

ENAQUA

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Date: January 7, 2014

Emily T. Carpenter
Water Protection Program,
Financial Assistance Center
Missouri Department of Natural Resources
1101 Riverside Drive,
Jefferson City, MO 65101

SUBJECT: Title 10—DEPARTMENT OF NATURAL RESOURCES
Division 20—Clean Water Commission Chapter 8—Design Guides
10 CSR 20-8.190 Disinfection. DRAFT 12/19/13

REFERENCE: Enaqua's review and suggested modifications to Section wording.

Dear Ms. Carpenter,

A draft copy of the referenced document was provided to Enaqua by Municipal Equipment Company, our Representatives in Missouri for review and comment.

Over the past few years, Enaqua has provided (with the approval of the Missouri Department of Natural Resources), our unique Non-Contact UV Disinfection systems for a number of large and small plants in Missouri such as Noel and Park Hills who have operated in excess of 25 years with little or no maintenance, and have recently upgraded to our newest designs, to new systems in operation over the last few years including a number of Lagoons.

It is with 28 years of experience in systems installed in Missouri, along with our experience with wastewater disinfection systems outside of the state, that we will draw upon in the determination of the sizing, treatment capacity and dosing on to make the comments and suggestions noted below (Specifically Section 6, ULTRAVIOLET RADIATION DISINFECTION and its sub sections.)

A. Section 6.B.1.A:

"6.B.1.A Dosage and System Sizing :

1. The UV radiation dosage shall be based on the design peak hourly flow.

A Treatment facilities with batch discharges should consider the need for flow equalization prior to the UV system in order to maintain continuous operation. If no flow equalization is provided for a batch discharger, the dosage shall be based on the peak batch flow."

This is a significant point, especially in the system sizing for batch process systems. The elimination of equalization can be a very large cost savings, provided the following treatment processes (UV included) can properly operate and perform operating on an intermittent basis.

If there is no equalization, then the UV system must be designed for peak batch flow and must be designed for frequent ON/OFF operation. Enaqua's systems along with other manufacturers can be designed for multiple on/off cycles per day.

We therefore suggest the following wording:

Suggested Revision-

6.B.1. A Dosage and System Sizing states:

1. The UV radiation dosage shall be based on the larger of the design peak hourly flow, or peak discharge flow, which

A Treatment facilities with batch discharges should consider the need for flow equalization prior to the UV system in order to maintain continuous operation. If no flow equalization is provided for a batch discharger, the dosage shall be based on the peak batch flow. Systems that will treat the peak batch flow shall be designed to have their power cycled up to a maximum of 24 times per day to accommodate hourly batch discharges.

B. Section 6.B.3 notes:

"6.B.3: This process should be limited to a high quality effluent having at least sixty-five percent (65%) ultraviolet radiation transmittance at two hundred fifty-four nanometers (254 nm) wave length."

Many Lagoons, Trickling Filters and Activated Sludge treatment plants do not produce a liquid effluent with 65% UVT; this however, should not be a limiting factor or threshold value.

It has been determined through actual installations, Pilot Testing, performance of other similar plants, and independent published studies that Ultraviolet Disinfection is a viable treatment offering for plants with water quality of 40% UVT and lower. Care has to be taken in the choice of the system, hydraulics and dosing, but it is viable and cost effective (especially for smaller discharge plants such as lagoons).

Requiring that small community plants provide an effluent of 65% UVT or better would put an additional and unnecessary burden on the community and plant, when there is UV Disinfection Treatment equipment available on the market today to address and treat lower quality Effluent. Systems that have true plug flow do not have the same issues with energy dispersion variations and as such Enaqua and other manufacturers who have plug flow and can show that their systems are capable of disinfecting lower quality effluent should be allowed to provide such

equipment if they can show actual plant data showing efficacy. We therefore suggest the following revision in wording of Section 6.B.3.

Suggested Revision:

6.B.3: This process should be limited to a high quality effluent having at least sixty-five percent (65%) ultraviolet radiation transmittance at two hundred fifty-four nanometers (254 nm) wave length, unless the UV system manufacturer can provide testing data and references from other reporting entities such as WWTP's or third parties not affiliated or paid by system the manufacturer, in which case, systems with lower than 65% UV Transmission will be allowed.

C. Section 6.D states:

"Section 6.D. Open Channel Design. Open channel designs consist of a channel open to the air with modular UV units that can be removed from the waste flow.

Due to the various designs of UV systems currently on the market and the variety of terminology for: Lamp Modules, Lamp Racks, Disinfection units etc.; it might be advisable to elaborate on this phrase slightly to include some "examples" of what "Modular UV Units" may consist of...(Lamp Modules, Lamp Racks, etc.).

Enaqua's Non-Contact Design employs removable Lamp Racks that are placed in between Polymer tubes through which the Effluent flows- this allows the removal of a single lamp rack without affecting the hydraulic flow (short circuiting).

