Boxall's Lane Water Treatment Works, Southern England (UK)

UV Used to Reduce Concentrations of Pesticides in Drinking Water

Story on p. 4
In semiconductor, bio-pharmaceutical, and beverage plants worldwide, Aquafine UV systems play a key role in disinfection, ozone destruction, TOC reduction, and chlorine destruction applications. Now, Aquafine UV units are available in custom-engineered, skid-mounted designs that save floor space and reduce project costs.

Featuring Aqualogic 2000, this standard-setting microprocessor control system monitors your entire UV system for simplified operation and maintenance. Housed in common enclosures, you'll save on installation and down time. Better yet, engineering costs for your entire project will be less because these custom systems are delivered to your job site turn-key ready.

Even our lamps save you money. Single-ended and color coded for accurate maintenance, Aquafine UV lamps reduce change-out time by half.

For more than 50 years, we've advanced UV technology. And today we offer everything you need in ultrapure water, and less.
Contents

Abstracts of Recent UV Articles .................................. 18-19
AWWARF Update – UV Disinfection Guidelines .................. 38
Aquafine’s Custom-Engineered UV Water Systems ............... 30
Call For Papers – IUVA 2001 ....................................... 13
Center for Applied Water Research (Berlin, Germany) .......... 9
Dieppe (France) UV Plant Survey Reveals Bad Control Gate .. 6-8
Differences Between Calculated and Biodosimetrically Measured Fluences in UV Plants for Drinking Water Disinfection – Practical Experiences with the Austrian National Standard M 5873-1 .................................................. 14-18
European UV Standards Evolving .................................. 10
Glaxo Wellcome (UK) Reduces Operating Costs With UV ... 9-10
Industry Updates ....................................................... 30-34
Meetings Calendar .................................................... 20
Odex4 UV Odor Control System Clears the Air ................. 12
Pesticide Level Reduction with UV in the U.K. .................. 4
Spanish Aquaculture Benefits from UV Disinfection ........... 5-6
UV Abstracts .......................................................... 18-19
UV System for Henderson, NV (USA) ............................ 32
UV Disinfection: Florida’s Perspective ............................ 35-38
UV Disinfection in Drinking Water Supply ......................... 22-25
UV Disinfects Water at Harveys Brewery (UK) .................. 8-9
UV Effectiveness Against Cryptosporidium ....................... 32-33
UV Helps Safeguard Aachen’s (Germany) Water Supply ....... 4-5
UV in Action in Europe .............................................. 4-12
UV System for World’s Largest Semiconductor Fab .......... 31-32
UV Water System for Ultrapure Water ............................ 30-31
Wedeco Now Market Leader in Italy, Too ......................... 33-34

Index of Advertisers

Aquafine Corporation .................................................. 2
Barr Associates, Inc. .................................................. 12
Bolton Photosciences Inc. .......................................... 30
Calgon Carbon Corporation ......................................... 29
Camp Dresser & McKee ............................................. 12
Capital Controls Group – Ultradynamics ......................... 21
Carollo Engineers ..................................................... 19
Clean Water Systems, International ................................ 8
EPA’s M/DBP Committee Agrees on UV Language ............. 26-28
EIT, Inc. ............................................................... 9
etaplus electronic gmbh & co kg .................................. 7
Hanovia Ltd. .......................................................... 38
Hydroqual, Inc. ....................................................... 28
International Light Inc. ............................................. 10
Malcom Pirnie, Inc. ................................................... 11
Philips Lighting ........................................................ 21
Severn Trent Services – Ultradynamics ............................ 6
Solar Light Co. ........................................................ 34
SUNTEC Environmental ............................................. 40
Trojan Technologies Inc. ............................................. 25
UltraViolet Devices, Inc. ............................................. 39
WEDECO GmbH ...................................................... 39

Editor-in-Chief: Dr. Rip G. Rice
Associate Editor: Dr. James R. Bolton

IUVA News (ISSN in process) is published bimonthly by the International Ultra Violet Association, Inc. and is free to IUVA members. Non-Member subscriptions are available from the office of the Editor-in-Chief 1331 Patuxent Drive, Ashton, MD (USA) 20861; Tel: 301/924-4224; Fax: 301/774-4493; E-mail: Rrice@IUVA.org. For IUVA membership information, contact Dr. James R. Bolton, Executive Director, International Ultra Violet Association, P.O. Box 1110, Ayr, Ontario, Canada NOB 1E0, Tel: 519-632-8190; Fax: 519-632-9827; e-mail: jrbolton@IUVA.org or kharvey@IUVA.org.

IUVA’s Web Page: www.IUVA.org

Editorial Board

James P. Malley, Jr., Ph.D.. Univ. New Hampshire, Chair
James R. Bolton, Ph.D., Bolton Photosciences
Keith E. Carns, Ph.D., P.E., EPRI, CEC
Jennifer L. Clancy, Ph.D., Clancy Environmental Consultants
Robert S. Cushing, Ph.D., P.E., Carollo Engineers
Karl G. Linden, Ph.D., Duke University
Bruce A. Macler, Ph.D., U.S. EPA
Thomas H. Marshall, P.E., Malcolm Pirnie
Michael Murphy, Ph.D., Aquafine Corporation
Ronald O. Rahn, Ph.D., Univ. Alabama at Birmingham
G. Elliott Whitby, Ph.D., SUNTEC Environments
This issue will feature a number of stories about UV in Action in some European settings. Many of the items contributed on these subjects were made available to us by our corporate sponsors, for which we are indeed grateful. In addition, however, there are two special features on European UV activities in other locations of this issue. These are articles written by Dr. Oluf Hoyer (UV Disinfection in Drinking Water Supply) and by Dr. Regina Sommers and her colleagues (Differences Between Calculated and Biodosimetrically Measured Fluences in UV Plants for Drinking Water Disinfection – Practical Experiences with the Austrian National Standard M 5873-1). Many thanks to all of our contributors for this issue.

Reducing Pesticide Concentrations in Drinking Water with UV

Over the past fifty years pesticides in the environment have become widespread, with vulnerable aquifers and surface water sources often becoming contaminated. Pesticide levels in drinking water are required by the Water Supply (Water Quality) Regulations (1989) in England and Wales to be less than 0.1 µg/L for individual pesticides.

Traditional water treatment processes have proved relatively ineffective at removing pesticides, with processes such as granular activated carbon (GAC) requiring lengthy contact times and large quantities of backwash water. For this reason, Hanovia Limited has developed an ultraviolet (UV) treatment system specifically for pesticide level reduction.

Both in terms of capital and running costs, UV is a cost-effective method of reducing pesticide levels. It acts by photolysis, using high energy UV to break the organic bonds in toxic pesticide compounds. Hydroxyl free radicals, also produced by photolysis, oxidize these molecular fragments into harmless compounds such as carbon dioxide, water and organic acids. A beneficial side-effect of UV treatment is microbiological safety, as it destroys any microorganisms present in the water, including Cryptosporidium.

This technique is being used in a scheme to reduce atrazine levels in the drinking water at Boxall's Lane, one of the largest water treatment works in southern England. Supplying over 42,000 customers, with a peak flow capacity of 670m³/hour, Boxall's Lane was the first water treatment works in Europe to be installed with a UV system for pesticide level reduction, and has been in operation for over five years.

(See photo on front page)

Issued by: Hanovia Limited, 145 Farnham Road, Slough, Berkshire SL1 4XJ, UK. Website: www.hanovia.co.uk. Company contacts: Jon McClean / Sean Appleton. Tel: +44 1753 515300. Fax: +44 1753 534277. E-mail: sales@hanovia.co.uk.

UV Helps Safeguard Aachen’s (Germany) Water Supply....

Herbert Künzel, Delta UV

When effluent discharges from a series of community WwTPs threatened raw water quality in a nearby reservoir, engineers from the German city of Aachen turned to UV as a final treatment step to prevent possible microbiological contamination of local water sources.

A rising population and the associated increased demand for potable water led engineers in Aachen to recommend the construction of a new reservoir in the city's North Eifel region. With the reservoir complete, recent weather fluctuations – extremes of drought and flood – started to cause an increase in the microbiological contamination of raw water. Delta UV, working in conjunction with city engineers, was hired to find the source of contamination.

The Aachen reservoir feeder region contains five major villages, Monschau, Erkensruhr, Konzan, Kalthausen and Einruhr, each with their own WwTP discharging between 30 and 250 L/sec. Further investigation revealed seepage from these community systems to be the likeliest source of reservoir contamination. To protect the North Eifel reservoir, it was decided to disinfect all effluent from these WwTPs to avoid microbiological contamination prior to discharge to creek or river water.

Delta UV recommended that wastewater from each community should be collected in a concrete pond, pumped with a capacity controlled pump to a stainless steel basin containing its "Vario" open channel UV system, and treated to ensure a pathogen.
reduction of $10^4$. Treated wastewater then would be fed to a covered stainless steel collection pond, prior to controlled discharge to creek or river water, ensuring the quality and safety of feed water to the Aachen reservoir.

The Delta UV Vario disinfection system is a UV irradiation system, which has been designed specifically to be mounted in an open channel. Its patented swimmer construction enables it to self-adjust to changing water levels. The system consists of two cylindrical stainless steel floats, which enable it to be held at the water surface. Two bearing frames, designed as ladders, each held by one of the floats, enable multi-height adjustments to be made in variable flow conditions.

The upper bearing frame sits above the water, the lower within the water. Two swivels are anchored to the bottom of the channel and connect with the two bearing frames, ensuring that the upper frame can be adjusted. The float of the upper bearing frame acts as a downstream under-flow weir. Its height is constantly adjusted by the flow of water, ensuring that the UV radiant length of the UV modules is always just covered by water. To optimize efficiency if the flow increases, the inclination of the swivels and modules decreases, keeping the adjustment of the UV modules to the water level exactly the same. A set of UV modules/reactors fits within the swimmer system. Designed as interchangeable stainless steel frames, these hold quartz sleeves containing the UV lamps.

Developed in association with Philips, these high intensity, low pressure lamps contain a yttrium oxide covering on their inner surface which has enabled a source of UV light to be produced for the first time. This design has not only produced a lamp giving greater efficiency but has also ensured that, apart from an initial reduction of less than 20% of its original capacity, the emission from this type of lamp will remain constant until the end of its serviceable life. In commonly used low-pressure lamps, the ageing process increases with the hours of operation.

The flow reactors are equipped with UV lamps orientated vertically to the water flow with a baffle in the reactor inlet to divert water at the inlet into a tangential flow. This design feature ensures that short circuiting cannot occur. All electrical connections are completely clear of contact with the water.

The continuous function control of the system is achieved by a selective UV sensor able to calibrate, measure and display continuously the intensity in the flow reactor of every UV lamp. If a predefined minimum value of UV intensity is recorded, an alarm is activated initiating the pneumatic quartz sleeve cleaning system. The adaptability of the Vario system was an essential element in its choice — especially with the varying local conditions — in determining the scale of system required to individually treat each village.

Water quality has a crucial influence on the effectiveness of UV units, and it was important that local transmissance levels were recorded in tailoring individual systems. Delta UV has developed an on-line transmission gauge which measures the spectral absorption coefficient of water. This unit monitors the analysis used for designing a UV disinfection plant, also giving a display and proportional output for documentation. Should the water quality alter in comparison to the initial analysis, the change is monitored.

The treatment system for the village of Monschau consisted of a Vario disinfection system incorporating 27 modules with six lamps per module. Erkensruhr, with a smaller population but with a similar system, has eight modules with six lamps per module, and the village of Konzan having a similar population also has a system containing eight modules with six lamps per module. Kaltanherberg has a larger system with 13 modules of six lamps each and the village of Einruhr with the smallest population has the lowest capacity system containing five modules with six lamps per module.

The total cost of uprating the treatment for these five villages using the Vario disinfection system was DM 2 million.


**Spanish Aquaculture Benefits from UV Disinfection**

Hanovia Limited has supplied four UV water treatment systems to Grupo Pescanova, Spain's largest aquaculture operator. The systems will be used to treat recirculated water at the Ayamonte Fish Farm in southern Spain.

