Preparing Activity: USACE Superseding
UFGS-46 66 56 (February 2011)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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OPEN-CHANNEL DISINFECTION EQUIPMENT

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SECTION 46 66 56

OPEN-CHANNEL DISINFECTION EQUIPMENT
05/21

NOTE: This guide specification covers the requirements for ultraviolet (UV) disinfection equipment for treatment of wastewater.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

PART 1 GENERAL

NOTE: This specification should be used to allow the Contractor to install proven "off-the-shelf" units supplied by reputable vendors. This guide specification includes technical requirements for ultraviolet disinfection equipment and controls. This specification will not be used for disinfection of water or industrial wastes.

1.1 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide

specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C82.4	(2017; R 2022) Lamp Ballasts - Ballasts for High- Intensity-Discharge and Low-Pressure Sodium Lamps
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(2022) Standard for Industrial Control and Systems: General Requirements

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-240-01	(2020; with Change 2, 2021) Wastewater Collection and Treatment

1.2 SUBMITTALS

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NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

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Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Layout; G[, [_____]]

SD-03 Product Data

Framed Instructions

Field Training; G[, [_____]]

Spare Parts

UV System Equipment

SD-06 Test Reports

Design Conditions

Operating Test

Site Visits

SD-07 Certificates

Manufacturer's Qualifications

Standard Products

Performance Testing

SD-10 Operation and Maintenance Data

Instruction Plan; G[, [_____]]

Operating and Maintenance Manuals; G[, [_____]]

[Six] [_____] complete [hard] [optical disc] copies of operating instructions and maintenance instructions. Each manual must have an index listing the contents and tab separators between sections. [Manuals must be bound in sturdy three-ring, loose-leaf binders.]

1.3 ADMINISTRATIVE REQUIREMENT

1.3.1 Preconstruction Conference

A preconstruction conference is required and all subcontractors, suppliers, and UV equipment manufacturer are required to attend.

1.4 MAINTENANCE MATERIAL SUBMITTAL

1.4.1 Extra Materials

Supply all new spare parts that are exact replacements and separately packaged. Submit the parts list including recommended spare parts and maintenance supplies with current unit prices and source of supply for each item of operable equipment. Include parts recommended by the manufacturer to be replaced after 1 and 3 years of service. List special tools, instruments, accessories, and special lifting and handling devices required for periodic maintenance, repair, adjustment, and calibration.

Include with the package bill of materials with quantity, item description, and part number. Furnish the following spare parts and safety equipment:

a. One completely assembled lamp module.
b. Ten percent of the total number of the system lamps.
c. Five percent of the total number of the system ballasts.
d. Ten percent of the total number of the system lamp sleeves.
e. Ten sets of lamp end seals.
f. Ten sets of lamp socket connectors.
g. [Four] [_____] personnel safety shields which block out UV wavelengths between 200 and 400 nm.

1.5 QUALITY ASSURANCE

1.5.1 Qualifications

1.5.1.1 Contractor Qualifications

Possess a minimum of [2] [_____] years of experience in the construction of water, wastewater, and/or industrial wastewater facilities.

1.5.1.2 Manufacturer's Qualifications

Manufacturer is required to demonstrate experience in the production of substantially similar equipment, and is required to show evidence of satisfactory operation of identical equipment to that proposed in at least

3 installations for a period not less than one year disinfecting secondary effluent with similar effluent flow and characteristics to the treatment plant in this contract.

1.5.1.3 Equipment Parts

Manufactured parts to standard sizes and gauges so that repair parts furnished at any time can be installed in the field. Ensure that like parts of duplicate units are fully interchangeable.

