Outside Perspectives: Consultants' Review of the Draft UVDGM

Paul Swaim, P.E., Senior Water Treatment Technologist, CH2M HILL, 9193 S. Jamaica St., Englewood, CO 80112
Joan Oppenheimer, Principal Scientist, MWH, 300 N. Lake Ave., Suite 1200, Pasadena, CA 91101
Kuang-Ping Chiu, Ph.D., Engineer, MWH, 300 N. Lake Ave., Suite 1200, Pasadena, CA 91101
Heather Mackey, Environmental Engineer, Black & Veatch, 8400 Ward Parkway, Kansas City, MO 64114

The USEPA's Draft UVDGM was officially issued for public comment on July 11, 2003. However, this is not the first request for comments and participation, as representatives of the drinking water treatment community have been provided the opportunity to review and comment on the document over the past two years. Thanks to the approach taken by the USEPA in developing this document, the firms represented by the authors of this article have been part of the group of stakeholders that were given the opportunity to provide input on the document since its inception. For this opportunity, we express our gratitude to the USEPA, to the consultant team that developed the Draft UVDGM, to the American Water Works Association, and to the Association of Metropolitan Water Agencies. Along with the USEPA, the latter two organizations organized and hosted two UVDGM Review Meetings in 2002 following the publication of the preliminary draft document in late 2001.

The authors of this article are very pleased with the changes to the UVDGM document since the preliminary draft. One of the key comments by the group of stakeholders at these UVDGM Review Meetings was that the document needed to be made more accessible and user-friendly, with better defined approaches for practitioners and State regulators to understand and implement. From this input, the Tier I and Tier II concepts were developed to greatly simplify the validation of UV reactors for drinking water applications.

The Draft UVDGM is a comprehensive document that brings together the current state-of-the-science in UV disinfection. The body of the document includes important, to-the-point information for project implementation, while the appendices provide a wealth of information for practitioners to understand the science behind the recommendations and requirements. The entire team responsible for the Draft UVDGM should be acknowledged for a job well done.

From our reviews of the UVDGM, we offer the following discussions related to a few of the topics addressed in the document, with the intent of providing some new perspectives on these issues.

RESPONSIBILITIES ASSIGNED TO THE STATES (Paul Swaim, CH2M HILL)

With the approach taken in the Draft UVDGM, the primacy agency (or "State") has a great deal of leeway and responsibility in deciding which of the UVDGM's many recommendations to turn into requirements. For example, it will be the State's responsibility to examine alternative application points for UV disinfection, determine redundancy requirements, consider alternative approaches to reactor validation, determine compliance with Tier I validation requirements, evaluate Tier II validation approaches, develop monitoring requirements, establish requirements limiting off-specification operation for filtered water applications, approve protocols for UV intensity sensor calibration checks and recalibration criteria, and determine when revalidation is necessary. This is a great deal of responsibility covering a wide range of new topics for drinking water systems.

UV disinfection is a developing technology with a multitude of new issues and concerns to evaluate and understand. While the States have very capable people to complete this task, in many cases, they may not have the time to digest the nearly 500-page UVDGM document and to gain a thorough understanding of the issues involved before they are faced with the need to make decisions on specific projects. To avoid significant discrepancies in requirements from state-to-state and to ensure that a uniform level of public health protection is provided by all systems implementing UV disinfection, additional guidance from the USEPA is likely to be necessary. Additional definition in the UVDGM on sensor calibration checking requirements, sensor recalibration criteria, and reactor changes that require revalidation would help to address this issue. To facilitate knowledge transfer, utilities and consulting engineers should encourage the involvement of State regulators in UV disinfection projects from the planning stages through startup.

UV REACTOR VALIDATION AND MONTHLY MONITORING REQUIREMENTS (Heather Mackey, Black & Veatch)

According to the LT2ESWTR, in order for the utility to receive Cryptosporidium credit, the UV reactor performance must be validated and the validation test results must

be sent to the State. Several validation protocols are available, including DVGW, ÖNORM, NWRI/AwwaRF, NSF Standard 55, and the UVDGM Tier approaches. According to the UVDGM, reactors previously validated under DVGW and ÖNORM protocols should receive 3-log credit for Cryptosporidium inactivation, while reactors validated under NWRI/AwwaRF Guidelines and NSF Standard 55 should be evaluated on a case-by-case basis. Reactors that are validated following the procedure outlined in the UVDGM (Tier I approach) can receive 3-log inactivation credit for Cryptosporidium at a reduction equivalent dose (RED) of 36 mJ/cm2 with an LP or LPHO UV system and at a RED of 42 mJ/cm2 with an MP UV system. The UVDGM also describes a Tier II approach that allows users to develop their own RED. However, there is little guidance on how to apply existing UV reactor validation test data based on test protocols that do not precisely follow the UVDGM approaches.

In addition to the validation report, monthly reports also must be prepared and submitted to the State. The monthly reports must list the percentage of water entering the distribution system that is not treated within validated conditions by the UV reactors. This percentage of water is referred to as "off-specification". For unfiltered systems, the LT2ESWTR allows 5 percent of the monthly water volume to be off-specification. Off-specification requirements for filtered systems are not stated in the LT2ESWTR; instead, they will be defined by the States. Unfortunately, the UVDGM offers little guidance to the States regarding the allowable percentage of off-specification water for filtered systems. Also, the UVDGM does not specifically correlate the potential needs of the UV system, such as a UPS or reactor redundancy, with the allowable percentage of off-specification water and the log-inactivation required for credit. In many cases, the costs of a UPS could meet or exceed the cost of the UV reactors. To prevent over-conservative designs, the UVDGM should include guidance on the percentage of off-specification water allowed for filtered systems.