UV is particularly effective at destroying the microorganisms responsible for fish diseases, including *Ichthyophthirius* (white spot disease), *Saprolegnia* (fungal disease), Viral hemorrhagic septicaemia (VHS) and Infectious pancreatic necrosis (IPN). As it does not affect the physical characteristics of the treated water, there are no undesirable side effects such as toxic byproducts, pH changes or temperature fluctuations. In addition, by lowering the levels of waterborne pathogens, UV allows stock densities to be increased with no increased risk of disease.

Issued by: Hanovia Limited, 145 Farnham Road, Slough, Berkshire SL1 4XB, UK. Website: www.hanovia.co.uk. Company contact: John Fernandez. Tel: +44 1753 515300. Fax: +44 1753 534277. E-mail: sales@hanovia.co.uk.
A survey performed on the UV disinfection unit of Dieppe (4.1 mgd, west of France) from August 1996 to August 1997 turned up the discovery that unsatisfactory fecal counts were related to the adjustment of a control gate. In 1994, the City of Dieppe, aided by the Seine-Normandie Water Agency, undertook a large depollution program. Diagnostics of the wastewater and rainwater systems were carried out in parallel with the construction of a new Wastewater Treatment Plant (WWTP). The WWTP discharges into the Arques, a river that empties into the port of Dieppe about 2 km from the plant. To protect the water on the adjacent beaches from any microbiological pollution, an ultraviolet (UV) disinfection system was installed on the discharge channel.

### Plant Characteristics

The UV unit is composed of two banks of low-pressure mercury vapor lamps positioned in an open concrete channel. The plant has a peak flow rate of 680 m³/h. Its two parallel treatment lines each consist of pretreatment (screening, degreasing and sand removal), biological treatment by activated sludge with nitrification and denitrification and clarification in a circular clarifier. The decanted and non-recirculated sludges are sent to centrifuges for thickening and dewatering. The plant was put into operation in May 1996, and the disinfection units were in operation by July 24, 1996.

The UV unit is a UV3000 series supplied by Truelight-Trojan. It comprises 304 low-pressure UV lamps distributed over two banks of 19 modules, each with eight lamps. The two banks are in series in an open concrete channel. The lamps are oriented parallel (horizontal) to the flow direction and there is a UV probe for each bank. A gate controlled by a float mechanism at the end of the channel maintains the water level for any input flow rate. The main lamp characteristics are an arc length of 147.5 cm, a power at 254 nm of 26.7 W (new lamp) and a power consumption of 65 W.

### Design Requirements

The design of a disinfection unit must provide disinfection guarantees that are possible even in the worst conditions, i.e., with one year old dirty lamps, and with flow at peak rates. At Dieppe, the design was based on the following characteristics:

- Peak flow rate = 680 m³/h
- Maximum suspended solids = 30 mg/L
- Minimum percent UV transmission = 40 percent

The disinfection guarantees demanded for the site by the public authorities are:

- Total coliforms less than 10,000/100 mL
- Fecal coliforms < 10,000/100 mL
- Fecal streptococci < 1,000/100 mL

### Monitoring Methods

Effluent turbidity and percent UV transmission (UVT) rates were continually monitored. Water flow rate and UV intensity measured by UV probes were monitored until April 1997. The self-monitoring program from May to September included monitoring for Enterococci and E. coli three times weekly downstream of the UV system and once upstream. From October to April, weekly tests included two downstream and one upstream analysis for Enterococci and one downstream and one upstream analysis for E. coli.
Potable and process water the world over benefit from HANOVIA ultraviolet disinfection. With over 40,000 installations worldwide, we have now gathered over 5,000,000 hours of mtbf (mean time between failure) data on our power supplies, lamps, monitors and wiper systems. Our infield failure rate for lamps is below 0.6%, which confirms our status as the manufacturer of the most reliable UV lamp. Independent audit of our lamp manufacturing facilities has shown our lamps to be over 30% more efficient when benchmarked against comparable lamps. We maintain an audit trail to certify lamps and monitors, indeed the HANOVIA UV monitor is the only absolute UV monitor and provides unrivalled reliability and accuracy. Our equipment has been independently certified to de-activate Cryptosporidium oocysts. The HANOVIA CFD model demonstrates the UV dose the entire flow has received. Talk to us about your ultraviolet requirements.
Survey Results

During the assessment period, the quality of the effluent after clarification was perturbed twice, during the construction work in December 1996 and in the very cold periods in January 1997 (air temperatures were -10°C for two weeks). Except for these two periods, the effluent quality was very satisfactory over the whole year, particularly for the percent UVT (between 52 and 63 percent) and the suspended solids count (3-21 mg/L). This was better than expected in the design phase of the project.

Before UV disinfection, bacterial concentrations were between 2 x 10³ and 8 x 10⁵ per 100 mL for both E. coli and Enterococci. In August 1996, performances were unsatisfactory with bacterial concentrations after UV disinfection proving to be abnormally high, between 100 and 10,000 per 100 mL. The two main hypotheses proposed were deposits on the quartz sleeves and the existence in the channel of a layer of water receiving insufficient radiation.

Operators washed bank 1 with acid on August 5. The analysis of bacteria the next day showed that there was no improvement in the disinfection level. If the counterweight of the control gate were improperly adjusted, the water level would not be properly regulated to ensure all the water was exposure to UV radiation as it passed through. Samples were taken at the top and bottom of the channel just after the effluent passed through the lamps. The data showed that the upper layer was poorly disinfected compared to the bottom layer. The gate was adjusted at the end of August.

After the gate adjustment, tests showed the UV system was very efficient at killing bacteria. For E. coli, 58 of 68 counts after UV were less than 100 per 100 mL. For Enterococci, 55 of 90 counts were less than 100 per 100 mL, with all samples for bacteriological analysis taken at peak flow. Such performances were linked to the effluent’s low suspended solids count and good percent UVT.

Because of the quality and low mineral content of the effluent, cleaning operations only consisted of one chemical cleaning every three months and one water-washing every 15 days.

Lamp Switching

Because of a high number of ON/OFF cycles, lamp failure increased after 5,500 hours of operation. Lamps had to be changed after 7,000 hours of operation, although the expected life of each lamp had been 8,760 hours.

The switching on and off of the banks was controlled by the flow rate through the channel. With the UV probes giving the signal for the lamps to switch, the fluctuations in the flow rates caused frequent switching, up to 15 per day. Most of the shut-offs were between 13 h and 23 h (1-11 ppm) and lasted only a few minutes.

The operators concluded that such an operating method accelerated aging of the lamps. They set a delay of 45 minutes for the lamps to switch off, allowing the flow rates to fluctuate more before the lamps needed to react. This resulted in an average of three daily on/off cycles and helped extend bulb life.

UV Disinfects Water at Harveys Brewery

Harveys Brewery in the historic town of Lewes in Sussex, southern England, has installed a Hanovia ultraviolet (UV) disinfection system to help safeguard its brewing process from the risk of waterborne microbial contamination. The Hanovia system treats all water drawn from an artesian well which subsequently comes into contact with product. UV destroys all waterborne microorganisms such as bacteria, yeasts and molds. It does not affect the pH or chemical composition of the water, ensuring that the unique flavor of the beer is not altered in any way.

CLEAN WATER SYS., INTL.
TRUE UV Meter, Monitor and Control Systems
28 years of experience

HANDEL HELD METER
Meters and Sensor systems to meet all needs.
(541)882 9993 FAX (541)882-9994
E Mail: CWS@CDSNET.NET
Established in 1790, Harveys is the oldest independent brewery in the county of Sussex. It produces a range of draught beers, including Harveys Sussex Best Bitter, and a selection of special seasonal brews. 35,000 Barrels a year are produced, mainly for the local market, but a proportion is exported as far afield as the USA and Finland.

Speaking about the Hanovia system, Miles Jenner, Head Brewer and Director, said, "Although the quality of the water from our artesian well is sound, we wanted to ensure there was no subsequent microbial contamination in-line. We chose UV as it is the simplest system to use with the least operator risk associated with it. By treating all water that comes into contact with product, including process liquor and rinse water, it gives us added peace of mind."

Hanovia UV systems have many other applications within breweries, including the treatment of deaerated, chase and makeup liquor, CIP rinse water, water for yeast propagation and pasteurizer recycling water. They also can be used in the packaging plant for the surface disinfection of crown caps, cans and bottle necks, or for treating jetting water. Special air treatment systems are available for disinfecting the head space in water storage tanks and for treating the air supply to yeast preparation areas.

---

**Center for Applied Water Research Founded in Berlin, Germany**

Berlin is a city with great potential for companies and institutions of higher learning engaged in water research. Berliner Wasser Betriebe, Vivendi, and the scientific landscape in Berlin enjoy a broad range of scientific know-how in water-related disciplines -- including hydraulic engineering, community water supply, processing technology, aquatic chemistry, aquatic microbiology, water analysis, as well as geology, hydrology, and inshore water ecology.

Initiated by Vivendi water, Berliner Wasser Betriebe, and the Berlin universities, a project and information network is being created that will take advantage of existing water research expertise and development, strengthen, and market it. The stated goal is to synergize local water companies and the Berlin scientific community under the auspices of the Berlin Center for Applied Water Research. The center will consist of two institutional divisions that will work closely together: a network office under the auspices of the Berlin Technology Foundation and a cooperative partnership between Vivendi water and Berliner Wasser Betriebe. The network office will be a service to Berlin-based water researchers and will coordinate knowledge and information, plan interdisciplinary activities, and manage project acquisition and public relations. The cooperative partnership will promote the creation of innovative water supply system solutions and technical components.

The center will receive substantial financial support from Vivendi water. The Berlin Center for Applied Water Research will be introduced to the public for the first time at the Berlin International Water Industry Trade Show (during Wasser Berlin 2000) in Hall 10.1, at the International Business Center.

---

**Glaxo Wellcome Reduces Operating Costs with UV**

Pharmaceutical manufacturer Glaxo Wellcome has reduced operating costs at its production facility outside London, England by installing Photon control systems for its Hanovia ultraviolet (UV) water disinfection units. According to Glaxo Wellcome's Fine Chemicals Engineering Manager:
"Since installing the Photon controllers, our engineers only have to change the lamps in the UV disinfection units when the dose falls below a predetermined level, rather than arbitrarily every 13 weeks, as they did before. This brings with it both cost and efficiency benefits."

Providing data-logging facilities which ensure full traceability of all disinfection procedures, the microprocessor-driven Photon systems monitor all significant disinfection parameters at once, including UV dose, UV intensity and lamp hours-run.

At the facility, raw water from the town’s mains supply is filtered and treated with UV before entering the primary circulation loop storage tank. This feeds the purified water ring main (secondary loop), which also is treated with UV. In all, there are four Hanovia UV disinfection units at the site. The units are continuous-running, except during the nightly sanitization, and treat a maximum water flow of 0.75 m$^3$/hour.

UV works by penetrating the cell walls of microorganisms and destroying their DNA. It has a kill rate greater than 99.99% and is effective against all known microorganisms including bacteria, viruses, fungi and their spores. Hanovia UV systems also remove chemical contaminants in the water by photolysis.

In the past, firms marketing point-of-use/point-of-entry water treatment equipment in Europe were faced with different standards in different countries. However, with the formation of the European Community, then the creation of the European Committee for Normalization (CEN), things are changing. By the way, the European term “Normalization” translates to “Standardization”.

The CEN is composed of the national standards bodies of Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxemburg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. The CEN was established to promote voluntary technical harmonization of national standards to facilitate the movement of goods and services throughout Europe so as to streamline trade.

For the water treatment industry, the move toward harmonized standards among the 15 member countries is entering a critical stage. Eight drafts are under development, including one for UV. The other seven are Mechanical Filters, Chemical Dosing Systems, Softeners, Electrolytic Dosing Devices, Nitrate Removal, Reverse Osmosis, and Active Carbon Filters.

The UV draft currently is scheduled to be sent to technical committees for approval in February 2003.

[Taken from T. Kane, “Europe Gets Down to Business”, Water Technology 23(9):44-46, 2000]
IN THE TIME IT TAKES YOU TO READ THIS, YOUR PROBLEM HAS DOUBLED.