1.6 DELIVERY, STORAGE, AND HANDLING

Protect from damage, deterioration, weather, excessive humidity, excessive temperature variation, dirt, dust, and contaminants equipment and materials delivered, handled, and placed in storage, from the time of shipment until installation is completed and the equipment and materials are ready for operation. Mark and store equipment to permit easy identification and inspection. Tag each item of the equipment or mark it as identified in the delivery schedule or on the shop drawings. Include with each shipment complete packing lists and bills of materials.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide an ultraviolet (UV) disinfection system complete and operational with controls and accessories as shown and as specified. Provide equipment suitable for outdoor open channel, gravity flow installation including, but not limited to, the following components, and appurtenances necessary for the interconnection of components, in the quantities required:

a. UV lamp module with support rack and bracket.
b. UV system instrumentation, controls, and power distribution.
c. Wireway and interconnecting cables.
d. Water level control device.
e. UV intensity monitoring system.
f. Elapsed time meter.
g. Cleaning system.
h. Spare parts.

2.1.1 Operation of Existing Facility

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NOTE: Include the following paragraph only where UV disinfection system is replacing another disinfection system at the existing wastewater treatment plant.

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Maintain the continuous flow of wastewater and disinfection until the new system is tested, approved and fully operational. No discharge of untreated wastewater, reduction in existing hydraulic capacity or organic treatment capacity is allowed.

2.1.2 Design Conditions

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NOTE: Determine or estimate plant flows, total

suspended solids (TSS), UV transmittance, and influent microorganism count. A value for UV transmittance must be determined from an independent laboratory. Occasionally, a wastewater quality may be encountered which exceeds the experience of design engineers (e.g. due to an unfamiliar process design, a familiar but poorly operated process, an under-designed plant, an unusual influent to the treatment plant, etc.). In these cases, a pilot study should be conducted to provide information required for design. Channels must be designed for peak design flow.

The reports listed below in subparagraphs a. thru f. need to be tailored by the designer to meet state standards where the process is being permitted.

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Ultraviolet equipment are required to disinfect wastewater effluent with the following characteristics:

Peak flow, cubic meter per sec Mgd	Initial [_____]
	Design [_____]
Average flow, cu. meter/sec Mgd	Initial [_____]
	Design [_____]
Minimum flow, cu. meter/sec Mgd	[_____]
Total suspended solids (TSS), mg/L	[_____]
Average turbidity, NTU	[_____]
UV transmittance at 253.7 nanometers (nm), through a 1 cm cell	[_____]
Influent [fecal coliform][_____], MPN/100 mL	[_____]

Submit the following reports confirming compliance with the design conditions characteristics:

a. Results of tests done by an independent testing laboratory showing effective hydraulic design of the reactor, including headloss calculations.

b. Documentation showing that the type of ballast required for the particular lamp supplied for the system have performed successfully for a period of not less than one year.

c. Hydraulic calculations demonstrating compliance with the specified hydraulic characteristics.

d. Residence time distribution (RTD) data plotted as concentration versus time, and as cumulative tracer passed versus time in accordance with UFC 3-240-01. The Contracting Officer reserves the right to require separate tests to be conducted on a system identical in design to the

proposed system if the hydraulic test data submitted by the manufacturer is determined to be unacceptable.

e. In the test unit used in the development of the RTD curves, use a number of lamps based on achieving the stated treatment adjectives for a worst case realistic influent scenario for the system. Utilize the same lamps, electronic lamp controller, ballast and automatic level controller as that proposed in the full scale system.

2.1.3 Performance Requirements

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NOTE: Typical values for nominal average intensity, UV density and theoretical retention time are 5100 microwatts per square cm, 3.35 watts per liter, and 7 seconds, respectively. Nominal average intensity will vary between manufacturers. Density depends upon the design of the particular UV system and the number of lamp banks. Retention time depends upon the channel geometry and number of lamp banks. Insert values per specified equipment manufacturer's calculations.
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2.1.3.1 Inactivation

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NOTE: Predominate effluent criteria used in performance requirements for UV systems is for whole body contact: 200 most probable number (MPN)/100 ml of fecal coliforms, with a maximum 7-day average of 400 MPN/100 ml. Some states have different microbe and disinfection standards; therefore, determine the site specific disinfection requirements from the state permitting authority.
****

Provide a system capable of reducing the influent [fecal coliform] [_____] count to [200 MPN/100 mL] [_____] on a 30 day geometric mean of daily samples.

