

SECTION 11282 - MEDIUM PRESSURE ULTRAVIOLET DISINFECTION SYSTEM

City of San Diego, CWP Guidelines

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NTS: This specification for a medium pressure ultraviolet disinfection system is a proprietary specification for the UV4000 system of Trojan Technologies, Inc. Its use must be approved by the City Project Manager.

The specification is based on a price to be pre-negotiated with Trojan during design which is made an allowance item in the bid.

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PART 1 -- GENERAL

1.1 WORK OF THIS SECTION

- A. The WORK of this Section includes providing one high intensity medium pressure, open channel gravity flow ultraviolet (UV) disinfection system, complete with an automatic mechanical/chemical lamp cleaning system, level control weir gate, and controller. The system shall be complete and operable with all controls and accessories as indicated.
- B. The UV system shall be purchased from Trojan Technologies, Inc. at the pre-negotiated price which is an allowance bid item.

1.2 RELATED SECTIONS

- A. The WORK of the following Sections applies to the WORK of this Section. Other Sections of the Specifications, not referenced below, shall also apply to the extent required for proper performance of this WORK.
 - 1. Section 11000 Equipment General Provisions
 - 2. Section 11292 Fabricated Weir Gates
 - 3. Section 13300 Instrumentation and Control
 - 4. Section 01660 Equipment Testing and Plant Startup

1.3 SPECIFICATIONS AND STANDARDS

- A. Except as otherwise indicated, the current edition of the following applies to the WORK of this Section:
 - 1. California Administrative Code, Title 22, Wastewater Reclamation Criteria for Unrestricted Body Contact.

1.4 SHOP DRAWINGS AND SAMPLES

- A. The following shall be submitted in compliance with Section 01300:
 - 1. Performance Study: Documentation to demonstrate, through testing performed elsewhere,

that the proposed system provides total coliform inactivation as required by Title 22. Testing must have been conducted on filtered effluent over a range of UV doses including doses higher than the design dose of 100 mW-sec/cm² to be employed on this project. The study must include data documenting total coliform inactivation, UV₂₅₄ transmittance, total suspended solids concentration, flow, turbidity, MS2 coliphage reduction, and calculated UV dose.

2. Shop Drawings

- a. Descriptive information including catalog cuts and manufacturer specifications for all components.
- b. Complete description of the proposed system in sufficient detail to permit an item by item comparison with the specification.
- c. Dimensions and installation requirements including layout, overall dimensions, required clearances, and general description of equipment, including location of electrical equipment, control centers, and other auxiliary equipment.
- d. Drawings with dimensions of the plan view and major sections of the proposed equipment items. The drawings should include the installed operating weight of each proposed equipment item.
- e. Where proposed equipment would result in changes to the layout presented in the contract drawings, provide general arrangement drawings (floor plans and elevations) to scale (1/4" = 1.0') showing revised layout to accommodate the proposed equipment. Any changes, if approved, to the layout and detailed design shown shall be at no increased cost to the OWNER.
- f. Electrical schematics, layouts, single line diagrams, interconnection diagrams, and internal wiring diagrams of the UV system.
- g. [All instrumentation and PLC shop drawing submittals shall conform to the requirements of Section 13300.]

1.5 SERVICES OF MANUFACTURER

- A. Manufacturers' services for training OWNER'S personnel, equipment system testing and startup shall comply with the requirements of Sections 01660 and 11000.
- B. **Inspection, Startup, and Field Adjustment:** An authorized service representative of the manufacturer shall visit the site for not less than [2] days to furnish the indicated services.
- C. **Instruction of OWNER'S Personnel:** The authorized representative shall also furnish the indicated services for instruction of the OWNER'S personnel in the operation and maintenance of the equipment including step-by-step troubleshooting procedure with necessary test equipment for not less than [2] days.