Breathe easily. In the fight against air contamination, Philips TUV Lamps kill or inactivate bacteria, viruses and other primitive organisms. Thanks to years of development and innovation, there’s no better choice too. Philips offers: - Coated soft glass technology for unparalleled high output over 9,000 hrs life - Wide range of single ended lamps permit compact equipment and easy lamp replacement - Environmental benefits (only 5 mg mercury dose) - Proven reliability

For further information, contact: Philips Lighting, Fax: +31.165.577907

PHILIPS
Let’s make things better.
Hanovia's new ODEX4 ultraviolet (UV) odor control system has been shown in recent independent trials to be highly effective at eliminating odorous emissions. The trials -- carried out by a leading British manufacturer of ready-made poultry products -- tested the ODEX4's effectiveness at reducing emissions of H$_2$S, Ethylamine, Ethyl Mercaptan and Methyl Mercaptan from the factory.

Both indoor and outdoor trials were conducted; initial concentrations of odorous molecules were between 10 and 20 ppm and, in all cases but one, less than 1 ppm of each substance was detected after passing through the ODEX4 treatment chamber. The only exception occurred when H$_2$S at 200 ppm was passed through the system, and even then the detected output was only 2 ppm.

Commenting on the trials, a spokesperson from the company said: "The results have been very encouraging; in virtually all cases less than 1 ppm of each odorous compound was detected after passing through the ODEX4 -- this is very low and certainly shows the effectiveness of the new system. The results are particularly interesting in light of the tough new government guidance notes for animal renderers." In a process called 'UV-enhanced oxidation', odor-laden air is drawn into the ODEX4 contact chamber containing a rack of specialized UV arc tubes which produce ozone (O$_3$) in situ. The O$_3$ molecules are split into highly reactive free radicals which attack the odorous molecules in the chamber, breaking them down into harmless, odorless compounds. The system is capable of treating up to 500 m$^3$/hour -- depending on odor load -- with a required contact time of only 15-20 seconds. Detectors in the chamber constantly monitor the odor-loading of the air and a PLC controls the number of UV tubes operating, ensuring efficient odor removal at all times.

The ODEX4 has many applications, including abattoirs, poultry farms and food processing facilities. Compact and silent in operation, it is simple and safe to operate with minimal maintenance requirements.

Issued by: Hanovia Limited, 145 Farnham Road, Slough, Berkshire SL1 4XB, UK. Website: www.hanovia.co.uk. Company contacts: Jon McClean/Sean Appleton. Tel: +44 1753 515300. Fax: +44 1753 534277. E-mail: sales@hanovia.co.uk.
CALL FOR PAPERS

for

The First International Congress on Ultraviolet Technologies
June 14-16, 2001, Washington DC, USA
Sponsored by the International Ultraviolet Association

Abstracts for papers are sought for the following topics:

UV Disinfection for Drinking Water, Process Water, Wastewater and Air
  Microbial inactivation
  Development/assessment of surrogates for disinfection performance
  UV dose measurement and verification
  Interactions/synergies with other disinfectants
  Water quality impacts on UV disinfection
  Semiconductor and ultrapure water applications
  Cooling water for the Power Industry
  Aquarium and fish hatchery
  Hospital and laboratory sterile water

UV Disinfection: Design and Full-Scale Experiences
  Specs and designs for the latest UV systems worldwide
  Designing large-scale UV facilities for filtered and unfiltered supplies
  Testing protocols
  Reactor hydrodynamic characterization
  Retrofitting UV into existing treatment facilities
  Integration with other system components
  Multi-barrier disinfection approaches
  Case studies

UV Disinfection Regulatory Approval Process
  State/Provincial regulatory updates
  Federal/International regulatory updates
  Approval processes for UV systems
  Testing and certification
  Operational criteria

UV Disinfection Hardware Technological Advances
  Reactors, Sensors, Lamps, Support Equipment

Operators Forum: UV Systems
  Operations and maintenance issues
  Energy optimization for UV treatment
  Experiential information for operators, lab managers
  How do I know if my UV system is working?

UV-based Advanced Oxidation
  Degradation of priority pollutants
  Disinfection under oxidization conditions

UV Curing
  Graphics, inks, and web printing
  Varnishes and coatings
  Photochemistry of UV curing

UV for Food and Packaging Disinfection
  Pharmaceuticals
  Juice and beverage disinfection
  Packaged food disinfection
  Cosmetics

UV Photochemistry/Photobiology
  Photoreactivation/repair
  Actinometry for dose measurement
  Tropospheric/upper atmosphere UV chemistry
  Specialty polymerization in Chemical Industry
  UV effects on humans (skin, tanning, cancer)
  UV applications for medical sciences

Absolute Abstract Deadline: Nov. 15, 2000

Abstract Protocol: – Abstracts should be no more than one page (A4 or letter size), single spaced in 12 pt. Times Roman Font. Abstracts must be received by Nov. 15, 2000 by mail (P.O. Box 1110, Ayr, ON, Canada, N0B 1E0), fax (519-632-9827) or electronically (by email attachment to kharvey@iuva.org or through the IUVA Web site www.iuva.org). Abstracts received after the deadline will be returned and not accepted. Authors will be notified concerning the acceptance or rejection of their abstracts by December 15, 2000. The deadline for receipt of the full paper will be March 30, 2001. Details concerning preparation of the papers will be sent out with the notice of acceptance of the Abstract.
Differences Between Calculated and Biodosimetrically Measured Fluences in UV Plants for Drinking Water Disinfection – Practical Experiences with the Austrian National Standard M 5873-1

Regina Sommer\(^1\), Alexander Cabaj\(^2\), Walter Pribil\(^3\), Thomas Haider\(^3\) and Georg Hirschmann\(^4\)

Hygiene Institut\(^1\) and Institute of Environmental Hygiene\(^5\), University of Vienna, Kinderspitalgasse 15, A-1095 Vienna, Austria;
Institute of Medical Physics and Biostatistics\(^3\), University of Veterinary Medicine Vienna, Veterinärplatz 1, A-1210 Vienna, Austria;
Austrian Research and Test Centre "Arsenal Research" \(^4\), Faradaygasse 3, A-1030 Vienna, Austria.

OVERVIEW

Austria has a long tradition in using UV-253.7 nm radiation for drinking water disinfection purposes. The main advantages are: (I) no chemicals must be added to the water, (II) no change of the water composition is to be expected and (III) no additional reaction time is needed (18). Nevertheless, there is one disadvantage: it is not possible to measure or calculate the applied microbiocidal fluence directly. This is because the microbiocidal efficacy depends on the intensity of the lamps, the flow and the UV transmittance-253.7 nm of the water being irradiated as well as on the hydraulic properties of the UV device. Due to inhomogeneous irradiation geometries and individual, unpredictable hydraulic behaviors in flow through systems, fluence distributions occur (6).

For a sufficient UV disinfection of drinking water a microbiocidal fluence of 400 J/m\(^2\) is necessary, as stated in the Codex Austriacus in 1993 (2), based on data about the UV sensitivity of pathogenic, water-transmittable microorganisms (4,7,8,11,12,20). The only possible method to measure the UV fluence delivered by UV flow through systems, so far, is biodosimetry (1,3,5,6,9,10,13,14,19). The result of such measurements is expressed as Reduction Equivalent Fluence REF (6). The REF is influenced by two functions, namely the fluence distribution among the microorganisms passing the irradiation plant (f) and the survival function of the biodosimeter (g) as can be clearly seen by the following equation:

\[
\text{REF} \left( \frac{N}{N_0} \right) = g^{-1} \left( \int_0^\infty g(H_0) \cdot f(H_0) \cdot dH_0 \right)
\]

REF: Reduction Equivalent Fluence, \(N\): number of surviving microorganisms, \(N_0\): number of microorganisms before irradiation, \(g(H_0)\): survival function of the biodosimeter, \(g^{-1}(N/N_0)\): inverse function of \(g(H_0)\), \(f(H_0)\): density function of fluence distribution among microorganisms after passing the irradiation plant, \(H_0\): fluence.

We developed a combined standard procedure consisting of a biodosimetric test and physical measurements of the radiation for type-testing of commercial UV plants. In February 1996, this method was incorporated in the Austrian National Standard M 5873 "Plants for disinfection of drinking water using UV radiation" (1). Moreover we established a test stand to perform type-testing of commercial UV plants. Since that time we have tested more than 30 UV devices from Austrian, German, Swiss and Dutch manufacturers in a flow range from 0.2 m\(^3\)/h up to 500 m\(^3\)/h. UV plants which have fulfilled all the requirements of the standard M 5873 may be certified by the Austrian Water Association (ÖGVW). Consequently, a variety of UV plants is available with such a certificate.

BIodosimetric Method According to the Austrian Standard (1)

Biodosimeter

Spores of Bacillus subtilis (ATCC 6633) are irradiated in a standard laboratory batch apparatus (wavelength 253.7 nm) and reduction in the number of the spores is determined as a function of the UV fluence in order to calibrate the sensitivity of the spores (13,14,15).

Test Stand

The test stand was established at the Austrian Research and Test Center "Arsenal Research" in Vienna.

Adjustment of Measurements

The UV plants are installed at the test stand. After an operating time of around 100 hours, the lamp output is reduced to a level which is equivalent to the value at the end of the lamp’s operating time. Each UV disinfection device has to be tested at three flows (maximum, minimum and one in between) and the corresponding water transmittances (253.7 nm; 100 mm) according to the manufacturer’s calculation for a fluence of 400 J/m\(^2\). The transmittance of the water is adjusted by pumping sodium thiosulfate-solution in the inflow and is continuously monitored by a flow-through spectrophotometer.
Figure 1. Measurement of the UV irradiance (W/m²) at a reference point at the wall of the irradiation chamber using a calibrated selective detector with adapter.

**Biodosimetric Test Procedure**

A stock solution of the UV calibrated spores is pumped into the inflow of the disinfection device in order to achieve a spore concentration of about $1 \times 10^7$/L in the water to be irradiated. The survival rate of the spores expressed as $N/N_0$ is used to calculate the Reduction Equivalent Fluence by applying the following equation:

$$
REF = -\frac{1}{k} \cdot \lg \left[ 1 - \left( 1 - \frac{N}{N_0} \right)^{10^{-d}} \right]
$$

where $k$ means the UV-sensitivity of the biodosimeter (m²/J) and $d$ is the parameter which describes the shoulder broadness of the calibration curve of the biodosimeter.

**Physical Measurements of the Radiation**

During the biodosimetric tests the UV irradiance (W/m²) is measured continuously at a reference point at a standardized measuring window in the wall of the irradiation chamber using a calibrated selective detector (SED 240, International Light) as well as the UV detector installed by the manufacturer of the UV plant (Figure 1). This parameter is called reference irradiance ($E_{REF}$, W/m²).

**UV Disinfection Devices**

More than 30 commercial water disinfection plants, single lamp and multiple lamp systems, were tested (Figure 2). The devices were equipped with either 1, 3, 4, 5, 6, 8, 9, 12, 28 low pressure mercury lamps of different wattage. The standard measuring window made of quartz glass according to ÖNORM M 5873 was installed in each device.

Figure 2. Commercial UV plant for water disinfection at the test stand in Vienna.

**RESULTS**

Some representative biodosimetric results of commercial single and multiple lamp systems (A-F) produced by different manufacturers are listed in Table 1. We compared our measured data with the fluence values as calculated by the manufacturer.

In general we found significantly lower microbicidal fluences than expected by the manufacturer. This difference between estimation and measurement increased with decreasing water transmittance. However, one single lamp system showed higher fluences than predicted by the calculation. This has been proven to be caused by reflection of the UV radiation at the wall of the irradiation chamber, as we reported previously (16).

The results of the type-test establish an approved range of application for each UV plant. Keeping to the three operating parameters (water flow, reference irradiance and UV-253.7 nm transmittance of the water) -- given by this approved range -- ensures a REF of 400 J/m² during operation and therefore a safe drinking water disinfection.
Table 1. Selected representative data of the biodosimetric type-testing of commercial UV plants from several manufacturers in comparison with dose values calculated by the manufacturer. UV plant A is a single lamp system, plants B, C, D, E and F are multiple lamp systems equipped with lamps of different wattage.