2.1.3.2 UV Dose

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NOTE: Conventional units for UV dosage are microwatt-seconds per square cm. The standard dosage of UV radiation is determined by the effluent; unfiltered effluent may require a 30,000 dosage while a dosage of 16,000 to 20,000 is more typical of filtered effluent to achieve a disinfection safety factor of 2.0. Insert value per equipment manufacturer's recommendation.
****

Use a UV dosage not less than [_____] microwatt-seconds per square cm based on peak design flow conditions, lamp output at 65 percent of its initial level after 1 year (8750 hours) of lamp operation without fouling on the lamp sleeves, and minimum UV transmittance as stated in paragraph Design Conditions.

2.1.3.3 Nominal Average Intensity

Ensure the nominal average intensity within the channel is not less than [_____] microwatts per square cm at a transmittance of 70 percent after 100 hour burn-in of lamps and with no fouling on the lamp sleeves.

2.1.3.4 UV Density

Ensure the UV density of the channel is not less than that required in the test runs, lab analysis, channel configuration, and residence times.

2.1.3.5 Retention Time

Ensure that the actual retention time (t) of the effluent within the system determined by hydraulic analysis is not less than 0.9 times the theoretical retention time (T). Ensure the theoretical retention time (T) is not less than [_____] seconds at the peak design flowrate.

2.1.3.6 Plug Flow

The flow characteristics through the system are expected to closely simulate ideal plug flow conditions under the full operating flow range. The Morrill Dispersion Index, defined as the time required for 90 percent of the salt and dye traces to pass, divided by the time required for 10 percent to pass, is to be less than 2.0. The ratio of the time required for 50 percent of tracer to pass to the mean residence time is required to have a value between 0.9 and 1.1. The ratio of the time of initial tracer appearance to the theoretical residence time is required to have a value greater than 0.5.

2.1.3.7 Dispersion

Ensure the dispersion coefficient, which accounts for the deviation of the channel's hydraulic behavior from that of perfect plug flow, is less than 100 square cm per second. Ensure the dispersion number (ratio of the dispersion coefficient to the product of flow velocity and channel length) is less than 0.l.

2.1.3.8 Turbulence

Flow through the system is required to be turbulent with a Reynolds Number greater than 4,000 at average flow.

2.1.3.9 Channel Volume

Make full use of the channel volume throughout the flow range. Ensure the ratio of the mean residence time (theta) to theoretical residence time (T) is greater than 0.9.

2.1.3.10 Headloss

Ensure the headloss caused by each bank of horizontal lamp modules is such that at the peak flow rate no lamp is exposed to the atmosphere and the maximum depth over the uppermost lamp sleeves is 40 mm 1.5 inch. The headloss through vertical lamp banks is not allowed to exceed 150 mm 6 inch.

2.1.3.11 Cross Sectional Area

Ensure the cross-sectional area occupied by the lamp module frame at the entrance and exit of each bank is no greater than 35 percent of the cross-sectional area occupied by the effluent in the channel.

2.1.3.12 Aspect Ratio

Provide a minimum aspect ratio (ratio of channel length to hydraulic radius) of 15 per lamp bank.

2.2 EQUIPMENT

2.2.1 UV System Equipment

Submit product data to include: design calculations relevant to the type of system proposed indicating removal performance including dose; nominal average intensity within each reactor; UV density; theoretical retention time of effluent within the system; dispersion coefficient; maximum headloss caused by each bank of lamp modules; lamp module cross-sectional area; aspect ratio of lamp bank; installation list; manufacturer's illustrations; and a statement by the equipment manufacturer listing any exception to or deviations from the contract drawings and specifications.

2.2.1.1 Layout

The physical layout of the system shown is based on equipment manufactured by [_____]. Submit drawings showing fabrication methods, assembly, accessories, installation details and point-to-point wiring diagrams; instrumentation and controls; equipment; dimensions; make and model; materials of construction and installation instructions. In the drawing, indicate clearances required for maintenance and operation and include complete wiring and schematic diagrams, equipment layout, dimensions, templates and directions for the installation of anchor bolts and other anchorages and any other details required to demonstrate that the system has been coordinated and will properly function as a unit.