In designs where the lamps and quartz sleeves come into contact with the effluent, removing a MODULE, disrupts the hydraulic flow (filling in the void left by the absent MODULE). This has a negative effect on disinfection and does not allow for changing lamps etc. while that bank is in service. We therefore request that the definition be changed as follows:

Suggested Revision:

6.D. Open Channel Design. Open Channel designs consist of a channel open to the air with modular UV units that can be removed from the waste flow. A "module" is defined as either a Rack consisting of one or multiple rows of lamps. Systems that do not have lamps "dipped" in the effluent but placed in a channel with removable racks shall also be considered Open Channel, Modular UV units."

D. Section 6.D.4 Reads:

"6.D.4 The approach channel must be unobstructed and have a minimum length of four feet (4') (1.2 m) before the first UV bank.

This requirement is only for systems that immerse the lamps (modules/Lamp Racks) in the effluent directly. This approach space is not required for Non-Contact style systems.

We therefore request that the definition be changed as follows:

Suggested Revision:

6.D.4 The approach channel must be unobstructed. The approach should have a minimum length of four feet (4') (1.2 m) before the first UV bank, if required by the manufacturer to ensure proper fluid flow dynamics as required for proper hydraulic function, otherwise, the approach may be per the requirements of the system manufacturer.

E Section 6.D.5 states:

6.D.5 A positive means of water level control must be provided to achieve the necessary exposure time and ensure that the UV lamps remain submerged at a near-constant depth, regardless of flow. Each UV bank should also have a water level sensor and a safety interlock that automatically shuts off the effected bank if a low-water level is measured."

This is only a requirement for systems where the lamps are immersed directly into the effluent stream. The purpose of maintaining the water level is to provide cooling medium for submerged lamps. There are UV Disinfection system designs (Enaqua included) that do not require a fixed water level to operate properly. In these cases, the velocity of the flow of water through the UV Disinfection system is already calculated and reflected in the dosage requirement.

We therefore request that you modify this language to read:

6.D.5 A positive means of water level control must be provided to achieve the necessary exposure time and ensure that the UV lamps remain submerged at a near-constant depth, regardless of flow in systems where lamps or quartz are in contact with water . Each UV bank should also have a water level sensor and a safety interlock that automatically shuts off the effected bank if a low-water level is measured. Systems that rely on Non-contact principals or those that do not immerse lamps or quartz do not require the lamps to be submerged.

F. Referring back to Section 6.2.B.4. As a general guide in system sizing for an activated sludge effluent with the preceding characteristics, a UV radiation dosage not less than thirty thousand microwatt seconds per centimeters squared ($30,000 \text{ uW} \cdot \text{s/cm}^2$) may be used after adjustments for maximum tube fouling, lamp output reduction after eight thousand seven hundred sixty (8,760) hours of operation, and other energy absorption losses.

By virtue of the term uW/s, the factor of exposure time is calculated into the dosage number. (Energy x exposure time = Dosage). To require a fixed exposure time (controlled by a level setting device) is contradictory to establishing a dosage requirement.

We recommend that this section be worded as follows;

“if the lamps/sleeves are immersed directly in the effluent flow; a means of maintaining the water level above the lamps, regardless of flow be provided”

Wording such as this would be less restrictive as to which UV Disinfection system designs the Plant / Engineer can consider and still require the minimum dosage requirement.

G. Section 6.D.6 states:

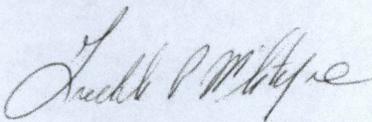
6.D.6 The downstream channel length must be unobstructed for a minimum length of four feet (4') (1.2 m) following the last bank of UV lamps and before a fluid-level control device

As in 6.D.4, the extra length of open channel and fluid level control device are not required in all Open Channel UV Disinfection Systems. We recommend this section be worded as follows:

6.D.6 The downstream channel length must be unobstructed for a minimum length of four feet (4') (1.2 m) following the last bank of UV lamps and before a fluid-level control device If the lamps/sleeves are immersed directly in the effluent flow, then the downstream channel length must be unobstructed for a minimum length of four feet (4') (1.2 m) following the last bank of UV lamps and before a fluid-level control device

Please accept these comments and observations in the spirit in which they are offered. Our desire is to allow the local plants, and Engineering firms to be able to select an appropriate UV Disinfection system that meets the requirements of the Department of Natural Resources standards, while being practical and affordable to the local residents that the treatment plant has to service.