<table>
<thead>
<tr>
<th>flow [m³/h]</th>
<th>water transmittance [% 253.7 nm; 100 mm]</th>
<th>( E_{\text{REF}} ) at 253 nm [W/m²]</th>
<th>( R\text{EF}^{**} ) [J/m²], measured</th>
<th>UV fluence [J/m²], calculated by the manufacturer</th>
<th>Difference between calculated and measured UV fluence [J/m²] %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UV PLANT A</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.8</td>
<td>34</td>
<td>32</td>
<td>524 ± 10</td>
<td>420</td>
<td>+25</td>
</tr>
<tr>
<td>3.1</td>
<td>52</td>
<td>36</td>
<td>566 ± 13</td>
<td>420</td>
<td>+35</td>
</tr>
<tr>
<td>3.4</td>
<td>73</td>
<td>42</td>
<td>622 ± 12</td>
<td>450</td>
<td>+38</td>
</tr>
<tr>
<td><strong>UV PLANT B</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>35</td>
<td>24</td>
<td>366 ± 5</td>
<td>450</td>
<td>-18</td>
</tr>
<tr>
<td>33</td>
<td>74</td>
<td>42</td>
<td>393 ± 8</td>
<td>500</td>
<td>-21</td>
</tr>
<tr>
<td>57</td>
<td>74</td>
<td>42</td>
<td>289 ± 16</td>
<td>350</td>
<td>-17</td>
</tr>
<tr>
<td><strong>UV PLANT C</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>29</td>
<td>21</td>
<td>493 ± 3</td>
<td>700</td>
<td>-29</td>
</tr>
<tr>
<td>85</td>
<td>48</td>
<td>33</td>
<td>440 ± 15</td>
<td>570</td>
<td>-23</td>
</tr>
<tr>
<td>126</td>
<td>74</td>
<td>45</td>
<td>516 ± 18</td>
<td>570</td>
<td>-9</td>
</tr>
<tr>
<td><strong>UV PLANT D</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>157</td>
<td>25</td>
<td>17</td>
<td>392 ± 10</td>
<td>443</td>
<td>-12</td>
</tr>
<tr>
<td>203</td>
<td>40</td>
<td>28</td>
<td>374 ± 12</td>
<td>465</td>
<td>-20</td>
</tr>
<tr>
<td>404</td>
<td>90</td>
<td>110</td>
<td>450 ± 9</td>
<td>340</td>
<td>+32</td>
</tr>
<tr>
<td><strong>UV PLANT E</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>11</td>
<td>9</td>
<td>317 ± 7</td>
<td>584</td>
<td>-45</td>
</tr>
<tr>
<td>71</td>
<td>36</td>
<td>23</td>
<td>388 ± 14</td>
<td>529</td>
<td>-27</td>
</tr>
<tr>
<td>115</td>
<td>80</td>
<td>61</td>
<td>432 ± 5</td>
<td>466</td>
<td>-7</td>
</tr>
<tr>
<td><strong>UV PLANT F</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>10</td>
<td>15</td>
<td>394 ± 8</td>
<td>816</td>
<td>-52</td>
</tr>
<tr>
<td>60</td>
<td>50</td>
<td>39</td>
<td>411 ± 9</td>
<td>683</td>
<td>-40</td>
</tr>
<tr>
<td>90</td>
<td>80</td>
<td>65</td>
<td>447 ± 9</td>
<td>584</td>
<td>-23</td>
</tr>
</tbody>
</table>

\( *E_{\text{REF}} \) ... Reference Irradiance

\( **R\text{EF} \) ... Reduction Equivalent Fluence (253.7 nm)
The described biodosimetric method is well suited to clarify further important questions such as the influence of reflection due to the material of the inner surface within the irradiation chambers (16), the influence of water transmittance and lamp intensity (17) or the influence of fluence distributions due to the hydraulic behavior of the water flow (6). Moreover, this method can be used to optimize UV disinfection plants helping to save costs of both, material and energy and to evaluate model calculations of the disinfection capacities of UV systems.

CONCLUSIONS

- Reliable data on UV fluence measurements in flow-through systems can only be obtained by biodosimetric methods and not by manufacturers' mathematical models as used so far (Table 1).
- For the safe UV disinfection of water a Reduction Equivalent Fluence REF of 400 J/m² has to be applied and three parameters have to be considered:
  - water flow (m³/h)
  - water transmittance (wavelength 253.7 nm; 100 mm)
  - reference irradiance E*REF (W/m²)
- For commercial UV plants the approved values for these three parameters have to be determined by a type-test and controlled during the disinfection process in the water works.
- Since February 1996 all these requirements have been fixed in the Austrian National Standard M 5873 and the first test stand for UV plants was established. The revised version "Plants for the disinfection of water using ultraviolet radiation - Requirements and Testing - Part 1: Low pressure mercury lamp plants" will be finished this year. An Austrian Standard on the use of medium pressure mercury lamps is in full progress.
- In the last 5 years we performed type testing of more than 30 commercial UV plants from several European manufacturers. Each UV plant, which meets the requirements stated above, are certified by the ÖVGW and obtains an approved range of application.

REFERENCES

Use of UV radiation for disinfection of foods is discussed. Topics considered include: advantages of low vapor pressure mercury UV sources (emit most of their energy within the far UV range, relatively cheap, long service lives, run at low operating temp.); effects of germicidal UV wavelengths (253-265 nm) on cell DNA; estimation of UV doses required to achieve a desired level of disinfection; factors affecting cell survival and resistance to UV treatment; UV absorption effects; techniques for measuring UV doses; estimating UV intensity; surface shielding effects; undesirable effects of UV treatment (can reduce nutritional value or affect appearance of foods); and use of UV in combination with other treatments (such as thermal processing or ozone treatment) to achieve a synergistic disinfection effect.


Recent studies have shown that Cryptosporidium parvum oocysts demonstrate high susceptibility to low dosages of medium-pressure ultraviolet (UV) light. These investigations have raised several questions, which include determination of minimum medium-pressure UV dosages necessary to inactivate C. parvum oocysts, elucidation of differences (if any) between medium- and low-pressure UV light for inactivating C. parvum oocysts, and evaluation of medium-pressure UV effectiveness in inactivating oocysts suspended in poorer quality water. To compare low- and medium-pressure UV, the authors exposed oocysts suspended in deionized water to UV delivered by either medium- or low-pressure UV lamps at bench scale using a collimated beam apparatus. The applied UV dosages ranged from 3 to 33 mJ/cm², and oocyst inactivation was assessed using the neonatal mouse infectivity assay. At 3 mJ/cm², medium-pressure UV showed a 3.4-log inactivation of oocysts, and low-pressure UV showed a 3.0-log inactivation, demonstrating that medium- and low-pressure UV did not differ significantly in inactivating C. parvum oocysts.

**High survival of neustonic zoea of larvae of American lobster Homarus americanus following short-term exposure to ultraviolet radiation (280 to 400 nm),** C.A. Rodriguez, H.L. Brown, and J.F. St-Pierre (Maurice-Lamontagne Institute, Dept. of Fisheries and Oceans Canada, Division of Ocean Sciences, P.O. Box 1000, 850 Route de la Mer, Mont-Joli, Quebec G5H 3Z4, Canada; Dept. d'océanographie, Université du Québec à Rimouski, 310, allée des Ursulines, Rimouski, Québec G5L 3A1, Canada). Marine Ecology, Progress Series: (Halstenbek), 2000, 193:305-309.

Ultraviolet radiation (UV-B = 280 to 320 nm; UV-A = 320 to 400 nm) is harmful to the planktonic early life stages of some marine organisms. In the Gulf of St. Lawrence, Canada, measurements of the diffuse attenuation coefficients have indicated that the maximum depth to which 10% of the surface energy penetrates at 310 nm is 3 m. Thus, organisms residing in this surface layer are exposed to UV radiation. During the summer spawning season (May to September), the first zoeal larval stages of the American lobster Homarus americanus are present in the first 2 m of the water column during the day. Thus, H. americanus larvae are exposed to UV radiation. We incubated stage I larvae of H. americanus under an artificial light source that simulated the irradiance conditions measured at a depth of 1 m in the Gulf of St. Lawrence waters near solar noon. Three spectral exposure treatments were used: (1) UV-B+UV-A+PAR; (2) UV-A+PAR; (3) PAR only. Larvae were irradiated for 4 day (2 h/day) and maintained thereafter under a natural photoperiod (fluorescent lamps) until first molt. Mortality was monitored daily throughout the experiment. There were no differences in mortality amongst the 3 spectral treatments. Larvae began dying at the same time and at the same rate independently of the spectral irradiation that they received. Thus, lobster larvae appear to be tolerant of short (2 h) exposures to UV radiation.

**Simulation of the effects of naturally enhanced UV radiation on photosynthesis of antarctic phytoplankton, A.U. Bracher and C. Wiencke (Alfred-Wegener-Institute for Polar and Marine Research, Postfach 120161, 27515 Bremerhaven, Germany). Marine Ecology, Progress Series: (Halstenbek), 2000, 196:127-141.**

The effects of spectral exposure corresponding to normal and depleted stratospheric ozone concentrations on photosynthesis...
and mycosporine-like amino acids (MAAs) contents of different natural phytoplankton communities were studied in early austral summer 1995/1996 during the JGOFS ANT XIII/2 cruise in the Atlantic Sector of the Southern Ocean. The radiation conditions were simulated in a special solar simulator in which the same sample was incubated under two light regimes differing in UV-B doses. In all phytoplankton samples the quantum yield of electron transport in photosystem II (PSII) decreased after incubation under increased ultraviolet radiation (UVR) levels. Only samples outside of phytoplankton blooms showed a significant lowering of photosynthetic production rate due to enhanced UV-B. Phytoplankton cells within the blooms probably received protection from UV-absorbing MAAs, because only their cells, chains or colonies of phytoplankton communities were large enough to act in combination with MAAs as effective sun screens. In addition, within the blooms, due to shallow upper mixed layers (UMLs) and stability within the water column, cells had probably enough light to maintain turnover rates of repair mechanisms at PSII and induce sufficient MAA synthesis; these processes were able to compensate for the negative effects of UVR. In contrast, the damaging effect on photosynthesis was much more severe on phytoplankton cells outside the blooms; most cells (70 to 90%) here were too small to receive protection from the MAAs present, and UMLs were deep and mixing rates high.

Comparative effects of ambient ultraviolet-B radiation on two sympatric species of Australian frogs, S.D. Broomhall, W.S. Osborne and R.B. Cunningham (Biological Sciences AO8, University of Sydney, 2006, Australia; Applied Ecology Research Group, University of Canberra, Australian Capital Territory, 2601, Australia; Statistical Consulting Unit, Australian National University, Australian Capital Territory, 0200, Australia. Conservation Biology, 2000 14(2):420-427.

Declines have been observed in a number of Australian frog species, many of these at high elevations. Alpine regions in Australia are likely to be particularly subject to increases in ultraviolet-B radiation (UV-B, 280-320 nm) because UV-B levels increase with elevation and because anthropogenic depletion of ozone has been particularly severe in the southern hemisphere. We compared survivorship of embryos and tadpoles of a declining species of frog, *Litoria verreauxii alpina*, with those of a sympatric non-declining species, *Crinia signifera*, under three ambient UV-B treatments, unshielded, control, and UV-B-excluding. Experiments were conducted in artificial water bodies established at three different elevations (1365, 1600, and 1930 m) in the Snowy Mountains of southeastern Australia. The exclusion of UV-B significantly enhanced survival of *L. v. alpina* (declining species) at all elevations. Overall, the probability of dying was highest in the unshielded treatments and lowest under the UV-B-excluding treatment for both species over all elevations. The probability of dying was significantly higher in *L. v. alpina* than in *C. signifera* for a given UV-B treatment at the two highest elevations. Our results support the hypothesis that ultraviolet radiation is likely to be a contributing factor in the disappearance of *L. V. alpina* at high elevations in southern Australia.