1.6 SPECIAL WARRANTY

- A. The CONTRACTOR shall replace, at no cost to the OWNER, each UV lamp which fails prior to the lamp operating life requirement of 5000 hours.
- B. Prior to expiration of 5000 hours, the CONTRACTOR shall respond to telephone notification of lamp failure from the OWNER by dispatching a competent repair person with spare lamps. Failed lamps shall be replaced within 48 hours of notification.

PART 2 -- PRODUCTS

2.1 GENERAL

- A. The UV disinfection system shall employ high-intensity, medium-pressure lamps only. Systems with low-pressure lamps are unacceptable. The UV disinfection system shall be an open-channel, gravity-flow system of modular design with flow parallel to the lamps. The UV disinfection system shall include electronic ballasts, an automatic, in-place mechanical/chemical cleaning system capable of cleaning the lamps while disinfecting, an integral lamp removal mechanism, control panel, detection systems, and automatic level controller.
- B. The UV disinfection system shall be designed to fit into the channel as described without modification of the channel dimensions. Any changes in the design shall be submitted to the CONSTRUCTION MANAGER for approval. The CONSTRUCTION MANAGER will require, as appropriate, that drawing submittals shall be stamped by an engineer registered in the State of California for changes to the original design as one of the conditions for approval of the changes.

2.2 DESIGN CRITERIA

- A. The UV disinfection system shall disinfect water with the following characteristics:
 - 1. Provide equipment which shall disinfect an effluent with the following characteristics:

a. Peak Flow (MGD)	[]
b. Average Flow (MGD)	[]
c. Minimum Flow (MGD)	[]
d. Total Suspended Solids (mg/L)	[]
e. Annual Effluent Temperature Range (degrees F)	[] to []
f. Average Turbidity (NTU)	[]
g. 5-Day BOD (mg/L)	[]
h. Ultraviolet Transmittance @ 253.7 NM (percent)	[]
 - 2. The UV system shall be installed in one open channel [] feet long by [] feet wide by [] inches deep.
 - 3. The effluent depth in the channel shall not exceed [] inches upstream of the UV system. The total headloss across the UV system at peak flow shall not exceed [] inches.
- B. The UV disinfection system shall provide a minimum UV dose of 100 milli-Watt seconds per square centimeter (mW-sec/cm²) at peak flow of [] MGD and UV₂₅₄ transmittance of [] percent in the filtered effluent with three banks active. This dose shall be the design dose for the UV disinfection system under the condition of lamps at the end of lamp life. Thus, the design dose of 100mW-sec/cm² shall be determined as the product of the design dose with new lamps and a lamp

age factor to account for lamp age at the end of lamp life. The method of UV dose calculation shall be the Single Point Source Summation (SPSS) method. The reactor shall be designed for the peak flow.

- C. [Two] reaction chambers shall be provided. Each reaction chamber shall provide [two] banks of high-intensity, medium-pressure UV lamps.
- D. The UV reaction chamber shall be furnished preassembled and ready for installation. The CONTRACTOR will fill the void space with concrete as directed by the Contract Documents and the UV Manufacturer's recommendations.

2.3 PERFORMANCE REQUIREMENTS

- A. Disinfection Requirements. The UV disinfection system shall provide a disinfected effluent that complies with the following bacterial requirements:
 - 1. Total coliform, measured as the median for any 7-day period, shall be less than 2.2 per 100 mL.
 - 2. Total coliform, measured as the maximum in any sample, shall be less than 23 per 100 mL.
- B. The operating life for each lamp in the reaction chamber shall exceed 5,000 hours.
- C. Power consumption shall not exceed [540] kilowatts with all lamps on and at the setting of maximum intensity.

2.4 DESIGN, CONSTRUCTION, AND MATERIALS

A. **General:**

- 1. All metal components in contact with effluent shall be Type 304 or Type 316 stainless steel.
- 2. All materials exposed to UV light shall be Type 316 stainless steel or Type 214 quartz, or otherwise be unaffected by UV light.
- 3. The system shall be designed for complete immersion of the UV lamps, including both electrodes and the full length of the lamp tube in the effluent. Both lamp electrodes shall operate at the same temperature and be cooled by the effluent. The major axis of the lamps shall be parallel to flow.