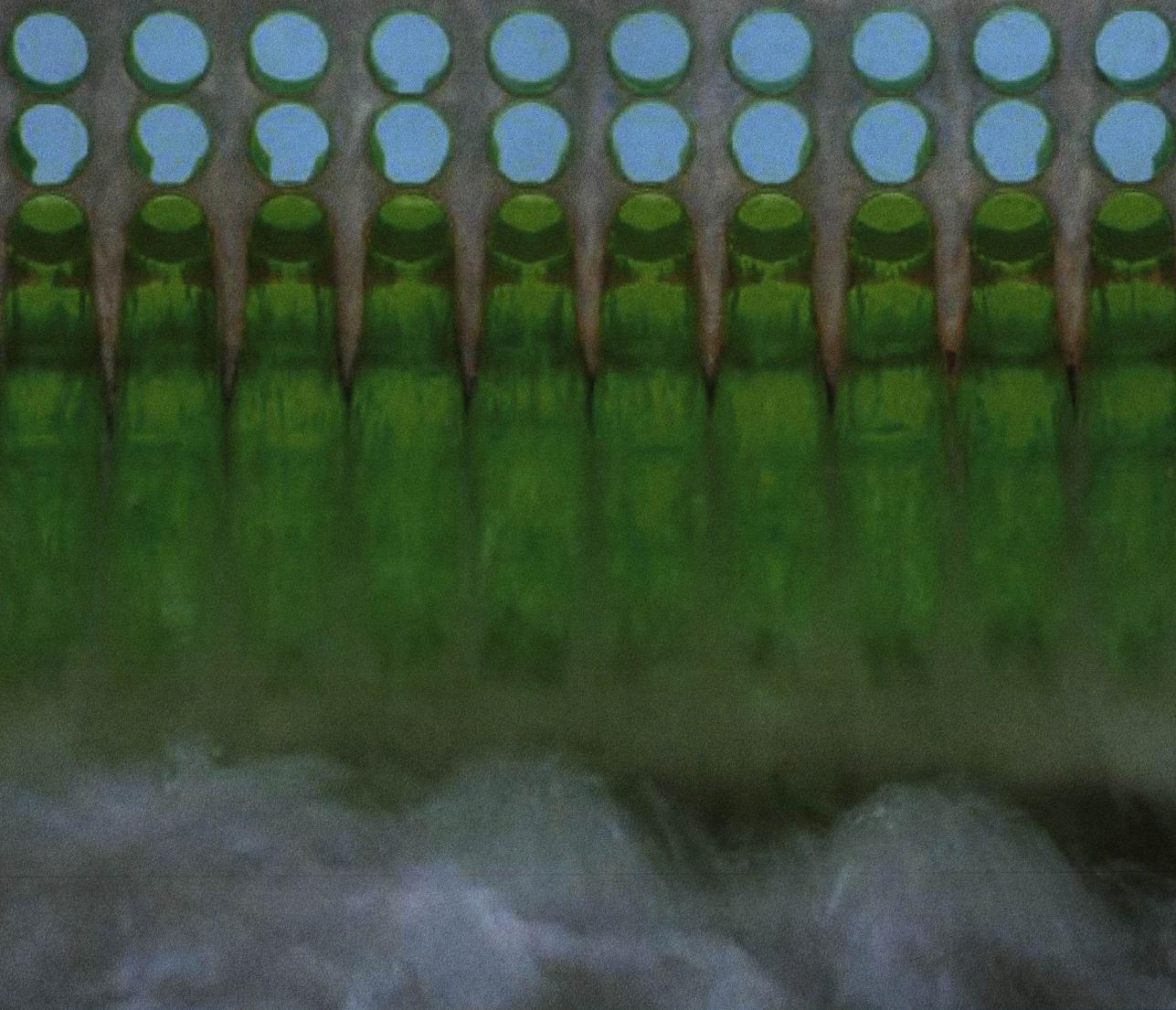
With best regards,



Rick McIntyre
Manager, UV Products

ENAGUA NON-CONTACT ULTRAVIOLET DISINFECTION SYSTEMS

MUNICIPAL WASTEWATER



DRY

SIMPLE

INTELLIGENT

ENERGY EFFICIENT

ENAGUA
A GRUNDFOS INNOVATION COMPANY



THE RIGHT CHOICE

UV is the most cost effective and environmental friendly disinfection solution for wastewater.

About UV Disinfection

Ultraviolet light irradiation is a proven disinfection process using short wave length 254nm Ultraviolet (UV) energy to neutralize harmful microorganisms. UV radiation disrupts the DNA of pathogenic organisms such as bacteria, viruses and molds, leaving them unable to replicate. UV has been used to disinfect various types of effluent from low-quality combined sewer overflow (CSO) to high-quality tertiary effluent.

UV - The preferred disinfection method in municipal wastewater

To comply with local bacteria limit regulations, municipal wastewater must be disinfected before discharging or reusing. The right choice of disinfection technology is one of the most important parts in the design process. UV is the preferred disinfection method for municipal wastewater discharge or water reuse applications compared to conventional chlorination technology. Today more than 20% of wastewater treatment plants in the United States are already using UV as their preferred disinfection technology and this percentage is rapidly increasing.