If UV equipment proposed is sufficiently different than that shown, submit detailed, modified layout drawings and descriptions for approval by the Contracting Officer within 5 working days following Notice to Proceed. Also obtain approval, if applicable, from the State permitting authority for the sufficiently different equipment and layout proposed within [15] [_____] working days following Notice to Proceed.

2.2.1.2 Equipment Construction

2.2.1.2.1 UV Lamp Module

a. Module consists of lamps with each lamp placed in an individual sleeve. Module is required to be capable of being withdrawn as a unit and replaced without interrupting operation of any other module, to be self-supporting in the channel, and to be capable of supporting a weight of 90 kg 200 pounds.

b. Horizontal lamp module a have lamps in sleeves sealed and supported in a NEMA 6P stainless steel frame. Electrical wires which carry power to the lamps and ballasts are required to be completely enclosed in the frame and isolated from the wastewater. The frame is required to be capable of protecting lamps and sleeves from foreign material or

debris within the channel.

c. Vertically oriented modules have lamps installed in a weatherproof, watertight enclosure. Fit sleeve to the enclosure using compression fitting and neoprene gasket. Wiring is required to include numbered terminal strips which correspond to the numbering in the main power panel. Fit lamp enclosure with a waterproof wiring connector to allow the enclosure to be disconnected and removed from the channel. Install lamp connection above the waterline or ensure it is waterproof. Provide a safety interlock switch to turn off power to the lamps when module enclosure covers are opened. Provide a Class B, ground fault circuit interrupter for each enclosure to turn off power if water enters the enclosure. Arrange lamps so that they can be replaced without disassembling or removing lamp module.

d. Ensure system allows for complete system shutdown or by-pass.

e. Ensure system allows for continuous disinfection while replacing lamps, sleeves, and ballasts; and while cleaning the lamp sleeves.

f. Individual lamp modules weighing 25 kg 55 pounds or less are required to be removable without requiring mechanical lifting devices. Systems with individual lamp modules weighing over 25 kg 55 pounds are to be provided with a mechanical lifting device as [specified] [indicated].

2.2.1.2.2 UV Lamps

a. Supply low-pressure mercury vapor type lamps of the hot-cathode, instant-start design in which the coiled filamentary cathodes are heated by the arc current. Provide a clamped design filament that withstands shock and vibration.

b. Ensure lamps have the following characteristics:

(1) 90 percent of UV radiation within the wavelengths of 233.7 to 273.7 nm.

(2) Produce a minimum UV intensity of 190 microwatts per square cm at a distance of 1 meter.

(3) Maximum power input of 65 watts (not including ballast losses).

(4) Have a minimum arc length of 1475 mm 58 inches.

(5) Rated to produce zero levels of ozone.

(6) Have a minimum UV output of 26.7 watts at 100 hours.

c. Provide a lamp base made of metal and ceramic, resistant to UV light and ozone. Ensure lamp tube is capable of transmitting 90 percent of the radiation produced therein.

d. Ensure that changing lamps does not require removal of the sleeve from the lamp module frame. Ensure lamp ballasts are capable of being replaced by plant operating personnel.

e. Ensure system uses lamps available from at least 2 currently active lamp manufacturers without modifications to the system.

2.2.1.2.3 UV Lamp Sleeve

a. Provide a sleeve consisting of clear fused quartz circular tubing rated for transmittance of 89 percent or more and not be subject to solarization over its life. Provide a nominal wall thickness between 0.8 and 2.09 mm 20 and 53 inch.

b. Configure sleeve such that one end of each sleeve is closed and the other end is sealed by a lamp end seal and compressed O-ring. The closed end of the sleeve is required to be held in place by means of a retaining O-ring. No part of the sleeve is allowed to come in contact with any steel in the frame.

2.2.1.2.4 Lamp End Seal and Lamp Holder

a. Configure sleeve so the open end of the lamp sleeve is sealed by means of a stainless steel nut which compresses an external sleeve O-ring seal. Ensure the sleeve unit has a surface which allows a positive hand grip for tightening without the use of any tools for removal.

b. Hold the lamp holder in place in such a way as to isolate and seal the lamp from the module frame and other lamps in the module. Configure the lamp sleeve such that in the event of a fracture, the seal prevents moisture from entering the module frame and the electrical connections to other lamps in the module. Incorporate UV resistant materials into the lamp holder to prevent lamp sleeve from touching steel.