B. **UV Module:**

- 1. Each UV module shall consist of UV lamps mounted on a Type 316 stainless steel frame.
- 2. Each lamp shall be enclosed in its individual quartz sleeve, one end of which shall be closed and the other end sealed by compressed O-rings.
- 3. All wires connecting the lamps to the connector (to power supply) shall be enclosed inside the frame of the UV module and shall not be exposed to the effluent.

4. Each quartz sleeve shall be independently sealed within the module.
5. The UV module shall be designed such that operating personnel at the plant can change the lamps and quartz sleeves.

C. UV Lamps:

1. The lamps shall be high-intensity, medium pressure germicidal UV lamps.
2. The filament shall be the clamped design, significantly rugged to withstand shock and vibration.
3. Lamp bases shall be of a metal and ceramic construction resistant to UV and ozone.

D. Lamp End Seal and Lamp Holder

1. The open end of the lamp sleeve shall be sealed by means of a Type 316 stainless steel sleeve nut which threads onto a sleeve cap and compresses the sleeve O-ring.
2. The sleeve nut shall have a knurled surface to allow a positive hand grip for tightening.

E. UV Lamp Sleeves

1. The UV lamp sleeves shall be Type 214 clear fused quartz circular tubing.
2. The quartz lamp sleeves shall be rated for UV transmittance of at least 89 percent and shall not be subject to solarization over the length of their life.

F. Electronic Ballasts

1. Input
 - a. Ballasts shall operate at 60 Mhz over voltages from 220 to 277 v. Variations of plus and minus 10 percent shall not affect ballast operations.
 - b. Ballasts shall have a power factor not less than 90 percent leading or lagging.
 - c. Ballasts shall emit conducted and radiated emission which comply with FCC regulations Part 15.
 - d. Protection against transients shall be in accordance with good engineering practice and as necessary for the reliability indicated below.
2. Output
 - a. The ballast shall operate each lamp with a maximum input power of [2800] watts.
 - b. The peak to average ratio of lamp current waveform shall be no greater than 1.6 at maximum lamp power and no more than 1.8 at any other lamp power.

3. Spectral Characteristics of Lamp Output
 - a. Maximize total lamp output in the germicidal range of the ultraviolet spectrum.
4. Construction
 - a. Ballasts shall meet the requirements of CSA Standard CAN/CSA - C22.2 No. 74-92 and be built according to VDE and UL standards.
 - b. Mean Time Between Failures shall be 150,000 hours.
5. Operating Conditions
 - a. Ballasts shall be able to ignite, warmup, and run lamps immersed in liquid with temperatures between 0 and 50 degrees C.
 - b. Ballasts shall not be harmed if lamp operation is attempted under short circuit and open circuit conditions.
6. External Controls
 - a. Ballasts shall be capable of power output in 16 incremental steps from 30 percent to 100 percent of rated lamp power.
 - b. Ballasts shall be capable of starting and shutdown by an optically isolated digital signal from remote equipment.

G. Electrical Subsystem:

1. The UV disinfection system shall be divided into four independent parallel electric subsystems.
2. Maximum total power consumption of the entire UV disinfection system shall be no greater than [] KW ([] KVA).
3. Electrical supply to each subsystem shall be [480 volts, 3 phase, 3 wire, 163 amps/line]. Transformers shall be furnished by the UV system manufacturer and shall be outdoor type, K-factor rated, isolation transformers. CONTRACTOR shall size the feeder circuit breakers to protect the transformers.
4. UV system manufacturer shall design and furnish harmonics mitigation means (filters) to meet latest IEEE-519, Table 10.1 - General System Requirements. The CONTRACTOR shall install the furnished equipment.
5. The UV PLC branch circuit shall have automatic transient protection. Transient protection shall be series hybrid design; consisting of an MOV first stage, air core inductor second stage, and an MOV third stage. Peak clamping voltage shall be 300 Volts for a 3 KA impulse current at 8 x 20 micro seconds in accordance with Category B, ANSI/IEEE C62.41-1991. Transient protection shall be **Transient Eliminator™, Model TE/AC03UL** as manufactured by **Advanced Protection Technologies, Inc.** or equal.