ADVANTAGES & BENEFITS

COMPARED TO CONVENTIONAL CHLORINATION

	Ultraviolet Light	Sodium Hypochlorite	Chlorine gas
Disinfection effectiveness	HIGH	HIGH*	HIGH*
Disinfection by products	NO	YES	YES
Safety risks	LOW	HIGH	HIGH
De-chlorination required	NO	YES	YES
Contact channel	SMALL	LARGE	LARGE
pH dependency, Corrosion	NO	YES	YES
O&M Cost	LOW	HIGH	MEDIUM
Capital Investment	MEDIUM	LOW	HIGH

*Cryptosporidium and Giardia are resistant against chlorination

ENAQUA – A GRUNDFOS INNOVATION COMPANY

In 2012, Enaqua proudly became part of Grundfos, the world's largest pump manufacturer.

Enaqua's strong belief that "Technology will always prevail" and its dedication to provide the most innovative and best available technology has put Enaqua at the forefront of the water and wastewater industry.

Enaqua pioneered the development of Non-Contact Ultraviolet Disinfection. Instead of immersing the UV lamps into the water stream, Enaqua developed Non-Contact disinfection technology which separates the UV lamps from the water and keeps the lamps dry. This provides exceptional disinfection and electrical components are not submerged in the water.



Meeting your water purification needs

Enaqua provides turn-key solutions, products and services:

- Non-Contact UV Disinfection Systems
- Ultrafiltration and Reverse Osmosis Systems
- Installation & Commissioning
- Membrane and Disinfection Process Evaluation
- On-site and Off-site Training
- Service, Troubleshooting Hotline and Field Support
- Control Panel Shop (UL-Certified)

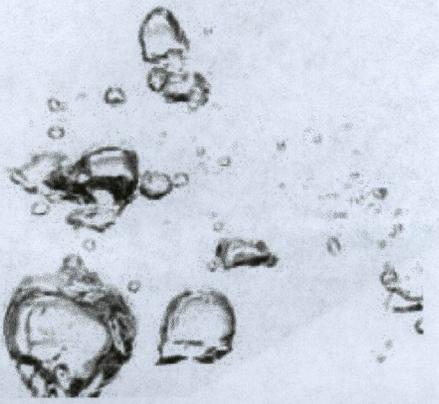
ENAQUA – A HISTORY OF INNOVATION:

1985	1990	1992	1993	1997	1999	2003	2007	2009	2012	2013
Water Technology Consulting First Non-Contact UV System Enaqua founded	Patented Non-Contact Opaque Fluid UV System	Chemical Recovery RO Systems Brackish Water RO Systems	Municipal UV Wastewater System	Distribution of Membrane Products	Large Municipal UV Wastewater Systems	Seawater Desalination RO Systems	UV Web-based Control System	UV / UF / RO Municipal Wastewater Systems	Ensure Dosing System (EDS)* SMART Lamps* Part of Grundfos Innovation	\$11 Million UV / UF / RO Chemical Recovery System

* Patent Pending

“ We have been happy with and impressed with the level of support and technical backup support provided by Enaqua and its staff as and when we need it, and are happy to know Enaqua is only a phone call away. ”

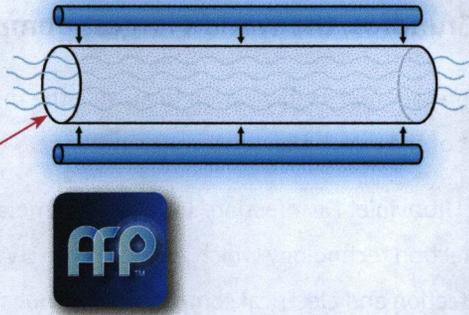
Plant Operations Supervisor
42 MGD WWTP



UV MADE SIMPLE – FEATURES AT A GLANCE

1 SMART LAMPS
Cost efficient non-amalgam
SMART lamp (page 9)

AFP™ TUBES
Fouling resistant virtually
self-maintaining (page 6)



2 FLOW & LEVEL PACING
Reduce energy consumption and
increase lamp life (page 9)



3 HEAT EXCHANGE SYSTEM
Controls temperature for optimal
UV lamp output



4 UV INTENSITY MONITOR
UV Sensor placed outside of AFP™
tubes – Dry without fouling



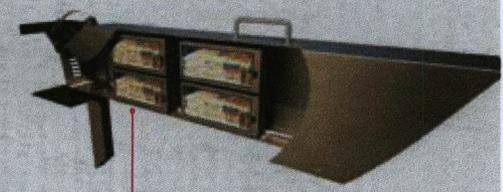


ELECTRICAL PANEL
Simple, compact and operator friendly HMI



ENSURE DOSING SYSTEM (EDS)
Intelligent monitoring, control and FAIL SAFE ensures compliance at all times (page 8)