2.2.1.2.5 UV Lamp Module Support Rack

Fabricate rack from stainless steel construction that does not allow UV light to radiate above the channel when the lamp modules are energized and fully immersed in the effluent.

2.2.1.3 Lamp Array Configuration

2.2.1.3.1 Horizontal

Arrange horizontal lamp configurations in a uniform array with lamps parallel to each other and to the flow. Space lamps evenly in horizontal and vertical rows with centerline spacings equal in both directions. Pattern the single array to be continuous and symmetrical throughout each reactor.

2.2.1.3.2 Vertical

Configure vertical lamps in a staggered uniform array with lamps parallel to each other, but perpendicular to the flow. Space lamps evenly with alternating rows offset by one-half the uniform centerline spacing.

2.2.1.4 Water Level Control

****

NOTE: If more than 1 channel is required, there needs to be a positive method of flow distribution to each channel. The downstream level control device is designed to build-up negligible head at peak flow rates and may not distribute flow equally to all channels. The equipment manufacturer should

be consulted for recommended methods of flow distribution in multiple channels.

Automatic Slide/Sluice Gates: These gates are required, two per channel, if the UV system is to operate in an automatic mode for multiple channel configurations. These gates are not necessarily supplied by the UV equipment manufacturer. Additionally, it is the gate manufacturer's responsibility to properly install and set up each gate, such that a gate closed limit switch, one per gate, is transmitted to the UV Control Center. Each gate must be able to receive one opening and one closing signal from dry 10 amp contacts located in the Control Center. To insure disinfection under all conditions, gate interlocking, both mechanical and electrical, is required to prevent all gates from being closed at any given time. These interlocks are the responsibility of the gate manufacturer.

During automatic operation, if channels are to be placed in and out of service, accommodations should be made to drain the channel when the channel is not in service. Channels, when out of service, must be completely isolated and not allow any leakage through slide gates or valves to enter final effluent.

****

a. Place a level control device [at the discharge end] [both ends] of each channel. Level control device is required to maintain constant channel water level within tolerances required to keep lamps submerged and prevent excessive water layer over the top lamps.

b. [Pivot the automatic level controller above the effluent water surface so that each unit opens across the width of the channel. Adjust counterweights using counterbalance weight at startup for the full flow range. Counterweights are not to require adjustment after initial setting. Use stainless steel, Lexan, Delrin bearings, counterweights of carbon steel with galvanized finish and corrosion resistant seal of neoprene or other suitable elastomer.] [Use stainless steel for fixed weirs.] [_____].

c. Install a water level sensor within the channel to provide an alarm indication and/or automatic system shutdown in the event the water level drop below the uppermost part of the top row of horizontal lamps. Provide alarm contacts for remote annunciation.

2.2.2 Electrical

2.2.2.1 Parameters

a. Divide the system into the proper number of parallel electrical subsystems for the peak design flow.

b. Power each electrical subsystem from a distribution center and include ground fault circuit detection, circuit protection, modules, and interconnecting cables.

c. Supply one power panel for each module and prewire by the manufacturer, except for the final connection of the individual modules to the power panel.

d. Provide standard ground fault detection with the UV equipment manufacturer.

e. House control and monitoring components and power supply in NEMA enclosures. Seal internal components from the environment. House system electronics to be used in an interior environment in enclosures conforming to NEMA 250 Type 12. House system electronics to be used in an exterior and corrosive environment, as defined in NEMA 250, in enclosures conforming to NEMA 250, Type 4X.

f. Provide sufficient cooling to ballasts. Ensure magnetic ballasts have a minimum allowable air flow per ballast of 0.014 cu. m/s 30 cfm.

g. Protect wiring and electrical connections against moisture to prevent electrical shorts or failure. Ensure electrical installation and materials conform to NFPA 70. Completely wired the unit requiring only an external connection for a single external power supply and remote control.

h. Ensure controls and designations conform to NEMA ICS 1.