6. Signal wiring interfacing each subsystem to the UV programmable logic controller (PLC) based controls and the Operator Interface Station (OIS) shall be as indicated.

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NTS: Instrumental specifications herein are enclosed in square brackets to denote areas which may require extensive coordination and editing for the individual project.

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H. Control and Instrumentation:

1. The Control and Instrumentation system shall be provided with the UV disinfection system and shall include a UV local control panel complete with PLC based controls and an Operator Interface Station.
2. Operational Description. An automatic flow and water quality paced control system shall be provided by the UV Manufacturer. The control system shall be PLC based and be configured to activate and deactivate lamps to maintain sufficient UV dose while conserving power. See Section 13300 for a detailed narrative of the required control strategy.
3. System Control Center (SCC):
 - a. The UV system control and monitoring shall be provided through a PLC and OIS which consists of a touchscreen. Hardwired panel devices and meters shall not be permitted.
 - b. The OIS shall be menu driven with automatic fault message windows appearing upon alarm conditions. The OIS and PLC shall be in accordance with Section 13300.
 - c. All hardware and software associated with the PLC and OIS shall comply with Section 13300. The UV manufacturer shall provide all hardware and software required to integrate the UV controls into the plant control system indicated in Section 13300.
 - d. The PLC equipment shall be provided complete with all programming to perform all operations functionally specified herein and as required for a completely debugged and operating system. All hardware and software shall be incorporated into the Factory Acceptance Test (FAT) indicated in Section 13300 so that all programs are completely debugged and operable prior to delivery of the systems and so that the UV controls are integrated into the plant control systems. The OWNER shall not be required to expend any programming effort in order to achieve a fully operational system.
 - e. The CONTRACTOR shall require the UV manufacturer to design the control logic, data base parameters, reporting requirements, alarm limits, and OIS graphics in conformance with Section 13300. All programming, graphic generation, testing, hardware and software documentation shall be performed under Section 13300. The UV manufacturer shall coordinate with the WORK of Section 13300.

I. Cleaning System:

1. An automatic mechanical/chemical cleaning system shall be provided as part of the UV disinfection system. The cleaning system shall be capable of cleaning the lamps while

disinfecting.

2. The cleaning cycle shall be automatically initiated, controlled, and monitored. The cleaning cycle intervals shall be field-adjustable within the range of once per hour to once per month. Manual operation of the cleaning system shall also be provided with an operator interface.
3. The lamp cleaning system shall conduct the cleaning operation without removing the UV lamps from the reaction chamber. Cleaning shall be accomplished by the system automatically wiping the lamp sleeve surface and simultaneously cleaning by contacting the lamp sleeve surface with acidic solution. The cleaning system shall provide complete cleaning of the UV lamps. No out-of-channel cleaning shall be required. No cleaning solution shall be lost to the plant effluent flow.
4. The system shall be supplied with all required cleaning reagents and solutions necessary for initial equipment testing and for equipment start-up.

