV Protocol, NSF/ANSI Standard 50 automatically reflects those improvements and efficiencies.

Some may be unfamiliar with the differences between the terms tested, validated, and certified as it relates to UV systems. A key difference between certification and a single validation (aka test) report is that certification also addresses the production location and changes over time in the entire UV system including the reactor, power supply and control system. In the UVDGM-2006, Section 5.13 is a list of components that if changed or modified most likely will require re-validation. Section 5.13 of the UVDGM represents the non-testing requirements of the LT2ESWTR. Some organization is responsible for assuring that any change in the components listed in section 5.13 of UVDGM is being monitored. An NSF Certification is designed to do such monitoring of the production facility.

NSF Certification is a process wherein, NSF acting as an independent third party performs annual unannounced audits at the production location of certified UV systems to evaluate for changes in components, suppliers, designs, etc. that potentially could affect performance. Under the system known as certification, manufacturers may submit changes for review by organizations like NSF. Some changes may require no testing, minor testing, or complete revalidation. Therefore, UV system certification provides much greater value to UV system users and purchasers than simple testing or validation alone.

Certification also has great benefit to product manufacturers as certification allows tor the public display of only limited information to protect a company's proprietary property and information while making public critical non-confidential details. A full validation (or testing) report is developed under NSF certification but it is NOT placed in the public domain. Rather, the certified company is given the validation report which is used as part of the basis for certification along with the facility inspection and other criteria. The manufacturer may then choose to provide the NSF validation report to persons or organizations that the certified company so desires. In this way a company can control what proprietary information it releases and to whom. In NSF's case, our policy requires that we send any request for such reports to the manufacturer. Often it is from a state regulator or water facility operator. With the manufacturer's permission, NSF can send the validation report directly to the intended party.

Under the present NSF Certification process, those manufacturers of products applying for certification for recreation water or drinking water applications undergo the same validation test and similar certification policies as described previously: certification listing, product marking, and a full validation report. However, there are differences in what models need to be tested. For drinking water applications, all make and model reactor configurations must be validated as required per the EPA LT2 rule. For NSF 50, there is some latitude and consideration of bracketing a family based upon testing at least two worst case models within a similar product/design family. Section 13.18 of NSF 50 (inserted below) explains the sample determination process.

SAMPLE SELECTION

When validating a range of aquatic or recreational water use UV systems for inactivation of cysts such as *Cryptosporidium* parvum, each of the following variables shall be used to determine which UV reactor/systems and components shall be tested within the range of product. Select at least two worst case models from the range of products based upon all of the following variables.

1. Test the unit representative of the worst case reactor hydraulics and UV dose delivery as determined by CFD modeling, including intensity and flow modeling;
2. Test the unit with the lowest power to highest flow rate;
3. Test one unit of each configuration (if family range contains U and S reactors, test each);
4. Test one unit of each UV lamp type (if alternate lamp types or suppliers, test each); or
5. Test one unit of each UV sensor type (if alternate UV sensor types/suppliers, test each).

NOTE - The above variables require that multiple UV systems are tested in order to validate a range of products.

Attendees will understand the practical terminology as it relates to product evaluation and system testing (ie a singular event also known as validation), versus product certification, i.e., initial evaluation and testing as well as ongoing conformity assessment. The presentation will provide a comparison of the UV evaluation criteria used in world markets. Further, the presentation will provide the technical aspects of product evaluation and testing as part of UV system validation and the merits of the harmonized set of criteria to aid manufacturers, facility operators, and public health officials.

CONCLUSIONS

NSF has developed several new third party testing and certification programs in response to new regulations and concerns in the drinking water, aquatics and recreational water industries. NSF Standard 50 has been updated with additional important harmonized Cryptosporidium criteria for UV system testing (aka validation), and certification. The latest performance certification for recreational water equipment will provide an easy way to evidence and verify compliance of UV disinfection systems.

REFERENCES

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USEPA Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule, November 2006, USEPA Environmental Monitoring and Support Laboratory, Cincinnati, OH 45268 USA