TCEQ REGULATORY GUIDANCE
Water Supply Division
RG-570 • Revised October 2019

Public Water System: UV Disinfection for Pathogen Inactivation Credit

A Public Water System (PWS) is required by Title 30 of the Texas Administrative Code (30 TAC) 290.42(g)(5) to request an exception to use ultraviolet (UV) light disinfection in order to receive pathogen inactivation credit from the Texas Commission for Environmental Quality (TCEQ). Prior to requesting an exception for UV pathogen inactivation treatment, the PWS must first verify that a validation report for the selected UV reactor system has been reviewed and approved by the TCEQ. Additionally, 30 TAC 290.46(s)(2)(E) also requires the PWS to meet calibration requirements for UV equipment used to operate the UV reactor system.

UV Reports, Approval, and Exception Review

UV Reactor Validation Report

The UV reactor validation report is a comprehensive third-party assessment of the components, and control system of a specific UV reactor. Validation testing must determine the operating conditions under which the UV reactor delivers the required UV dose for the inactivation of waterborne pathogens. Each UV reactor used for potable water treatment must be validated in accordance with the requirements specified in the UV Disinfection Guidance Manual (UVDGM) published in November 2006 by the U.S. Environmental Protection Agency (USEPA). A UV reactor must be verified to perform UV disinfection by validation tests of operational conditions specified in the UVDGM.

Validated Operating Conditions Must Include:

1. Flow Rate;
2. UV Intensity measured by a UV Sensor; and
3. UV Lamp Status.

Validation Testing Must Include:

1. Full-scale testing of a reactor that conforms uniformly to the reactor used by the water system; and
2. Inactivation of a test microorganism whose dose-response characteristics have been quantified with a low-pressure mercury vapor lamp.

Validation Testing Must Account For:

1. UV absorbance of the water;
2. Lamp fouling and aging;
3. Measurement uncertainty of on-line sensors;
4. UV dose distributions arising from the velocity profiles through the UV reactor;
5. Failure of UV lamps or other critical components; and
6. Inlet and outlet piping or channel configurations of the UV reactor.

The UVDGM requires a UV reactor validation report to have an executive summary describing the overall results of the validation tests performed on the UV reactor.

The executive summary should include the:

1. Validated dose or range of validated doses;
2. Log credit achieved for the UV reactor's target pathogens; and
3. Operating conditions that were validated.

Documentation should include all reactor and component information that impacts UV dose delivery and monitoring, and a validation test plan that documents the key components of UV reactor testing. In addition, a validation report must have detailed documentation of all the validation test results, all the elements of the test plan, and a summary of the field-verified UV reactor properties. Finally, the QA/QC data and analysis for the validation testing data is a crucial part of the validation report required to substantiate the tests and conditions of UV reactor operation.

The UVDGM cites other standards used before 2006 for validation testing of UV reactors. These other standards are as follows:

1. Austrian Standards Institute (ÖNORM) Standards
    a. ÖNORM M 5873-1 for low pressure (monochromatic) reactors (2001); and
    b. ÖNORM M 5873-2 for medium pressure (polychromatic) reactors (2003).
2. German Association for Gas and Water (DVGW)
    a. DVGW W294-1, -2, and -3 (2006);
        i. Part 1 - Requirements on the Status Function, and Operation;
        ii. Part 2 - Status Tests of the Technical Function and Disinfection Effectiveness; and
        iii. Part 3 - Sensors and Transmission Windows for the Radiometric Supervision of UV Disinfection Devices – Requirements, Tests and Calibration.
3. National Water Research Institute (NWRI)
    a. Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse, 3rd ed. (2012).

TCEQ UV Reactor Approval Letter

Any UV reactor manufacturer that desires to sell their UV reactor systems for operation by public water systems in the State of Texas must first submit the UV reactor validation report to the TCEQ Technical Review and Oversight Team (TROT) for review and approval. The manufacturer must submit the validation report and all supporting documents and appendices to TROT. For more information on submitting a validation report to TROT, please see Validating Ultraviolet Disinfection for Public Water Systems[1] on the TCEQ website.