A number of photochemical and non-photochemical advanced oxidation processes were employed for the treatment of simulated dyehouse effluents containing six commercial reactive dyestuffs and various assisting chemicals at concentrations typically found in the textile dyeing and rinsing process stages. Effects of oxidant (H$_2$O$_2$) and catalyst (Fe$^{2+}$-ion) dose on decolorization kinetics, reduction in UV$_{254}$ nm and DOC were evaluated for each oxidation process. Treatment efficiencies also were assessed in terms of EE/O and EE/M values to compare electrical energy requirements of the investigated AOPs. UV-light assisted treatment processes were found more effective in DOC and UV$_{254}$ nm removal, whereas the non-photochemical O$_2$/OH$^-$ and O$_2$/H$_2$O$_2$ oxidation systems were significantly faster in decolorization of the dyehouse effluent than the H$_2$O$_2$/UV treatment process. Results clearly revealed that once optimal reaction conditions were established, the inhibiting effect of the complex wastewater matrix could be overcome and dyehouse effluent ingredients degraded successfully by all examined AOPs at feasible treatment times and electrical energy consumption.
Upcoming Meetings

Meetings With IUVA Involvement

2000 Meetings

Wasser Berlin 2000, Berlin, Germany, October 23-27, 2000 – IUVA is invited by the IOA (International Ozone Association) to participate in the technical program. Contact: IUVA, Ayr, ON, Canada (see p. 3 insert) or IOA, EA3G office, 83 Av Foch, F-75116 Paris, France, Tel: +33 1 53 70 13 58; Fax: +33 1 53 70 13 40; e-mail: IOA_Paris@compuserve.com. See Preliminary Program in IUVA News issue #1/2000. See Final Program (UV papers only) in IUVA News issue #4/2000.

2001 Meetings

First International Congress on UV Technologies, Washington, DC, June 14-16, 2001 – Hyatt Regency Hotel (downtown DC, adjacent to Washington Convention Center). See Call for Papers elsewhere in this issue.

Meetings Of Other Organizations

2000 Meetings


Watertech '2000 Microelectronics Water, Portland, OR, USA, Nov. 13-15, 2000. Contact: Miriam Slejko, Tel: 303-973-6700; Fax: 303-973-5327; water@talloaks.com; www.talloaks.com


AWWA Water Quality Technology Conference, Salt Lake City, UT, USA, Nov. 5-8, 2000. Contact: AWWA, 6666 West Quincy Ave., Denver, CO 80235. Tel: 303-794-7711.


AquaTech Latin America 2000, Porto Alegre, Brazil, Dec. 3 - 8, 2000. Contact: Boston RAI, Tel: +1-978-922-7707; Fax: +1-978-922-1191. E-mail: homero@bostonrai.com www.aquatechrai.com


2001 Meetings


Third NSF International Symposium and Technology Expo on Small Drinking Water and Wastewater Systems, Washington, DC, April 22-25, 2001. Contacts: Cherrioe Bacon, NSF International, 789 Dixboro Road, Ann Arbor, MI, 48105; Tel: 734-827-6865; Fax: 734-827-6831; E-mail: bacon@nsf.org
Lighting the way in

ultraviolet technology

For over 50 years, Ultra Dynamics has been the source of illuminating ultraviolet solutions for industry. We have developed superior systems for disinfection and oxidation, for use with reverse osmosis, ultrafiltration, deionization, TOC reduction, ozone destruction, and other processes. We have met the highly specific requirements of critical applications ranging from ultrapure water, to HVAC, to marine, to offshore oil rigs. In ultra-reliable treatment of water and wastewater, the ultra-violet technology of Ultra Dynamics really shines.
Introduction

Ideally, quality drinking water should not require disinfection. However disinfection must be present and safely work in any case where pathogens in drinking water may potentially occur. An ideal disinfection procedure should always be actively present, but should never lead to detrimental modifications of drinking water constituents. This is the case with disinfection using ultraviolet light (UV-disinfection).

Action Mechanism of UV-Disinfection

UV-radiation of wave length between 240 and 290 nm penetrates the cell (due to Beer’s Law the small diameter of pathogens of less than 20 nm is hardly a barrier for UV light) and causes dimerization of adjoining uracil bases in the DNA, respectively the RNA double helix in the cell nucleus. When numbers of dimers exceed beyond enzymatic repair, the cell is no longer able to divide and to multiply and the organism which is elsewhere intact will die.

Unlike UV-disinfection, chemical disinfectants attack the cell wall and the cell content (protoplasm), leading to cell destruction and thus to killing of the organism.

Chemical disinfectants also react with substances present in the water. On one hand disinfectants are consumed and thus no longer are available for disinfection in the dosed concentration; on the other hand these reactions lead to potentially health hazardous, or at least undesired disinfection by-products such as, for instance, chlorinated compounds.

UV-absorbing substances in the water, measured as spectral attenuation coefficient at 254 nm ( SATC-254), attenuate UV-light in such a way that higher irradiance is needed for disinfection. However no by-products are produced and only if irradiance is hundreds to thousands of times higher than required for disinfection may any measurable modifications be expected.

Verification and Monitoring of Disinfection Efficiency

Disinfectants added to the water may be measured as residual concentration after a certain reaction time, but an application of UV radiation sufficient for disinfection cannot be determined as a residual or as a modification of the water. UV light is generated in the UV-reactor and acts merely within the irradiated volume passed by the water. This process must be instantly monitored. There is no standard design for UV-reactors which could guarantee a sufficient disinfection performance. Influences on the generation and distribution of UV light in the reactor need to be monitored together with the flow rate. Only this means can ensure that the conditions under which disinfection performance has been successfully validated by biodosimetric type-testing be monitored and maintained during application.

Influences on UV Disinfection Technology

Two factors play a decisive role with UV disinfection: radiation intensity (irradiance -- fluence rate) and irradiation time (radiant exposure – fluence). Each microorganism when passing through the irradiation chamber shall be exposed to a fluence of at least 400 J/m² to guarantee an inactivation of more than 4 decimals.
UV-light must be produced and transferred into the water in the reactor. It is generated by electric discharge in bar-shaped UV lamps. These must not come into contact with water and therefore are located in protective sleeves (see Figure 2).

![Figure 2. Schematic of a UV unit.](UVsys.bmp)

Propagation of UV-light and intensity distribution within the reactor is very complex. It is being absorbed, diffracted, reflected and scattered on its way from the lamp through the protective sleeve and in the water. Merely propagation reduces intensity. When passing the reactor, flow patterns occur which locally differ very much and are also subject to considerable fluctuations. These flow patterns become more complicated by asymmetric currents at the entrance. Thus UV light intensity and detention times differ locally and are not constant over time.

To ensure that potentially present pathogens are exposed for a sufficient length of time to the UV light, it must be made sure that the water passes through the complicated irradiation field in such a way that each volume increment can accumulate sufficient UV light such that the integral of the product of local fluence rate and residence time gives a fluence of at least 400 J/m³.

**Need for a biodosimetric test**

To achieve sufficient disinfection performance an inactivation by 4 decimals or 4-log steps is required. Already a very small partial volume of 0.1% with insufficient fluence counteracts this requirement, even if the calculation may suggest sufficient radiant exposure. Even very sophisticated calculation models at their best allow only to achieve a good reactor design. Calculation cannot prove sufficient disinfection efficiency. Only a biodosimetric test using appropriately sensitive microorganisms can approve disinfection performance of UV systems under specified conditions (flow rate, water quality, state of the reactor, etc.).

**Need for Monitoring**

The state of the reactor, which includes also UV lamps, undergoes changes. For instance, UV radiation is never constant but depends on, amongst others, temperature, voltage, lamp age and UV absorbing layers on the lamp sleeves. Moreover lamps may not ignite or fail. Also, UV absorbance of the water is not constant. Compared to visible light, UV light is much more absorbed by constituents of the water; therefore changes in the water and buildup of deposits on the sleeves cannot be detected visually.

Therefore, an uncomplicated and reliable monitoring is required to ensure that conditions, for which sufficient disinfection performance has been validated, are also met during application. This monitoring must include:

1. all to be in normal electrical operation condition (lamp monitoring)
2. all lamps to have the same age (service time recording)
3. maximum flow to be maintained (flow monitoring or flow rate limitation)
4. irradiation conditions in the reactor to be better or equal as during biodosimetric testing (irradiance monitoring)

Items 1 through 3 can be easily monitored by conventional means. Monitoring irradiance, however, requires a standardized monitoring window and UV sensors with specified optical and mechanical properties that allow reproducible measurements. Continuous monitoring UV system sensors must be counterchecked in regular intervals with a handheld reference measuring instrument.
with the UV sensor of the reference meter to be inserted into the monitoring window instead of the system's sensor (see Figure 3). This procedure is similar to measurements of residual chlorine.

With type-tested UV systems, one or several pairs of values for maximum flow rate and minimum irradiance are supplied which are engraved on the nameplate and which are to be monitored by the control unit.

The essential difference beyond measurement of residual chlorine content is that the residual chlorine content has been fixed by the German Drinking Water Directive to be between 0.1 and 0.3 mg/L at end of treatment, whilst in case of UV disinfection different minimum irradiance values must be met depending on the specific unit and operation conditions. Automatic monitoring, however, ensures that pre-alarm signals are triggered before water flow is being interrupted in case the disinfection performance is no longer sufficient.

Figure 3. UV sensor with monitoring window and handheld read out according to DVGW standard W 294.

Monitoring and testing

To safely use UV disinfection, a standardized on-line irradiance measurement must be available along with a test procedure that gives evidence that disinfection performance equal to a fluence of 400 J/m² is met under maximum flow and minimum irradiance. Both these requirements are met since the publication of the DVGW standard W 294 ,,UV-disinfection systems for drinking water supply- requirements and testing , in October 1997. At the same time the DVGW testing laboratory for UV disinfection systems was established at Wahnbachtal-sperrenverband in Siegburg near Bonn. The testing facilities allow biodosimetric tests of UV systems with flow rates up to 3,000 m³/h (Figure 4).

DVGW Standard W 294

Based on experiences made with testing of UV systems, a revised version of DVGW standard W 294 is in preparation. The future title will read : DVGW standard W 294 ,,UV Systems for Disinfection in Drinking Water Supplies". The document will be subdivided into three parts :

Part 1 ,,Requirements for Equipment and Operation of UV Systems ,
Part 2 ,,Testing of Technical Functions and Disinfection Performance ,
Part 3 ,,UV-Sensors for Monitoring of UV Systems - Requirements and Testing

Figure 4. Testing facility with a 3,000 m³/h UV-disinfection system.
Part 1 will provide information for the use and the monitoring of UV-systems, amongst others advice for system selection with respect to flow rate and water quality using application tables and operation specifications to control for flow rate and minimum irradiance. It is stated that lamps and sleeves must be specified and marked to prevent misuse during replacement. Furthermore, instructions are given for installation, regular checks, cleaning and maintenance.

Part 2 is addressed to testing laboratories and manufacturers of UV systems. Test procedures and evaluation of test results are described in this part as well as test equipment.

In this context a special issue of the testing procedure shall be explained: The test is independent with respect to the type of the UV light source used. This implies that for appropriate monitoring the only need is to use system sensors with a spectral response adapted to the emission of the lamp type used (at present low pressure and medium pressure mercury lamps), the properties of which are set out in part 3. This approach ensures that UV systems with novel UV light sources can be tested in the same way and that merely the properties of the sensors they require must be described and verification be specified per an appendix to part 3. In specific cases it may be sufficient to compare reference monitoring of new lamp types to existing sensor types.

Part 3 is going to extend the existing mechanical specifications of UV sensors for on-line monitoring and reference measurements that are inserted into the standardized monitoring windows on the UV reactor. Detailed indications will be given for optical properties and their validation. According to the use with specific UV light sources, requirements for system sensors with respect to spectral selectivity will be different and need to be adapted to certain lamp types. The most simple type are sensors for Hg-low pressure lamps.

Conclusion

UV disinfection has become a practical and safely validatable disinfection procedure by specifying the requirements for testing and monitoring in DVGW standard W 294. A standardized biodosimetric testing procedure and monitoring with standardized UV sensors is introduced and successfully applied. On-line monitoring of irradiance can be counterchecked with handheld reference sensors and makes it possible that UV systems can be used for drinking water disinfection with the same level of confidence and safety as in conventional chemical disinfection.

References


UltraViolet Devices, Inc.

- Systems & Components for Air and Water Disinfection
- Technology Leader
- ISO 9001 Certified
- FDA-QSR Compliant Class II Manufacturer
- Concept Design, Development & Validation
- Power Supply Design/Test
- Proprietary Lamp Fabrication
- UV Lamp
- Authorized Distributor Philips UV Lamps
After 19 months of deliberative discussions and negotiations, the U.S. EPA's Microbial/Disinfection ByProducts Advisory Committee has reached agreement on language with respect to UV technologies in drinking water treatment to be included in regulations scheduled for proposal in May 2001. This language is reprinted at the end of this article.