5 INDIVIDUALLY FUSED AND SWITCHED LAMP RACKS
No cranes required, simple maintenance (page 7)



SINGLE LAMP BALLAST
Non-prorated Warranty up to 24 on/off cycles per day

OPEN DISCHARGE
No level control mechanism required – simple hydraulic design

INLINE & IN-CHANNEL MODULES
Plug & Play Variable Inlet and Outlet configuration (page 10)

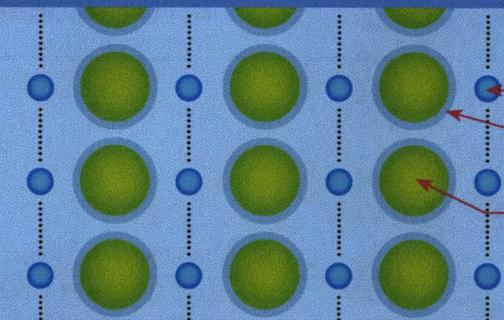
PREFABRICATED SYSTEMS
Self-contained easy to install

» **ALWAYS DRY – AFP™ NON-CONTACT UV TECHNOLOGY**
Enaqua – The Pioneer in cost effective Non-Contact UV design

Enaqua's Non-Contact Disinfection systems have water flowing through the AFP™ tubes with the UV lamps on the outside surrounding the tubes. The lamps are always dry. In traditional quartz systems, the UV lamps are contained in fouling prone quartz sleeves and submerged in the water.

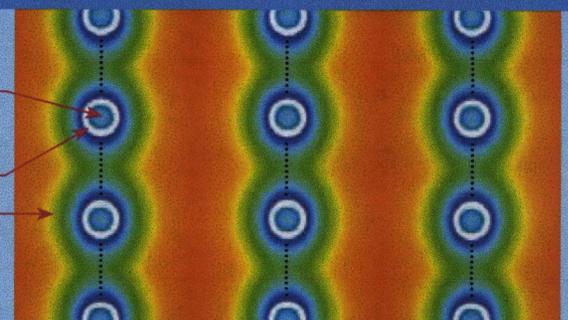
TECHNOLOGIES IN COMPARISON

ENAQUA AFP™
 NON-CONTACT TECHNOLOGY

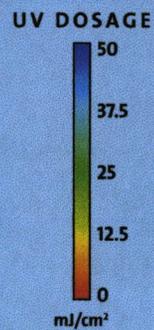


- Low cost high output lamps
- No quartz sleeves
- Fouling-resistant AFP™ tube
- Turbulent flow provides self-cleaning of AFP™ tube
- No AFP™ tube replacement under normal conditions
- Simple pipe hydraulics makes UV disinfection easy to predict
- No level control devices required

QUARTZ SLEEVE UV
 TRADITIONAL CONTACT TECHNOLOGY



- High cost amalgam lamps
- Fragile quartz sleeves with risk of mercury and glass contamination
- Fouling-prone quartz sleeves
- Cleaning system required
- Quartz sleeves need to be replaced over time
- Channel hydraulics makes UV disinfection less predictable
- Level control devices increase footprint



Enaqua's design software is validated by a unique 3D flow modeling algorithm and third-party witnessed bioassay testing.



AFP™ TUBES – THE SECRET BEHIND THE PERFORMANCE

AFP stands for “Activated Fluoropolymer” which Enaqua specifically developed for Non-Contact UV applications:

- High transmission of UV light
- Fouling resistant smooth surface
- Robust, flexible, fracture resistant material
- No deterioration
- Chemically stable
- Proven over 20+ years of continuous operation

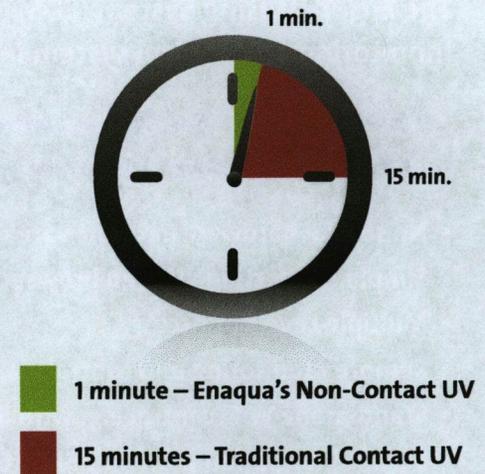
» **SIMPLE** – MAINTENANCE MADE CLEAN, FAST AND EASY
Enaqua's Non-Contact UV technology system maintenance is simple:

NO MORE:

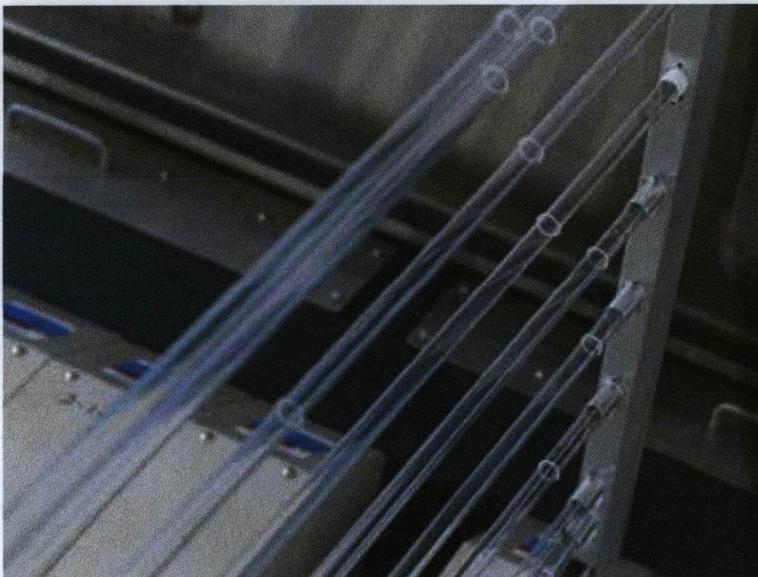
- High cost amalgam lamps
- Dirty and fouled quartz sleeves
- Problems with quartz cleaning devices
- Need to interrupt or remove any hydraulic seals
- Heavy duty cranes required for system maintenance
- Time consuming lamp replacements
- Algae growth on the lamp racks
- Quartz sleeves to break and replace*
- SCADA programming

*No AFP™ tube replacement under normal conditions (20+ year history)

TYPICAL LAMP REPLACEMENT TIME



ENAQUA'S NON-CONTACT UV



TRADITIONAL CONTACT UV



“Our maintenance on the Enaqua UV units over the last few years is essentially zero...We no longer have cleaning as a standard SOP as the system seems to keep itself self cleaning... We have not had to use any chemicals to keep the tubes and lamps clean and performing.”

Plant Superintendent
 20 MGD CSO WWTP

» INTELLIGENCE – YOU DON'T WANT TO MISS... WHERE ENERGY EFFICIENCY MATTERS

The Ensure Dosing System (EDS) is the most comprehensive monitoring and control system in the industry.

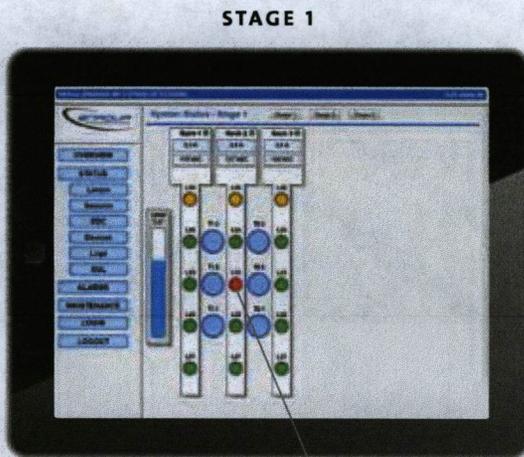
UV SCADA built in – Full system control and performance monitoring wherever and whenever you want:

- No special hardware and software requirements
- Simple connection via web browser
- Multiple Levels of Access
- Remote monitoring and control via Internet
- Stand-alone WiFi control e.g. with iPad®
- SCADA integration with ModBUS TCP/IP
- Remote troubleshooting
- Email and text notification