TROT reviews a UV-reactor validation report, and if the required UV-reactor test results are verified in accordance with the UVDGM, TROT drafts an approval letter. The approval letter is comprised of approval conditions, operational limits of approval for the UV reactor, and a summary of the validation report's content. The approval letter then goes to the manufacturer for review, with correspondence between the TROT reviewer and the manufacturer to resolve any technical issues in the approval letter.

The UV-Reactor approval letter has the following approval conditions:

1. Site-specific exception and plan review required;
2. UV Reactor specifications table;
3. UV Reactor installation requirements;
4. Validated operational conditions table;
5. Which UV dosage-delivery approach the UV Reactor will use:
    a. Intensity Setpoint Approach (ISA); or
    b. Calculated Dose Approach (CDA).
6. A UV reactor using a CDA algorithm requires:
    a. Validated Dose (D_{val}) equation;
    b. Reduction Equivalent Dose (RED_{calc}) equation. Please note, for Medium-Pressure reactors, the RED_{calc} calculation must include a reactor-specific Action Spectra Correction Factor (ASCF). Further information for guidance on the ASCF is available in the Water Research Foundation Web Report #4376, "Guidance for Implementing Action Spectra Correction with Medium Pressure UV Disinfection."

The UV-Reactor approval letter has the following operational limits of approval:

1. A UV reactor using a Calculated Dose algorithm requires:
    a. Which RED_{calc} formulas must be used (if more than one was developed) and under what conditions; and
    b. Which RED Bias Factor (B_{RED}) and sensitivity values must be used to calculate the D_{val} for Validated Dose.
2. Site-specific exception-request statement for UV disinfection to receive credit for pathogen inactivation; and

[1] Validating Ultraviolet Disinfection for Public Water Systems

3. Site-specific plans-and-specifications statement for UV-reactor installation to be reviewed by the TCEQ Plan Review Team (PRT).

The TCEQ UV-Reactor Approval Letter has the following summary for the validation report:

1. Testing approach, which includes:
    a. Test microorganism;
    b. UV Transmittance (UVT) adjustment chemical(s);
    c. Number of tests performed and dates of tests.
2. Validation results summary table.

UV-reactor manufacturers consider the validation reports to be confidential and typically ask the TCEQ to exclude the numeric coefficients (used in the UV reactor's dose equations) when issuing the TCEQ UV-Reactor Approval Letter. If the letter is approved, the TCEQ UV-Reactor Approval letter must reference the section(s) of the validation report that contains the necessary coefficients. In addition, the TCEQ UV-Reactor Approval Letter must notify the manufacturer that the PWS facilities utilizing their reactor(s) must keep a copy of the complete validation report and all supporting documentation on site.

UV Reactor Exception Request

A PWS that wants to employ UV disinfection for pathogen-inactivation credit in Texas must request an exception. The PWS must first verify the validation report for the UV reactor system selected by the PWS has been reviewed and approved by the TCEQ. The current list and table of TCEQ-approved UV reactors can be found on the Validating Ultraviolet Disinfection for Public Water Systems[2] web page. Next, the PWS submits a request for an exception to TROT for UV disinfection using a TCEQ-approved UV reactor system. The UV-disinfection exception-request submittal must have information detailing the proposed use of the UV reactor at the PWS with technical drawings, flow diagrams, operational parameters, and standard procedures to use and maintain the UV reactor system.

The TCEQ UV-disinfection exception letter details UV reactor specifications, installation requirements, operational requirements, reporting requirements using the Surface Water Monthly Operation Report (SWMOR) alternate form (SWMOR-Alt), any necessary concentration time (CT) study revisions, and also encloses a copy of the TCEQ UV-Reactor Approval Letter for the selected UV system proposed for UV disinfection. A TCEQ UV-Disinfection exception letter grants the PWS use of the proposed UV reactor under detailed conditions.

The first exception letter condition covers UV-Reactor specifications as follows:

1. Include the "Spec Table" from the TCEQ UV-Reactor Approval Letter;
2. Specify the number, type, and part numbers for the lamps; and
3. Specify the number, type, and part numbers for the sensors.

[2] Validating Ultraviolet Disinfection for Public Water Systems

The next exception letter condition covers UV-Reactor installation requirements as follows:

1. The UV reactor must be installed with five (5) pipe diameters of unobstructed straight pipe immediately upstream; or
2. The results of a computational fluid dynamics (CFD) model must be included with the engineering plans and specifications submittal to PRT.