2.2.2.2 Interconnect Cables

a. Multiconductor unshielded cable suitable for outdoor installation.

b. Thermoplastic rubber insulation with operating range of minus 60 to 125 degrees C minus 76 to 52 degrees F with low temperature flexibility and flame retardants.

c. UV stabilized jacketing resistant to oils, chemicals, fuels, solvents, and to mechanical abuse and abrasion.

d. Cable supplied by the equipment manufacturer in sufficient length and number for a complete system.

e. Cable of a modular repairable type to allow for field replacement and repair of its components by plant operators.

2.2.2.3 Connectors and Receptors

Waterproof Type S.O. cable connectors for in-line connection. Design to allow fast and easy positive coupling and uncoupling. Mount connector out of possible flood-prone environments. Use "snap-on" style connectors having no threads that allow for visual confirmation that the connection is locked in place.

2.2.2.4 Ballasts

Supply ballasts that conform to ANSI C82.4; are coordinated to the ballast supplies; are rated for [120] [208] [240] [277] [480] [volts] [the voltage indicated]; and have a power factor of not less than 90 percent at a crest factor of 2.0 or less, and a voltage range of not less than plus or minus 10 percent. Ensure ballasts are suitable for operating at [minus 15] [minus 30] [minus 40] degrees C [5] [minus 22] [minus 40] degrees F and

above. Locate and/or enclose magnetic ballasts in an environment not susceptible to the effects of heat, cold and moisture. Use modular design ballasts allowing for quick disconnect and replacement by operators.

2.2.2.5 Cableway

If required by the equipment manufacturer, install cable in weatherproof and submersible cableway. Fabricate the cableway of stainless steel, 1.98 or 1.59 mm thick 14 or 16 gauge. Ensure cableway is gasketed and completely watertight under a submerged condition.

2.2.2.6 Instrumentation and System Controls

2.2.2.6.1 Controls

Provide equipment of the fully automatic program control type capable of receiving standard 4-20 mA control signals from the plant effluent flowmeter. Control of 2 or more banks of modules by turning lamp banks on and off in proportion to flow variations. Provide controls capable of continuously adjusting the UV intensity automatically in proportion to wastewater flow. Provide controls that require no manual attention other than adjustment of the required UV intensity.

2.2.2.6.2 Lamp Status Indicators

a. Provide indicators that indicate the status whether ON/OFF of each lamp in the module being powered.

b. Provide indicators to indicate the status "POWER ON", only, in each module.

c. Ensure the lamp monitoring system indicates the geometric location of each individual lamp and operating status of each lamp by means of a neon lamp or alpha-numeric data display (LED or LCD). Upon lamp failure, illuminate the corresponding lamp and activate contact closure for remote alarm annunciation. Provide contact closure for remote annunciation to indicate lamp module failure due to ground fault interruption.

2.2.2.6.3 UV Intensity Detection System

a. Provide a submersible UV sensor to continuously sense the UV intensity produced in each bank of lamp modules. Ensure the sensor measure only the germicidal portion of the light emitted by the lamps within the channel between 254.5 and 255.0 nm. Display the UV intensity on the intensity meter. Locate each UV intensity probe at a point of minimum expected intensity within the lamp array. Mount the probe to any lamp in the array using a clip-on and self-aligning mount to assure the proper spacing from the tube without necessity of hand tools. Factory calibrate the probe with verification in the field prior to startup. The UV equipment manufacturer is required to provide justification for the sensor location.

b. Provide one UV intensity meter per bank of lamp modules. The meter is required to indicate safe intensity, low intensity, and unsafe intensity by means of color codes on the meter face, or have a 0 to 100 percent scale. Clearly label the UV intensity meter and locate on the remote control panel.

c. Provide a nonresettable elapsed time meter per bank of lamp modules. Ensure the meter records hours of UV bank operation from 0 to 99,999 hours.

d. Provide one hand/off/auto switch for each UV bank and for each automatic slide gate shown and specified.

e. Time delay alarms to prevent nuisance alarms.