J. UV Transmittance Analyzer:

1. An on-line UV transmittance analyzer shall be furnished by the UV Manufacturer. The system shall be integrated to operate with the System Control Center. The monitor shall consist of three components: an analyzer, sensor and sampler. All of the components shall have NEMA 4X enclosures.
2. The unit shall be used to continuously monitor the percent UV transmittance of the effluent to be disinfected. The unit shall have a response time such that each reading is updated every 30 seconds. The unit shall have a reading range of 0 to 100 percent transmittance. The accuracy shall be plus and minus 1 percent of full scale transmittance. The resolution shall be 1 percent transmittance. All of the transmittance analyzer components shall be capable of operating at a temperature range of 20 to 120 degrees fahrenheit.
3. The unit shall contain a low pressure mercury vapor lamp. The sampler shall have the capability of having its optical components cleaned by a removable cuvette. For calibration, there shall be a self contained solution of organic-free, distilled water, with a minimum volume of 1 liter which shall have 100 percent transmittance. The frequency of calibration shall be menu selectable.
4. The analyzer shall have an analog output. The output shall be bracketed by the software selection to 1 percent T, 4-20 mA or 0.1, 1.0 and 10 VDC, 12 bit resolution D/A. The output shall be capable of being isolated from ground by removal of a ground link. The analyzer shall have 2 setable alarm conditions with one sensor. The alarms shall be high, low or off. The analyzer display shall be LCD with graphics capable of 60 minute or 24 hour graph.
5. The analyzer microprocessor shall be a **Motorola M6811C11** or equal. The analyzer input shall be from 8 interactive sealed membrane function switches. There shall be a serial port connection from the analyzer to the sensor which shall be RS422/485/232. The sensor microprocessor shall be a **Motorola M6811C05** or equal.]

2.5 SPARE PARTS

A. The CONTRACTOR shall furnish the following spare parts:

	<u>Quantity</u>
1. High-Intensity, Medium Pressure, UV lamps	[]
2. Quartz lamp sleeves and sleeve holder seals	[]
3. Lamp/Sleeve "bullet" assemblies	[]
4. Electronic ballasts	[]
5. Face Shields, able to block UV light wavelengths between 200 and 400 NM	[]
6. Gallons of cleaning solution	[]

2.6 MANUFACTURERS

A. The UV Manufacturer must provide documentation to demonstrate it meets the following requirements.

1. At least 1 open-channel, gravity-flow, medium-pressure lamp UV disinfection system, as described herein, designed to treat at least 10 mgd, has been operating for at least 2 years at the time of bid of this contract. The UV system documented must be installed at a location in the United States treating municipal wastewater.

B. **Manufacturers:**

1. **Trojan Technologies, Inc., London, Ontario: System UV4000™.**

PART 3 -- EXECUTION

3.1 INSTALLATION

The UV equipment shall be installed in strict accordance with the Contract Drawings, and with the supplier's recommendations, instructions, and shop drawings.

3.2 EQUIPMENT TEST

- A. After the system has been installed and when treated wastewater and power are available, the Manufacturer shall test each item of the UV system in order to demonstrate that the UV system has been properly manufactured, assembled, and installed, and that it is functioning properly. The Manufacturer shall furnish such labor, materials, services, accessory equipment, chemicals, and additional instrumentation, as may be required to complete all tests until the equipment is accepted.
- B. The UV system shall be operated for a minimum trial period of 7 consecutive days, during which the CONTRACTOR shall make such changes and adjustments to the equipment as may be found necessary to conform with the requirements herein. The UV system shall be operated with [plant filtered] effluent.
- C. The MANUFACTURER shall perform equipment checks and requirements that shall verify at

least the following:

1. Proper installation and alignment of UV support racks or frames.
 2. Watertightness of all submerged equipment.
 3. Proper placement of reaction chamber and UV lamp modules to assure submergence under all flow conditions encountered.
 4. Adequate electrical wiring and connections.
 5. Proper operation of instrumentation, alarms, and operating indicators associated with the UV equipment.
 6. Proper operation of interconnection with plant flow meter.
 7. Proper placement and operation of ballast, cooling fans, and filters in the control panels.
 8. Adequate ventilation in the control panels.
 9. Proper operation of lamp module shut-off switches and ground fault circuit interrupters.
 10. Proper operation of lamp removal mechanism
 11. Proper operation of lamp cleaning system. The lamp cleaning system shall be operated at least twice per day during the test period.
- D. Upon completion of the equipment test period, the CONTRACTOR shall submit to the ENGINEER written certification that all UV equipment and accessory equipment associated with the UV disinfection system have been properly installed, are in good condition, are functioning properly, and are in accordance with the Contract Documents.

- END OF SECTION -