The next exception letter condition covers UV-Reactor operation requirements as follows:

1. From the TCEQ UV-Reactor Approval Letter:
    a. the validated range and conditions table;
    b. for a UV reactor using a CDA algorithm:
        i. the D_{val} validated dose equation; and
        ii. the RED_{calc} equation.
2. Site-specific pathogen-inactivation requirements to achieve via UV disinfection, including special requirements for plants that want viral-removal credit for high dose (advanced oxidation) UV reactors.
3. Any applicable site-specific requirements/limitations as follows:
    a. Restrictions imposed by the TCEQ UV-Reactor Approval Letter;
    b. Redundancy requirements, if applicable, from Long Term 2 Enhanced Surface Water Treatment (LT2) monitoring and Bin-classification results:
        i. Redundancy is not required for plants assigned to LT2 Bin 1; and
        ii. Redundancy is usually required for plants assigned to LT2 Bins 2, 3, and 4.
4. Additional restrictions needed to ensure the UV reactor can be properly monitored:
    a. Reference Sensor and replacement duty sensors;
    b. On-line UVT analyzers;
    c. Flow meters; and
    d. Ability of the PWS operator and any TCEQ field investigator to verify the equations to calculate D_{val}.
5. Reporting Requirements for SWMOR-Alt Form:
    a. Customizing the SWMOR-Alt form to mimic the SWMOR-Alt dialog boxes if possible (similar to the same way TROT does in the CT Study letters for chemical disinfectants and also the direct-integrity-test (DIT) letters for membrane units). The SWMOR-Alt form should be customized to record the following data:
        i. Type of UV reactor;
        ii. Maximum validated flow rate;
        iii. Site-specific log removal credit target;
        iv. Minimum required intensity (ISA reactors) or dose (CDA reactors); and
        v. Minimum validated UVT.
    b. Explicitly requiring the PWS to follow the instructions for completing the SWMOR-Alt form to accurately report UV disinfection parameters;
    c. Noting atypical issues:

i. Reporting data for a UV reactor that has fewer than 1 sensor for every 2 lamps;
ii. Lamp status must also be continuously monitored and recorded at least once every 15 minutes; and
iii. When one or more lamps fail, the SWMOR-Alt must show a 0.0 mW/cm2 sensor reading, or D_{val} =0 for the 15-minute interval of lamp failure.

d. Dealing with UV reactors used at direct-potable-reuse (DPR)/indirect-potable-reuse (IPR) plants;
e. UV reactors operating in a series configuration; and
f. Customizing the SWMOR-Alt form to include viral-removal credit for high-dose CDA reactors; area on the UV-CDA Worksheet to adjust the Validation Factor (i.e., the RED Bias coefficient (B_{RED}), ASCF, etc.) for viruses.

6. Viral-removal Credit Reporting Requirements:
   a. Use the Validation Factor Ratio cells on the UV-CDA worksheet of SWMOR-Alt form.
7. UV-Reactor System Calibration Requirements:
   a. Reference Sensor(s);
   b. Duty Sensor(s); and
   c. UVT analyzer, if used.
8. Special Reporting Requirements not covered by SWMOR-Alt Form for PWS Operations.
9. On-site Records Retention Requirements, including:
   a. A copy of the TCEQ UV-Disinfection Exception Letter and enclosure(s);
   b. A copy of the UV-Reactor Validation Report; and
   c. Any supporting documents for:
      i. Reference UV Sensors;
      ii. Replacement of duty sensors; and
      iii. Assisting the PWS operator and any TCEQ field investigator to verify the equations to calculate D_{val} validated dose.
10. Plan and Specifications to be submitted to PRT for review and approval prior to installation and operation of the UV reactor system for UV disinfection at the PWS.

If you have questions regarding this guidance document or need to discuss some specific issue in complying with its requirements as they apply to your PWS, you may call 512-239-4691 and ask to speak to a member of the Technical Review and Oversight Team (TROT). You can also try the TROT Exceptions web page[i] for further exceptions information.

[i] http://www.tceq.texas.gov/drinkingwater/trot/exception