2.2.2.6.4 Minor Alarms

Provide minor alarms and dry contacts to indicate that maintenance attention is required. Include the following minor alarms:

a. Low warning UV intensity.
b. Individual lamp failure.

2.2.2.6.5 Major Alarms

Provide major alarms and dry contacts to indicate an extreme condition in which the disinfection performance may be jeopardized. Include the following major alarms:

a. Low UV intensity.
b. Lamp failure of 2 or more adjacent lamps.
c. Multiple lamp failure.
d. Module failure.

2.2.2.6.6 Flow Pacing

****

NOTE: If the system consists of 2 or more banks of lamps, the system can be flow-paced using a signal from an effluent flow monitoring device in the plant.

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a. Provide a flow pacing system to turn the UV banks on and off in relationship to the signal received from the plant effluent flowmeter. Ensure the flow pacing sequence is as recommended by the UV equipment manufacturer. Where lamp dimming is used, provide a controller to allow plant operator to ratio the flow to UV dosage and UV intensity. Where on/off control is used, ensure the system allows the operator to vary the flowrate setting and allow the operator the option to operate individual banks in either the manual or automatic mode. Provide logic and time delays to regulate the UV bank ON/OFF cycle to prevent excessive cycling on both startup and shutdown of the UV bank. Multicycle lamps may be specified in applications which demand up to 100,000 annual cycles.

b. The normal mode of operation places each effluent channel continuously in service.

2.2.3 Cleaning System

2.2.3.1 General Requirements

Provide cleaning equipment and cleaning solutions. Provide a cleaning system that is [a permanent in-channel installation] [an out-of-channel installation] [a portable cleaning installation with basin] for cleaning

individual lamp sleeves or entire lamp modules.

2.2.3.2 Cleaning Tank

Fabricate portable cleaning tank of stainless steel and equip with air blower (compressor), lamp module rack, hose connections and drains. Ensure tank holds at least [3 horizontal modules] [1 vertical module] and is equipped with hard rubber casters. Provide sealed cover for tank to prevent spilling. Equip unit with disconnect switch, a grounded plug and 3 m 10 feet of outdoor cable.

2.2.3.3 Cleaning Rack

Provide a cleaning rack mounted above the portable cleaning tank to hold one horizontal module above the cleaning liquid for hand wiping of the sleeves.

2.2.3.4 Cleaning Fluid

Provide sleeve conditioner and cleaning solution 12 months of normal operation. Supply conditioner and cleaning solution in containers not greater than 20 L 5 gallon capacity.

2.3 MATERIALS

All metal in contact with plant effluent is required to be either Type 316 or Type 304 stainless steel, passivated. Wiring which may be exposed to UV light is required to be a material that resists degradation by UV light. Material exposed to UV light is required to be stainless steel, passivated; quartz; polytetrafluoroethylene or other UV resistant material.

2.3.1 Standard Products

Provide material and equipment which are the standard product of a manufacturer regularly engaged in the manufacture of the product and which essentially duplicate equipment that has been in satisfactory operation for at least 2 years prior to bid opening. Submit written evidence that equipment and accessories are products of a qualified and experienced manufacturer. Ensure equipment is supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.3.2 Nameplates

Provide major equipment items with the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

2.4 ANCHOR BOLTS

Provide stainless steel anchor bolts of the size required and with ample strength for the purpose intended by the Contractor. Embed anchor bolts directly during placement of concrete at depths sufficient to account for potential concrete spalling or deterioration.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

Perform installation in accordance with the drawings, shop drawings, and manufacturer's instructions and recommendations.

3.3 FIELD QUALITY CONTROL

3.3.1 Operating Test

After Contractor and Contracting Officer have mutually agreed that the equipment installation is complete and ready for continuous operation, conduct an operating test of the equipment and controls in the presence of the Contracting Officer to demonstrate satisfactory operation.

Include in the book form test report all field tests performed to adjust each component and field tests conducted to prove compliance with the specified performance criteria. Ensure the test report indicates the final position of controls.