Background


The current regulations under development are intended to address complex risk trade-offs between the two different types of contaminants (microbial and disinfection byproducts). In keeping with a phased M-DBP strategy agreed to by stakeholders during the 1992-93 negotiated rulemaking on these matters and affirmed by Congress as part of the 1996 Amendments to the Safe Drinking Water Act, EPA issued the final Stage 1 Disinfectants and Disinfection Byproducts Rule (DBPR) and Interim Enhanced Surface Water Treatment Rule (IESWTR) in December 1998. These two rules built upon stakeholder agreements reached in 1993 but also reflected the more recent 1997 Agreement in Principle signed by stakeholders who participated in an intensive Stage 1 M-DBP Federal Advisory Committee Act (FACA) negotiation process from March 1997 to July 1998.

As part of the 1996 amendments to the SDWA, Congress established deadlines for the M-DBP rules, beginning with a November 1998 deadline for promulgation of both the IESWTR and the Stage 1 D/DBP Rule. Related statutory deadlines for the Stage 2 M-DBP process require that EPA promulgate a Stage 2 Disinfectants and Disinfection Byproducts Rule (DBPR) by May 2002. The Agency plans to promulgate the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) by May 2002, as well. The central challenge of the Stage 2 M-DBP rule development process has been to assess information and research not fully considered in the Stage 1 process or only available since 1998 and evaluate whether and to what degree EPA should establish revised or additional DBP and microbial standards to protect public health.

As agreed to during Stage 1, EPA has convened a Stage 2 M-DBP Advisory Committee made up of organizational members (parties) named by EPA. The purpose of the Advisory Committee is to develop recommendations for the Stage 2 DBPR and LT2ESWTR to be proposed in 2001. This Committee met from March 1999 through September 2000, with the initial objective to reach consensus. The Agreement in Principle document is the Committee’s statement on the points of agreement reached.

Why is not the IUVA formally represented on the M/DBP Advisory Committee? Recall that the IUVA was not formed officially until June 1999, by which time the M/DBP Advisory Committee had been constituted. Additionally, and as will be pointed out later, the U.S. water treatment community had not viewed UV as a potentially major player until EPRI/WWARF-sponsored research showed UV to be quite capable of inactivating Cryptosporidium parvum oocysts.

On the other hand, IUVA is represented on the M/DBP’s Technical Work Group (the TWG) by Dr. James Bolton, IUVA’s Executive Director. Additionally UV’s interests are represented on the Advisory Committee itself by the WWEMA (Water and Wastewater Equipment Manufacturer’s Association) by Charles Reading, Jr., and Gary Van Stone (WWEMA’s Alternate Representative).
Your Editor-in-Chief (and author of this article), having considerable expertise in EPA's regulatory affairs and in ozone technologies, has been involved in the development of EPA's drinking water standards ever since 1972, and served as an Alternate Representative of the International Ozone Association on the M/DBP Advisory Committee. He also has been a member of the M/DBP Technical Work Group for the past three years. Consequently, he has attended more than 90% of the M/DBP Advisory Committee and Technical Work Group meetings over the past eight years.

During the period March 1999 to the present (September 2000), the view of the stakeholder parties with respect to ultraviolet radiation for potable water treatment has changed rapidly and dramatically. In the early days of negotiations, there was little knowledge on the Committee or in the TWG and/or understanding of the role(s) of UV in potable water treatment. However, with the relatively recent confirmation that UV radiation can inactivate Cryptosporidium parvum oocysts when efficacy is determined by animal testing, all that has changed. At present, the Committee has accepted the potentials for UV in water treatment for oocyst inactivation, but still has some nagging questions and uncertainties regarding the practical application(s) of UV for potable water treatment, particularly for large scale systems. Hence the UV language recently agreed upon.

When reading the UV language, it is important to keep in mind that this language is recommended to EPA to be used when the Stage 2 M/DBP rules are proposed in May 2001. At that time, comments from the public will be solicited, and any members of the UV community will be free (and welcomed) to submit any comments and data to support possible proposed changes in language at that time. The new regulations are scheduled for promulgation in May 2002.

**UV Language Agreed Upon**

5.0 **Ultraviolet Light**

5.1 Based on available information, EPA believes that ultraviolet (UV) disinfection is available and feasible. However, information is needed in order to clarify how UV disinfection will be used as a tool for compliance with the proposed LT2ESWTR. Issues of particular importance include engineering issues like: hydraulic control, reliability, redundancy, monitoring, placement of sensors, lamp cleaning and replacement, and lamp breakage, as well as confirmation of the information underlying EPA's assessment that UV is available and feasible.

5.2 Concurrent with publication of the proposed rules, EPA will publish the following:

5.2.a Tables specifying UV doses (product of irradiance \(I\) and exposure time \(T\)) needed to achieve up to 3 logs inactivation of *Giardia lamblia*, up to 3 logs inactivation of *Cryptosporidium*, and up to 4 logs inactivation of viruses.

5.2.b Minimum standards to determine if UV systems are acceptable for compliance with drinking water disinfection requirements. These standards will address the following:

1) A UV Validation Protocol to be established for drinking water applications of UV technology. Protocol to be premised on post-filter application of UV. Protocol will include the following:

   a) Water quality criteria and site specific performance demonstration requirements for alternative placement of UV treatment in WTP (water treatment plants).

   b) Demonstration of adherence with the UV dose tables for inactivation per the identified protocols

   c) Testing of UV reactors to validate performance under worst case conditions (These independent testing protocols would necessarily encompass a range of worst case conditions appropriate to the range of WTPs that must comply with the LT2ESWTR).

   d) Minimum UV sensor performance characteristics (e.g. accuracy, stability, sensitivity).

2) Description of on-site monitoring required to ensure ongoing compliance with required dose, including necessary testing and calibration of UV sensors.

5.2.c UV Guidance Manual, the purpose of which is primarily to facilitate design and planning of UV installations by familiarizing State/Primacy Agencies and utilities with important design and operational issues, including:

---

1 The FACA Committee recommends that EPA analyze the Deutscher Verein des Gas und Wasserfaches (DVGW) Technical Guidelines W 294 in developing the validation protocol.
Redundancy, reliability and hydraulic constraints in UV system design including design limitations with respect to plant/pipe size

2) Design considerations to account for water quality (e.g., UV absorbance, turbidity), lamp fouling and aging

3) Appropriate operations and maintenance protocols to ensure performance of UV lamp (e.g., sleeve cleaning systems).

4) Recommendations for water systems when soliciting UV disinfection systems to ensure conformance to criteria described under 5.2.b.

5) Instructions on routine equipment and water quality monitoring practices used to assure reliable UV performance over time.

5.3 The availability of UV disinfection is a fundamental premise of this Agreement in Principle. The FACA (Committee) recommends that EPA incorporate into the final LT2ESWTR provisions in 5.2 that will facilitate the approval of UV technology by Primacy Agencies. EPA agrees in the proposed LT2ESWTR to request comment on which criteria should be incorporated into the final LT2ESWTR.

5.4 EPA agrees to publish revised IT tables and revised guidance manuals as part of the final LT2ESWTR that reflect comments on earlier drafts.

5.5 EPA agrees to conduct a stakeholder meeting during the comment period for the proposed LT2ESWTR to update stakeholders on a range of issues including the status of UV and any outstanding guidance manual issues.

5.6 If EPA identifies substantial new information related to the availability or feasibility of UV, EPA agrees to publish this information in a NODA (Notice of Data Availability). If EPA determines that this information significantly impacts the basis for provisions in this agreement, EPA agrees to reconvene the FACA (M/DBP Advisory Committee) to address feasibility and availability of UV.

Comments

All of this is very good news for UV technology. And the fact that the IUVA is now available to the EPA (and others) as a formal association for advancing the understanding and acceptance of UV technologies means that we will be involved in the development of the items EPA has agreed to publish - e.g., IT tables, minimum standards to determine compliance acceptability for UV, a UV validation protocol (recommended to be patterned after the German DVGW Technical Guidelines W 294), and a UV Guidance Manual. Additionally, EPA will convene a stakeholder meeting during the Stage 2 M/DBP rules comment period (after May 2001) to update stakeholders on a range of issues, including the status of UV and any outstanding Guidance Manual issues, and to reconvene the FACA M/DBP Advisory Committee, if necessary, to address feasibility and availability of UV technologies.

When this Editor considers that in March 1999 there was (a) no IUVA and (b) no consideration being given to the potentials of UV in developing EPA’s Stage 2 drinking water regulations - we can now say with impunity,

UV – you’ve come a long way baby!!
Calgon Carbon's Sentinel™ System Is

Shattering the Myths

ABOUT UV DISINFECTION

Calgon Carbon Corporation, one of the most trusted names in drinking water treatment, has the facts about UV Disinfection:

**THE MYTHS ABOUT UV**

1. Ineffective for cryptosporidium and giardia disinfection.
2. Strictly for small groundwater systems.
3. Too large to fit into a typical filtration plant.
4. Unreliable.

**THE STRAIGHT, PROVEN FACTS**

1. New research shows that Calgon Carbon's Sentinel™ UV Disinfection System is effective—at very low UV doses—for cryptosporidium and giardia.
2. New surface water regulations now require increased microbial control and decreased disinfection by-products (DBPs). Sentinel™ provides a complete microbial barrier with no DBP formation.
3. Unlike large multi-lamp systems, Sentinel™'s compact design provides the highest possible UV-power-to-footprint ratio for drinking water applications—especially for a surface water treatment plant pipe gallery.
4. Sentinel™ delivers reliability with its patented Quickwipe™ quartz cleaning technology; the latest in UV sensing and monitoring equipment; and proven, robust electromagnetic power supplies.

Now EPA/NSF/ETV Verified for Crypto Inactivation

UV Dose Response for Protozoa, Bacteria, Viruses

Need more information about the Sentinel™ UV Disinfection System? Call Calgon Carbon Corporation at

1-800-422-7266
 VALENCIA, CA -- August 2000 -- Aquafine Corporation now offers custom-engineered UV water treatment systems that meet the toughest purity standards for industrial water treatment. Designed for applications where multiple UV units are required, Aquafine skid systems combine several UV treatment chambers and electrical enclosures into one turnkey system, saving valuable floor space. This compact design is particularly useful in semiconductor ultrapure water systems where TOC levels in the 0.5 ppb range are required. The systems are also well suited for biotechnology, pharmaceutical, and beverage applications.

"Without question, new semiconductor Fabs want their ultrapure water systems on line fast to ensure increased wafer yield production," states Michael J. Murphy, president of Aquafine Corporation. "By providing a customized turnkey UV system, we can design it specifically to work within an allotted space, provide the proper flow rate and correct UV dosage for the process intended and save valuable installation and set-up time."

The skid-mounted systems feature compact control cabinets that house Aquafine's Aqualogic 2000™ controls, which provide continuous, detailed UV system feedback, including absolute real time UV intensity measurement for validation and audited production processes. The system may be configured to be monitored from any desktop via the 4-20 mA output signal. Total access to UV intensity, temperature, lamp status, running time and cycle count is available via PC.

As with all Aquafine products, these customized systems employ state-of-the-art manufacturing processes such as T-drill connections and orbital welding that ensures longevity and purity. Manifolds, valves, and sample ports are all designed to customer specification.

Contact: Aquafine at 25230 West Avenue Stanford, Valencia, CA, 91355, call (661) 257-4770 or (800) 423-3015, fax (661) 257-2489, email sales@aquafineuv.com or visit them on the web at www.aquafineuv.com.

Send for your FREE copy of the Booklet "Ultraviolet Applications Handbook" by James R. Bolton, Ph.D.

Bolton Photosciences Inc.

Offering consulting and research services in:
- Ultraviolet technologies;
- Ultraviolet disinfection;
- Advanced Oxidation destruction of pollutants in contaminated waters;
- UV lamp testing.

92 Main St., Ayr, Ontario, Canada N0B 1E0
Tel: 519-741-6283; Fax: 519-632-8941
Email: jbolton@boltonuv.com
Aquafine Corporation custom-engineered UV water treatment system for industrial water treatment.