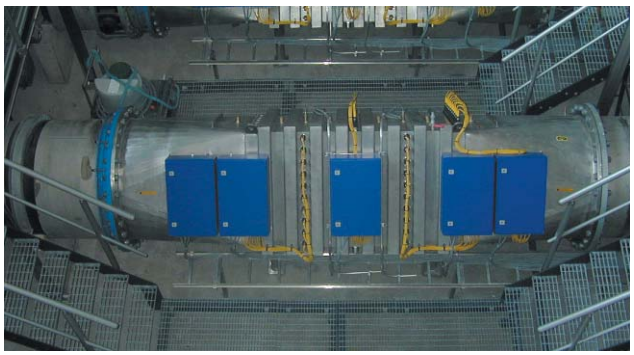
The monthly report must also include the percentage of sensors that were checked for calibration. According to the UVDGM, the duty sensor should undergo a monthly calibration check using a reference sensor, and the result must be reported to the State as required by the LT2ESWTR. To compare the duty sensor to the reference sensor, the power level should be set at the typical operating level. However, the UVDGM does not discuss the issues associated with checking the calibration of wet or dry sensors.

Calibration checks of wet sensors would require taking the reactor off-line and replacing the duty sensor with the reference sensor. The system then would be restarted and operated at the same power levels as before the shutdown to determine whether the duty sensor is still calibrated. For checking dry sensors, the reactor can remain on-line and the duty sensor can be removed and replaced with the reference sensor. However, if the duty sensor output is tied into the dose-pacing strategy of the reactor, changing a dry sensor while the reactor is on-line could trigger an alarm. Therefore, the UVDGM should address these issues by providing examples of sensor checking protocols that will avoid complications such as nuisance alarms and shutdowns.

IMPORTANCE OF ESTABLISHING ACCURATE LAMP OUTPUT FACTORS IN UV SYSTEM DESIGN (Joan Oppenheimer and Kuang-Ping Chiu, MWH)

Proper sizing of UV systems to achieve a minimum dose requirement under a specified range of flows is a function of the system's lamp technology, lamp geometry, quartz-sleeve cleaning efficiency, and reactor hydraulics, as well as the water quality conditions and redundancy requirements at the installed location. The LT2ESWTR requires that UV equipment is validated [40 CFR 141.729(d)] through an on-site or off-site process and the design and installation footprint can be affected by the specific approach selected for validation. The UVDGM does a good job of discussing some of the pros and cons of on-site versus off-site validation.

When the off-site validation approach is selected, State regulators may still require an on-site commissioning study, particularly if any deviations have occurred between off-site validation and on-site installation conditions. When this situation occurs, the design criteria utilized for lamp aging and lamp fouling factors can have a critical influence on whether the commissioning study successfully demonstrates compliance with design specifications. Appendix J of the UVDGM discusses the impacts of sleeve fouling and lamp aging on system design performance and discusses on-site testing methodologies that can be performed to optimize lamp output performance. Such testing is considered to be independent of reactor microbial inactivation performance validation and, therefore, is not necessarily included even when on-site validation is performed.



Helsinki, Finland, Low Pressure High Output UV System (Photo courtesy WEDECO AG Water Technology)

Since final UV vendor selection frequently is based on cost considerations, lamp performance factors can become a critical element in vendor specification costs. The use of more or less conservative factors for aging and fouling can shift the distribution of capital and O&M costs and impact the present worth assessment. Therefore, it is imperative that engineers perform due diligence investigations before accepting lamp aging and fouling factors provided by vendors whenever on-site testing as described in Appendix J is not included as part of the design process.

THE NEED TO REVISIT THE UVDGM AND SAFETY FACTORS IN THE FUTURE (PAUL SWAIM, CH2M HILL)

The Tier I approach presented in the Draft UVDGM incorporates a great deal of progress and refinement to the safety factor approach for establishing operational setpoints since the preliminary draft UVDGM was issued in 2001. Even so, many of the safety factor components addressed in the Draft UVDGM utilize assumptions and very small data sets to identify appropriate safety factors. For example, the "RED bias" safety factor, which accounts for dose distribution and delivery by UV reactors, was developed based on an assumed worst-case reactor adapted from a wastewater UV installation documented in the literature.

Albany, NY, USA - Medium Pressure UV System, 40 mgd (Photo courtesy Trojan Technologies, Inc.)

In the coming years, new developments and advances in the state of the science related to UV disinfection are anticipated. Research throughout the drinking water community will result in advancements, such as better sensor positioning, new generations of lamp and sensor technology, greater understanding of sleeve and lamp performance over time, as well as new reactor validation techniques. Some of these developments will directly affect the safety factors incorporated in the Tier I validation approach. Therefore, the USEPA should consider incorporating a scheduled review of the UVDGM as part of the LT2ESWTR. This review should be conducted in three to five years. With this planned review, unnecessary conservatism associated with UV system operation can be limited to further enhance the cost-effectiveness of UV facilities.

Photo courtesy WEDECO AG Water Technology