3.3.2 Performance Testing

a. Begin performance testing after the UV equipment has been installed and field tested. Collect samples at times when the flow through the plant is at or near the peak flow rating from one section of the channel. Where multiple systems are supplied, the plant flow is required to be at or near the peak flow rating of at least one system or one section of the UV system.

b. Analyze the samples collected for the following, using standard testing methods or procedures:

   (1) [Fecal coliform] [_____] in MPN/100 mL just prior to UV disinfection.

   (2) [Fecal coliform] [_____] in MPN/100 mL just after UV disinfection.

   (3) Total suspended solids prior to disinfection.

   (4) Percent UV transmittance at 254 nm with 1 cm cell length prior to disinfection.

c. Continue performance testing for 14 days and collect samples 3 times per 24 hour period. Record the data obtained in booklet form. Ensure test reports indicate the final position of controls.

d. The effluent quality exiting the UV unit is required to be equal to or better than the specification requirement. Continue retesting for at least 2 consecutive days or until satisfactory bacteriological results have been obtained.

e. Submit statements signed by responsible official or representatives of

the manufacturer attesting to conformance to the specified requirements. Date the statements after performance testing has been completed, include the name the project, and list the specific requirements which are being certified.

3.3.3 Manufacturer's Representative

Provide the services of a qualified manufacturer's field service representative to supervise the installation, adjustment, testing of equipment and instruct plant operators in the care, operation, and maintenance of the equipment.

3.3.4 Site Visits

Manufacturer's representative is required to assist in the proper installation and checking of the equipment for a period of time necessary to insure a completed installation. Submit a written report of the results of each visit by the manufacturer's representative, including purpose and time of visit, tasks performed and results obtained.

The representative is required to, for a period not less than three full days, start up the equipment, supervise initial operations, perform the required field tests and instruct plant operators in the proper care, operation and maintenance of the equipment. Upon request of the Government, at any time during the 1-year warranty period, the representative will recheck the system, recalibrate and adjust equipment, answer plant operator's questions and review operation and maintenance procedures.

3.4 ADJUSTING AND CLEANING

Test, calibrate, adjust and operate to verify its satisfactory operation. Clean equipment of dirt, dust and foreign matter.

3.5 CLOSEOUT ACTIVITIES

3.5.1 Operating and Maintenance Manuals

a. Submit operating instructions outlining the step-by-step procedures required for system startup, normal operation, short- and long-term deactivation, and shutdown. Include an introduction and overall equipment description, purpose, functions, and simplified theory of operation in the beginning of the instructions. Include the manufacturer's name, model number, service manual, parts list, and brief description of each piece of equipment and its basic operating features in the instructions. Include component layouts, simplified wiring, and control diagrams for the system as installed. Ensure performance test data is reflected in the operating instructions.

b. Submit maintenance instructions listing routine maintenance procedures, calibration procedures, possible breakdowns and repairs and troubleshooting guides, prior to the start of the training course.

3.5.2 Field Training

Include a combination of classroom and hands-on training at the site. Instruct designated maintenance and operations personnel in the recommended corrective and preventive maintenance procedures for the equipment. Submit the proposed lesson plan of field instruction, 30 days

prior to commencement of scheduled training. Cover each item contained in the operating and maintenance manuals in the field training.

3.5.2.1 Instruction Plan

Prepare a lesson plan which includes the elements presented in the outline specified below. Identify specific components and procedures in the proposed lesson plan. Detail specific instruction topics. Reference and attach to the proposed lesson plan training aids to be utilized in the instruction where applicable. Describe any hands-on demonstrations planned for the instruction and estimated duration of each segment of the training in the lesson plan.

3.5.2.2 Training Outline

Include in the instruction, as a minimum, the following elements presented in the following outline:

a. Equipment operation.
b. Detailed component description.
c. Equipment preventative maintenance.
d. Equipment troubleshooting.
e. Equipment corrective maintenance.
f. Hands-on demonstrations.

3.5.2.3 Framed Instructions

Post framed instructions under glass or in laminated plastic, including wiring and control diagrams showing the complete layout of the entire system, where directed. Prepare condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system in typed form and post beside the diagrams. Post the framed instructions before acceptance testing of the systems.

-- End of Section --