With water quality standards becoming increasingly stringent, UV treatment provides the answer by destroying microorganisms without the assistance of chemicals, which leave harmful byproducts. The USD series is recommended for use in any ultrapure application with stringent quality or performance criteria such as those of the FDA, cGMP, and 3A/USDA. All 10 standard models can be configured for TOC level reduction, as well as disinfection, chlorine destruction and ozone destruction. They range from 40 to 630 GPM (9.1 to 143.2 m³/h) and will serve most medium flow rate processes.

The USD series employs state-of-the-art manufacturing processes such as T-drill connections and orbital welding that ensure longevity and purity. Sanitary inlet/outlet connections are standard on all units and sanitary ferrule end plates replace the normal bolted and threaded design. Aquafine's Aqualogic 2000™ microprocessor control system provides continuous, detailed UV system feedback, including absolute real time UV intensity measurement for validation and audited production processes. The unit may be configured to monitor the system from any desktop via the 4-20 mA output signal. Total access to UV intensity, temperature, lamp status, running time and cycle count is available via PC.

Contact: Aquafine at 25230 West Avenue Stanford, Valencia, CA, 91355, call (661) 257-4770 or (800) 423-3015, fax (661) 257-2489, email sales@aquafineuv.com or visit them on the web at www.aquafineuv.com.

Aquafine UV Water Treatment Systems
Chosen for World's Largest Semiconductor Fab

Valencia, CA – August 30, 2000 – Aquafine Corporation has been named supplier for the UV water treatment equipment for the new Chartered Semiconductor Manufacturing (CSM) Fab 7 in Singapore. This $2.1 billion
A semiconductor fab is said to be the largest in the world and is expected to be operational by mid-2001. Aquafine will supply their next-generation TOC level reduction UV systems. "Aquafine TOC level reduction units are perfect for an application such as this. Deploying powerful, high-intensity UV lamps, the units are able to oxidize trace organics into free radicals and carbon dioxide, which are easily removed by ion exchange resins and/or degasifiers," says Mike Murphy, president of Aquafine.

The CSMC fab will be equipped to support advanced manufacturing process technologies. The clean room alone will be approximately 170,000 square feet, making it one of the largest eight-inch wafer fabrication centers in the world. This is the second Singapore fab, in recent months that has specified Aquafine's UV systems.

Aquafine Corporation, founded in 1949, is the world's leading manufacturer of ultraviolet water treatment equipment for pure and ultrapure applications and supplies UV equipment to semiconductor manufacturers worldwide. Aquafine meets or exceeds the most stringent specifications in a variety of industries ranging from semiconductor to biopharmaceutical, food and beverage to power generation. For more information, contact Aquafine at 20910 Avenue Paine, Valencia, CA, 91355, call (661) 257-4770 or 800/423-3015, fax (661) 257-2489, email sales@aquafineuv.com or visit them on the web at www.aquafineuv.com.

Aquafine Wins Contract for First U.S. Water Treatment Plant to Credit Cryptosporidium Inactivation

ERLANGER, KY -- The City of Henderson, Nevada recently awarded Aquionics Inc. the contract for a project that will make the city's drinking water treatment plant the first surface water plant in the United States designed for Cryptosporidium inactivation with approval from the State and the U.S. EPA.

"We are excited about utilizing this technology," says Mike Morine, Project Engineer for the City of Henderson. "We take our commitment to the health and safety of our residents very seriously, and we are implementing this project to provide the best possible disinfection for our community."

Based in Erlanger, Kentucky, Aquionics was selected following an international search conducted by the City of Henderson, in conjunction with the Nevada State Health Division and the engineering firm CH2M HILL. Scheduled for completion in 2001, the Aquionics ultraviolet (UV) disinfection system will provide at least 99 percent inactivation of Cryptosporidium oocysts, the infective stage of the organism which is resistant to chlorine. The Henderson plant treats up to 18 million gallons of water per day from nearby Lake Mead. Four Aquionics Photon units (manufactured in the UK by Hanovia Limited), allowing for 33 percent redundancy, will provide UV disinfection at the Henderson plant.

Cryptosporidium is a single-celled parasite that invades the human digestive and respiratory systems, causing cryptosporidiosis. While the disease is often asymptomatic, intestinal cryptosporidiosis can cause severe diarrhea lasting two to four days in adults or up to four weeks in children.

During a 1993 outbreak in Wisconsin, according to EPA reports, approximately 400,000 people contracted cryptosporidiosis. More than 4,000 people were hospitalized, and at least 50 deaths were attributed to the disease. Other recent U.S. outbreaks have been reported in Georgia, Nevada and Oregon.

UV disinfection is among only a few proven methods for rendering Cryptosporidium harmless, and it does so without the use of chemicals. UV light has been used successfully for disinfection of industrial process water and municipal effluent worldwide and for drinking water treatment in Europe for many years. Recent research documenting the effectiveness of UV disinfection against Cryptosporidium oocysts and Giardia cysts has made the technique a powerful and cost-effective alternative to ozone disinfection and other methods for water treatment.

Aquionics Inc. is a market leader in UV technology for progressive, non-chemical disinfection and contamination control. A member of the international environmental corporation HALMA plc, Aquionics offers nearly 20 years experience in the manufacture, application and development of UV equipment.

For more information about Aquionics and its family of products, call the company's U.S. headquarters at 1-800-925-0440.

Independent Tests Show UV to Be Effective Against Cryptosporidium

Independent tests, commissioned by Hanovia Limited and carried out by Clancy Environmental Consultants, Inc., have shown ultraviolet (UV) technology to be highly effective at destroying the waterborne parasite Cryptosporidium parvum. Cryptosporidium is a protozoan parasite commonly found in the waste of farm animals. Four species are recognized, with
Cryptosporidium parvum being the species responsible for causing cryptosporidiosis, a gastrointestinal illness in humans and animals. Cryptosporidium oocysts get into the water supply by surface water run-off -- it is estimated by the American Water Works Association (AWWA) that the organism is present in 95% of all surface water in America. The oocysts are impervious to chlorine disinfection and the most effective methods of control known to date are ozonation and/or filtration.

The tests evaluated the inactivation of C. parvum oocysts from recreational water by the Hanovia UVP61 system, and were completed in November 1999. Recreational water inoculated with C. parvum oocysts was passed through the UVP61 system and subsequently given to laboratory mice. Non-UV-treated water was given to different mice as a control.

Tissue samples taken a week later from all the mice showed a significant percentage of the control animals to be infected with C. parvum, while no infection was detected in any of the mice given UV-treated water, regardless of UV dose. Calculations showed that at least a 4.4 log-inactivation of oocysts was achieved by the UVP61 system at all UV doses tested.

These results agree with those found in a study by Clancy et al. [1], which reported >4.5 log inactivation of oocysts with medium pressure UV doses of 3 to 81 ml/cm². This demonstrated effectiveness of UV is significant in view of the findings of Carpenter et al. [2], that chlorine is not effective against Cryptosporidium in recreational water.

The results also are significant in the light of the new DWI (Drinking Water Inspectorate) regulations in the UK, demanding continuous monitoring of high-risk water sources for Cryptosporidium, which came into effect on 31st March this year (2000). A full copy of the Clancy results can be obtained from Hanovia Limited (tel: +44 1753 515300; e-mail: sales@hanovia.co.uk).

References
European strategy largely implemented

Mr. Klink stressed that the moves taken in Italy have all but concluded the European strategy that Wedeco announced at last year’s stock market flotation. He went on to say that the group is represented today in most European countries following takeovers such as those in Austria, England, Spain and now Italy as well as being represented by its own companies via the expansion of locations in Switzerland, Poland and France. He added that in the remaining European countries Wedeco is active with the support of its German parent company and through its representatives.

Focus on overseas in the future

Mr. Klink announced that the focus of future activities would now primarily lie overseas, priorities being chiefly the development of the group’s market position in North and South America and Asia.

He went on to say that early this spring, the U.S. side of operations embarked on an expansion course with a number of acquisitions. According to Mr. Klink, the American subsidiary Wedeco Ideal Horizons, which has its own manufacturing facilities for a complete range of UV disinfection applications, is already firmly established in the North American market, which offers a great deal of potential due to the increasing replacement of chlorination with UV disinfection both in the drinking and wastewater sectors.

Mr. Klink explained that for future expansion in Asia Wedeco will be setting up a Representative Office which will be manned by an experienced manager who will be responsible for production, sales and marketing in these markets and providing support to the local representatives and sales staff. In this manner, the group will be able to fully exploit the opportunities for continued market development that arise.

Ready for the MDAX

Mr. Klink stated furthermore that Wedeco – whose shares are listed from today on the MDAX following a decision by the Working Committee for Share Indices of Deutsche Börse AG – is exceptionally well equipped for this stock exchange market segment. The inclusion in this group of Germany’s 70 most important listed medium-sized businesses is based on Wedeco’s excellent performance, Mr. Klink stressed. The group’s interim turnover of DM 41 million with an increasing backlog of orders is up 52% on last year’s figures and net income, at DM 3.7 million, has increased by as much as 112% over the same period last year.

For further information please contact: Ralf König, Manager Public Relations. Phone: 0049 (0) 211 9519618; FAX: 0049 211 9519630; ralf.koenig@wedeco.net

Please find the original photo (UV-System K Series) at http://www.wedeco.de/news/pressefoto_e.html

ADVANCING UV TECHNOLOGY

LPX200

Ultraviolet Disinfection System

"WORLD'S FIRST SUBMERGED BALLAST"

SELF-COOLING

BALLAST TECHNOLOGY

Increased reliability

Reduced footprint

Reduced operating costs

AUTOMATIC LAMP CLEANING

Enhanced efficiency & lower operating costs

SUPERIOR LAMP TECHNOLOGY

Improved design for increased throughput

MODULAR DESIGN

Flexible modules to suit site-specific installation requirements

SUNTEC environmental

TORONTO • LOS ANGELES • TOKYO

106 Rayette Road, Unit #1 Concord, Ontario Canada L4K 2G3
Phone: 905.669.4450 Fax: 905.669.4451 Email: info@suntecuv.com
Visit our web site at http://www.suntecuv.com
This paper examines issues related to the permitting and use of UV irradiation for wastewater disinfection in Florida. Issues related to high-level disinfection and reuse applications are highlighted.

**Disinfection Requirements**

As shown in Table 1, Florida defines five disinfection levels for various water reuse and effluent disposal options in state rules governing domestic wastewater management (1) and water reuse (2). Of most interest are the basic disinfection requirements, which apply to most surface water discharges and many land application and reuse projects, and high-level disinfection requirements, which apply to some of the most popular reuse activities in Florida (irrigation of residential properties, areas accessible to the public, and edible crops). These rules include relatively detailed design and performance requirements for chlorination systems. Fecal coliforms are used as the indicator organism in the definitions of most disinfection levels.

Florida's disinfection rules (1) note that chlorination offers several disadvantages and encourage alternative disinfection systems. However, no design standards are included for alternative disinfection systems. The fecal coliform, requirements apply to any disinfection system—regardless of the disinfectant used. The result is that any proposal for UV disinfection is evaluated by the Florida Department of Environmental Protection (DEP) on a case-by-case basis. This generally yields a lower level of certainty (or, at least, a perception of reduced certainty) that a permit will be issued for a UV system than would be encountered if the utility had proposed a chlorination system. It is believed that this contributes significantly to the relatively small number of UV installations in Florida.

**High-Level Disinfection Concerns**

Florida's high-level disinfection criteria date back to experimental virus removal work done by Dr. Flora Mae Wellings (3) in support of St. Petersburg's landmark reuse project. She determined that the high-level disinfection criteria were sufficient to ensure production of reclaimed water that was essentially pathogen-free. Subsequent analyses for virus in reclaimed water have demonstrated the ability of the high-level disinfection criteria to produce reclaimed water that is essentially virus-free (4-7).

The original impetus for the inclusion of filtration as part of the high-level disinfection system was for conditioning the water to maximize the effectiveness of the disinfectant for virus inactivation (7). As interest in protozoan pathogens has increased, filtration also has been shown to remove protozoan pathogens (7-8).