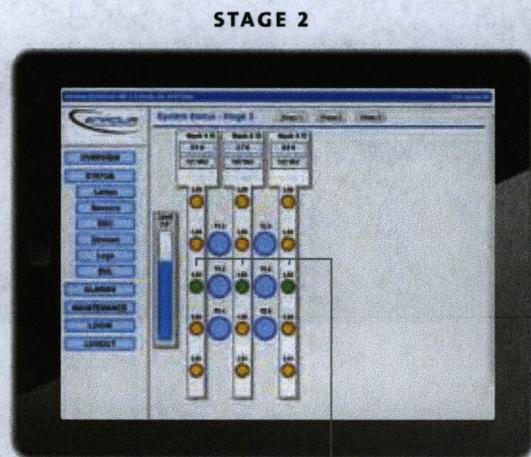


Fail Safe – Intuitive protection

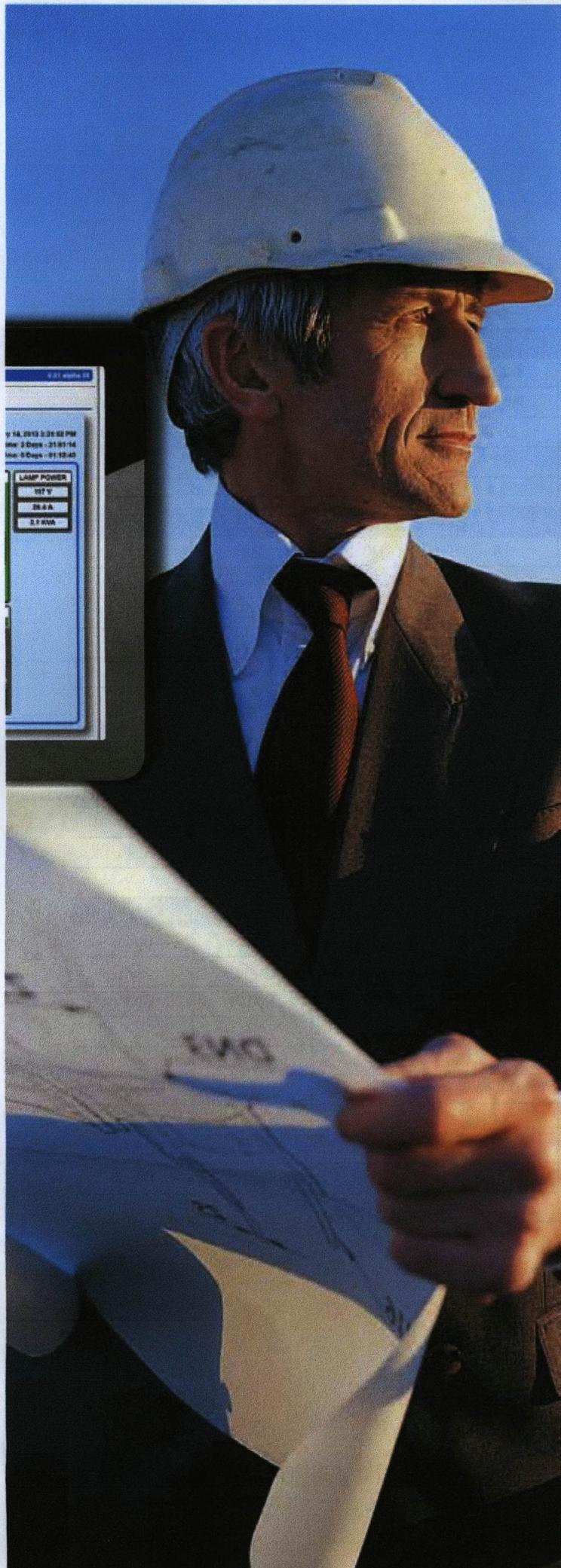
Enaqua's FAIL SAFE intelligence ensures compliance at all times. In case a lamp in one stage fails, the system will command selected lamps in a redundant stage to power-on to compensate for any UV dosage reduction (see application example).



Lamp fault in stage 1: Alarm Alerts

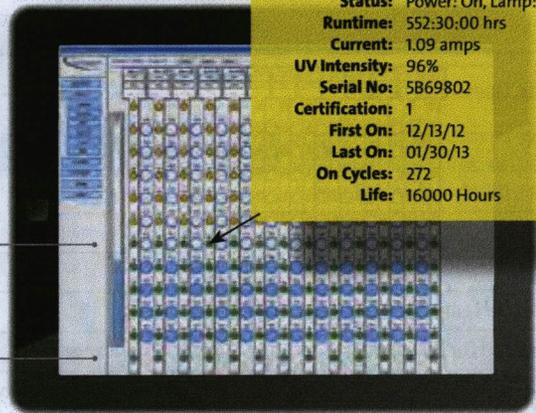


Automatically turns on selective lamps to compensate faulty lamp position in stage 1



SMART Lamps – Advanced lamp control

Enaqua's Low Pressure High Output (LPHO) lamps are equipped with a unique ID for monitoring status, runtime, date installed and other key parameters.

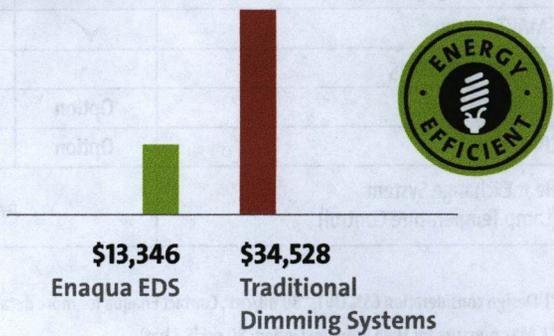


Name: Stage1-LR06-LN010
Alarm: None
Status: Power: On, Lamp: On
Runtime: 552:30:00 hrs
Current: 1.09 amps
UV Intensity: 96%
Serial No: 5B69802
Certification: 1
First On: 12/13/12
Last On: 01/30/13
On Cycles: 272
Life: 16000 Hours

Flow & Level Pacing – Best energy efficiency

Enaqua's Flow & Level Pacing system automatically turns on only lamps which are required. This improves lamp and ballast life and reduces power consumption compared to systems that use "dimming".