The DEP has concluded that chlorination systems designed and operated to meet the high-level disinfection requirements produces reclaimed water that is "essentially pathogen-free" and is safe for the intended, non-potable reuse activities.

Florida does not have extensive experience with UV and other alternative disinfection systems, particularly for high-level disinfection applications. From the public health perspective, the fundamental question that the DEP has directed at UV and other alternative disinfection systems has been:

If the alternative disinfection system is designed and operated to meet the fecal coliform and total suspended solids (TSS) limits for high-level disinfection, will the reclaimed water be of the same (or better) quality from a pathogen standpoint as reclaimed water that has been chlorinated and meets the fecal coliform and TSS standards?
Table 1. Florida's Disinfection Requirements

<table>
<thead>
<tr>
<th>Disinfection Level</th>
<th>Requirements</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Level (a)</td>
<td>2,400 fecal coliforms/100 mL</td>
<td>Pretreatment requirement for overland flow systems</td>
</tr>
<tr>
<td>Basic (a)</td>
<td>200 fecal coliforms/100 mL (annual average)</td>
<td>Most surface water discharges &amp; land application systems</td>
</tr>
<tr>
<td>Intermediate (a)</td>
<td>14 fecal coliforms/100 mL (annual average)</td>
<td>Discharges tributary to shell fishing waters</td>
</tr>
<tr>
<td>High-level (a)</td>
<td>Fecal coliforms:</td>
<td>Public access reuse systems &amp; edible crop irrigation (projects permitted under Part III of Chapter 62-610 (2)</td>
</tr>
<tr>
<td></td>
<td>75% of observations less than detection, Maximum: 25 fecal coliforms/100 mL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TSS &lt; 5.0 mg/L before disinfection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Filters &amp; chemical feed required</td>
<td></td>
</tr>
<tr>
<td>Full Treatment (b)</td>
<td>Total coliforms less than detection</td>
<td>Indirect potable reuse &amp; ground water recharge</td>
</tr>
</tbody>
</table>

Notes: 
(a) Defined in Chapter 62-600, F.A.C. (1) 
(b) Required by Chapter 62-610, F.A.C. (2) Criteria reflect the basic provisions of the drinking water standards.

As a result, the DEP had been reluctant to permit UV or other alternative disinfection systems for high-level disinfection applications without pilot studies or other pathogen data to answer this fundamental question (9).

For UV systems, the lack of a measurable residual also entered into the DEPs historical reluctance to permit UV for high-level disinfection applications. Florida’s reuse rules require continuous monitoring for disinfectant residual and turbidity as a means for controlling the high-level disinfection system to ensure that only acceptable quality reclaimed water is delivered to the reuse system.

**Interest in UV Disinfection**

Interest in alternative disinfection systems (primarily UV) has been growing in Florida since about 1990. Because of the emphasis on reuse in Florida, much of this interest has focused on high-level disinfection applications. In discussions with several of the major manufacturers of UV equipment in the early 1990s, the DEP noted its concern for pathogen data to support the use of UV for high-level disinfection applications.

While UV equipment manufacturers and suppliers noted their interest in conducting studies needed to justify UV for high-level disinfection applications, no studies were completed and no data was provided to support UV for high-level disinfection.

Looking at the possibility of doing its own research, the DEP was successful in funding a literature review of alternative disinfection systems (UV and ozonation), which was envisioned as being the possible first phase of a possible multipart study designed to support alternative disinfection systems. This literature review (10) identified the UV guidelines published by the National Water Research Institute (NWRI) (11) as providing a pathogen basis for UV disinfection criteria that would meet or exceed Florida’s high-level disinfection requirements.

As noted in the following section, the DEP concluded that the NWRI guidelines provide reasonable assurances that a UV system will be designed, operated, and monitored in a manner that will ensure production of high-quality reclaimed water that will have a pathogen content less than or equal to a reclaimed water treated by chlorination.
Regulatory Framework for UV Disinfection

Currently, UV systems can be readily permitted in Florida for projects involving low level, basic, and intermediate disinfection. These facilities must be designed and operated to meet the fecal coliform performance standards established in Chapter 62-600, F.A.C. (1). Given that the state does not have design criteria for UV systems contained in our rules, each project will be evaluated on its own merits.

For high-level disinfection applications, UV can be permitted in Florida using either of the following two approaches:

3. The design, operation, and monitoring of the UV system must comply with all requirements of the NWRI guidelines for UV disinfection." Filtration and chemical feed facilities must be provided. The fecal coliform and TSS performance criteria for high-level disinfection must be met.

4. Proposals for UV systems that do not comply with the full NWRI guidelines must be supported with pilot studies that include pathogen data (enterovirus, Giardia, and Cryptosporidium) justifying the design and operation parameters. The intent is to demonstrate that the UV system will produce reclaimed water that meets the performance standards for fecal coliforms and has a pathogen content no greater than what is anticipated from a chlorination system. Filtration and chemical feed facilities must be provided. The fecal coliform and TSS performance criteria for high-level disinfection must be met.

In both cases, all rule requirements related to the reuse system must be met.

UV Experience

While there is growing interest in UV disinfection, chlorination remains the overwhelming choice among domestic wastewater utilities in Florida. Of approximately 3,000 permitted domestic wastewater treatment facilities, only 21 currently employ UV. Of these, 16 are designed to meet basic disinfection requirements, 1 meets intermediate disinfection, and 4 provide high-level disinfection. Of the four high-level disinfection systems permitted in Florida, two were designed to meet the full requirements of the NWRI guidelines, one was supported by pilot- and full-scale testing, and one features UV with a complete chlorination system running in series.

Future Needs and Direction

The DEP anticipates that interest in UV disinfection will increase significantly over the next decade. In order to facilitate implementation of UV systems in Florida, the DEP would like to see the following activities accomplished:

1. Develop internal guidance on permitting of UV systems in Florida. This would include development of templates for standard permit conditions for a range of UV applications.

2. Update the NWRI UV guidelines to address a wider range of disinfection applications and technologies. It is recommended that UV guidelines be developed to meet the disinfection levels included in EPA's Guidelines for Water Reuse (12), which are similar to Florida's requirements.

3. Develop detailed design and performance criteria for UV (including dose requirements) in Florida's domestic wastewater rules. Ideally, these rules would be based on updated NWRI guidelines (assuming the guidelines are updated to reflect EPA's Guidelines for Water Reuse).

4. Incorporate rule requirements governing UV applications into Permit Builder - DEP's expert system that aids DEP permitting engineers in the development of standardized permit conditions for domestic wastewater and water reuse facilities.

References

2. Florida Department of Environmental Protection, Domestic Wastewater Facilities. Chapter 62-600 Florida Administrative Code. 1996, Florida Department of Environmental Protection; Tallahassee, FL.

3. Florida Department of Environmental Protection, Reuse of Reclaimed Water and Land Application. Chapter 62-610, Florida Administrative Code. 1999, Florida Department of Environmental Protection; Tallahassee, FL.


5. Crook, J. Viruses in Reclaimed Water. 1989, Meeting the Challenges of the 90s: Proceedings of the 63rd Annual Technical Conference. FS/AWWA, FPCA, and FW&PCOA; St. Petersburg Beach, FL.

6. Rose, J.B., and R.P. Carnahan, Pathogen Removal by Full Scale Wastewater Treatment. A report to the Florida Department of Environmental Protection. 1992, University of South Florida; Tampa, FL.


This extended abstract appears in UV 2000 – A Technical Symposium, published by and available from the National Water Research Institute, 10500 Ellis Avenue, P.O. Box 20865, Fountain Valley, CA 92728-0865; Fax: 714-378-3375; email: nwrigina@hotmail.com. Price = $15.00 (U.S.).

AWWARF Project Update – UV Disinfection Guidelines for Drinking Water

by Albert Ilges, AWWARF Senior Project Manager

The inherent nature of ultraviolet (UV) disinfection poses some unique challenges to the drinking water community. Critical factors that must be considered include 1) the number and type of UV lamps, 2) reactor hydraulics, 3) inactivation requirements, 4) impacts of water quality, and 5) instrumentation and controls. As a result, UV disinfection systems will require more site-specific design considerations than typical chemical disinfectants.

AWWARF and the National Water Research Institute are developing UV disinfection guidelines for reclaimed water and drinking water. More than 30 experts from universities, consulting firms, and state and federal regulatory agencies (with the assistance of a technical panel of manufacturers) will help to create a state-of-the-science document.

At a meeting in Pomona, CA, on April 14-16, 2000, the participants identified the issues that will need to be addressed in the guidelines. The reclaimed water guidelines will update and expand the 1993 UV Disinfection Guidelines for Wastewater Reclamation in California and UV Disinfection Research Needs Identification to be national in scope.

The drinking water guidelines will cover seven topics: 1) dose design, 2) reactor design, 3) reliability and redundancy design, 4) monitoring and alarms, 5) field testing before startup, 6) performance monitoring, and 7) engineering reports.

The drinking water guidelines will be dose-neutral (i.e., will not specify required doses for pathogen inactivation) and, in general, will not be prescriptive.

Supplemental protocols will provide tools to help implement the guidelines. For example, a protocol for equipment validation might contain sections on 1) test-facility requirements and setup, 2) microbiological testing, 3) testing and sampling requirements, and 4) data analysis and reporting.

Two things are certain: UV technology for drinking water applications is developing at an incredible pace and there is still much to learn (some of which will come only after full-scale installations). As UV technology advances and utilities gain hands-on experience, these guidelines will need revision, as did the guidelines they replace.

The final report is expected to be available during the last quarter of 2000. AWWARF subscribers can place advance orders by sending an email to <rfreports@awwarf.com> and requesting the final report for project #2674.

HydroQual, Inc.

HydroQual, Inc. Environmental Engineers & Scientists
1 Lethbridge Plaza
Mahwah, New Jersey 07430
(201) 529-5151
www.hydroqual.com

- UV Process Design
- UV Biosassays & Hydraulics
- UV System Evaluations
- Water Quality Studies & Analysis
- Water & Wastewater Treatment
- Environmental Compliance
- Field & Laboratory Studies
WEDECO AG Water Technology is the European market leader for water disinfection with ultraviolet light. As a stock-listed company concerned about health care we strive to ensure a healthy, safe water supply. Our dramatic growth rate is due primarily to our technological edge.

**UV in use**
More than 35,000 WEDECO-systems are already installed worldwide. Using standardised as well as custom designed systems, we offer solutions for drinking water, process water, ultrapure water, sewage and project specific applications. The broad goal of our business is to provide the most compatible solution for both mankind and the environment as well as the most economic solution for our clients.

**Efficient Technology**
At the core of WEDECO-Systems are the unique Spektrotherm UV-lamps. They operate to a large extent independent of water temperature and their particularly high performance makes them far superior to conventional low pressure lamps. Microprocessor controlled "smart" electronic ballasts designed specifically to power Spektrotherm UV-lamps increase their effectiveness. We are committed to intensifying our R & D activities in order to extend our technological lead in all areas of UV-disinfection.

For more information:
WEDECO AG Water Technology
Boschstraße 4
D – 32051 Herford
tel: +49/5221/930-128
fax: +49/5221/930-131
e-mail: int_business@wedeco.net
http://www.wedecoag.com

In USA contact:
WEDECO-Ideal Horizons, Inc.
212 Ideal Way
Poultney, Vermont
05764 USA
tel: +1/802/287-4488
fax: +1/802/287-4486
e-mail: sales@wedecouv.com

European market leader in UV-disinfection
Concerned about cryptosporidium and giardia disinfection? Or perhaps, complying with new DBP requirements? Take heart.

By carefully listening to the needs of municipalities and engineers, Trojan has developed the right UV answer for today’s municipal drinking water challenges. The result: a system that delivers industry-leading performance and efficiency, and flexible lamp cleaning options; a small footprint that makes it easy to install, even in very restrictive pipe galleries; and advanced controls to ensure continued efficiency and results.

With more than 20 years experience, the largest installed base of UV systems for water disinfection in the world, highly-trained technicians and an extensive network of support centers around the globe, you can trust Trojan to get it right.

For an information kit describing Trojan’s engineered UV solutions for municipal drinking water disinfection, call 1-888-220-6118 or visit our website. Meet us at AWWA, Denver, June 11-15, 2000.