ANNUAL ENERGY COST COMPARISON



Actual comparison of bid guaranteed UV energy costs for Wastewater Plant, Peak 28MGD, Average 6MGD, \$0.10/kWh.

» FEATURES AND FUNCTIONS

For specific selection and sizing please contact Enaqua

		M3	M4	M5	C-Series	D-Series	E-Series
MAXIMUM FLOW AND PRESSURE							
Flow Range*1	MGD	0.03 - 0.12	0.04 - 0.17	0.2 - 0.5	0.5 - 10	0.5 - 21	0.5 - 27
	gpm	20 - 80	30 - 120	140 - 350	350 - 6944	350 - 14600	350 - 18500
	m ³ /h	5 - 18	6.8 - 27	32 - 80	80 - 1600	80 - 3300	80 - 4200
Max. Operating Pressure	psi	40*2	40*2	40*2	20	15	10
	bar	2.8	2.8	2.8	1.4	1.0	0.7
MECHANICAL DATA							
Max. Number of AFP™ Tubes	pcs	2	2	6	120	120	120
AFP™ Tube Inner Diameter	inch	2.4			2.4	2.9	3.5
	mm	60.3			60.3	73.7	88.9
Max. UV Lamps per Stage	pcs	8	8	15	156	156	156
Inlet and Outlet Configuration	inch	Flange 2	Flange 4, 6	Flange 8, 10	In-Channel or Flange Options		
Wetted Materials		AFP™, 304SS Option: 316SS, PVC, CPVC			AFP™, 304SS Option: 316SS		
Multistage Design		-	-	Option	Option	Option	Option
ELECTRICAL DATA							
Operating Voltage at 50/60 Hz	V, 1PH	120, 220			220		
	V, 3PH	-			220, 380, 415, 480*3		
Ballast Type		Auto Ranging 110-277 VAC 50/60 Hz with 5 Year Warranty					
CONTROLS							
LCD Status Display		✓	✓	✓	Option	Option	Option
Hand-Off-Automatic Switch		✓*4	✓*4	✓	✓	✓	✓
Control Light: Alarm/Running		-	-	✓	Option	Option	Option
Individual Lamp Rack Fuse and Switch		✓	✓	✓	✓	✓	✓
UV Status LEDs in Lamp Racks		-	✓	✓	✓	✓	✓
Ensure Dosing System (EDS)		Option	Option	Option	✓	✓	✓
SMART Lamps		✓	✓	✓	✓	✓	✓
Flow & Level Pacing		-	-	-	Option	Option	Option
Fail Safe		Option	Option	Option	Option	Option	Option
UV Sensor		Option	Option	Option	✓	✓	✓
Heat Exchange System (Lamp Temperature Control)		Ambient Air Exchange			Air to Air Air to Water		

*1 Design consideration 65% UVT, ~30 ml/cm², Contact Enaqua for more details

*2 Max pressure for High Pressure Option: 80 psi (5.5 bar)

*3 Three-phase voltage requires neutral wire

*4 On/Off switch only



M3 Series

Compact unit ideal for package treatment plants where simplicity is the key.
Flow rates up to 80 gpm (18 m³/h)*1



M4 Series

Low flow system ideal for lagoon applications where cost efficient redundancy matters.
Flow rates up to 120 gpm (27 m³/h) *1



M5 Series

Self-contained sewage disinfection for small communities looking for low maintenance.
Flow rates up to 350 gpm (80 m³/h) *1



C Series

Along with the D and E Series, the C Series are customized units designed for medium to large flows with fouling resistant AFP™ tubes. Controls can be “stand-alone” or incorporated into the Plant SCADA system.
Flow rates up to 10 MGD (1600 m³/h)*1



D Series

Along with the C and E Series, the D Series are designed to minimize maintenance requirements. AFP™ tubes are self-maintaining and rarely need cleaning.
Flow rates up to 21 MGD (3300 m³/h)*1



E Series

Along with the D and C Series, the E Series are designed to minimize the required footprint, head loss and reduce power consumption. Both in-channel and flanged models are available.
Flow rates up to 27 MGD (4200 m³/h)*1



In-Channel and Multistage Systems

Multistage in-line and in-channel solutions for high flow and low UVT applications.

» ENAQUA – UV MADE SIMPLE NON-CONTACT ULTRAVIOLET DISINFECTION

- The **Engineer's Choice** for State-of-the-Art Technology
- The **City Manager's Choice** for Low Capital Cost
- The **Superintendent's Choice** for Low O&M Cost
- The **Operator's Choice** for Simple Operation
- The **Contractor's Choice** for Simple Installation
- The **Finance Director's Choice** for Lowest 20 Years Capital and Operations Cost Potential



DESIGNED AND MANUFACTURED IN USA

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Product number: 982455310333

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