ISSUE THEME: UV for Air Treatment

Witham and Jones, “UV in HVAC Systems” – pp 4-5

Gobulukoglu, “A Safer Germicidal UV Air Disinfection Proposal” pp 14-17

Rahn, “Longitudinal Actinometry Applied to Upper-Room UV Disinfection”, p 23

“UV Eliminates Airborne Pathogens in Hospital Air Ducts”, p 6

“UV Protects Labs from Airborne Microbial Contamination”, p 6

Letters – “Microwave UV for Air Treatment”, p 8

UV-Air Treatment Topical Group Being formed, p 8

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Contents

Air Treatment Topical Group Being Formed ............. 8
Correction Notice .................................. 5
Edmonton (Canada) EPCOR UV Installation ............. 18
Industry Updates .................................. 3
IUVA News — Issue Themes Announcement ............. 19
IUVA’s Member Zone ................................ 19
IUVA’s Southeast Ultraviolet (UV) Disinfection One Day Conference - Tampa, FL, Sept 6, 2002 .... 12
Letters — Microwave UV for Air Treatment .......... 8
Meetings Calendar ................................ 12-13
New IUVA Members ................................ 20-21
NYSERDA Assistance Available for Water/Wastewater ...... 19
Theme Article: “Multiple Applications of UV in Heating, Ventilation and Air Conditioning (HVAC) Systems”, by Dave Witham and Daniel Jones .......... 4-5
Theme Article: “A Safer Germicidal UV Air Disinfection Proposal”, by Ismail Gobulukoglu .......... 14-17
Things to Come .................................... 8
UV in Action — UV-H2O2 @ Fountain Valley, CA ...... 22
UV Eliminates Airborne Pathogens in Hospital Air Ducts .... 6
UV Papers at Aquatech 2002 .................................. 9-10
UV Protects Labs from Airborne Microbial Contamination .. 6
UV at WQTC ........................................ 10
UV at WEFTEC ..................................... 10

Index of Advertisers

American Ultraviolet Company ......................... 11
AWWA – Water Quality Technology Conference .......... 6
Aquafine Corporation ................................ 2
Atlantic Ultraviolet Corporation ......................... 13
Barr Associates, Inc. ................................ 9
Black & Veatch ........................................ 6
Bolton Photosciences Inc. ......................... 19
Calgon Carbon Corporation ......................... 24
Camp Dresser & McKee ................................ 17
Carollo Engineers ..................................... 10
eta plus electronic gmbh & co kg ......................... 23
Hydroqual, Inc. ....................................... 10
IUVA Proceedings and IUVA T-Shirts ................. 18
Malcolm Pirnie, Inc. .................................. 11
Solar Light Co. ........................................ 23
UltraViolet Devices, Inc. ............................ 22
Xenon Corporation ..................................... 21
Wek-Tec .............................................. 22

Upcoming Issue Themes – Deadlines

Issue #5/2002 – Food Disinfection With UV (August 15)
Issue #1/2003 – UV In Asia (Dec 1, 2002)
Issue #2/2003 – AOTs / UV Curing (Mar 1, 2003)
Issue #4/2003 – UV for Air Treatment (June 30, 2003)

Your Editors are soliciting articles and advertisements for these topics. Please contact either Rip Rice or Jim Bolton (see below) with (a) intentions to submit, (b) written contributions, or (c) special advertisements (item “c” to Rip Rice).

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

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IUVA’s Web Page: www.IUVA.org

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Multiple Applications of UV in Heating, Ventilation and Air Conditioning (HVAC) Systems

by

Dave Witham, Vice President New Technology (DaveW@vhinc.com)
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Over the past five years, the residential and commercial heating, ventilating and air conditioning (HVAC) marketplace has become increasingly interested in utilizing ultraviolet light within HVAC systems to improve indoor air quality (IAQ). The application of UV for indoor air quality is not new. UV's ability to disinfect air has been understood for many decades. In the 1940s and 1950s it was successfully employed to disinfect air in hospitals, medical facilities and army barracks as well as being used extensively in food preparation facilities. Although some ultraviolet was used within HVAC equipment, the most extensive use at that time was through upper air treatment fixtures. These were passive ultraviolet lamp fixtures generally mounted above the occupant's level and designed to irradiate the upper air in a room through convective air currents within the room. This type of UV application is still popular, and currently is under further study at the Harvard School of Public Health.

As the use of ultraviolet light in HVAC systems has become more prevalent due to the benefits gained by utilizing ultraviolet light within an HVAC system, applying the technology has tended to be thought of as one application, that is, one size fits all. However, there are two quite different types of HVAC applications. In one application, surface irradiation (such as air conditioning coils, drain pans and filters), relatively low levels of ultraviolet intensity may be used to obtain the desired effect. For the second application (disinfect an air stream), higher intensity ultraviolet is required due to the short residence time. In the larger commercial HVAC unit, ultraviolet treatment of a moving air stream is done in combination with appropriate levels of filtration to improve the efficiency of microbial reduction. UV disinfection of moving air streams can be accomplished in large HVAC equipment or in equipment as small as stand-alone room air cleaners.

Each of these two types of applications requires a completely different approach, and amount of ultraviolet energy. The manner in which ultraviolet inactivates airborne pathogens is similar to that in water, following the classic decay relationship:

\[ S = e^{-kt} \]

where \( S \) is the surviving fraction of microbes, \( k \) = the rate constant different for each microbe, \( I \) = UV intensity or fluence, and \( t \) = time.

UV Surface Disinfection

The dosage delivered to the microbes is found in the relation intensity times time (irr). Thus for an application where surfaces are irradiated, and exposure times are very high (up to 24 hours per day), high intensities are not required. It is more important to fully bathe these surfaces and components in ultraviolet light. The benefits of this type of application can be a reduction in maintenance and utility costs as well as improvement in indoor air quality.

Ultraviolet radiation on air conditioning coils can help maintain their cleanliness and thus reduce the pressure drop and loss of airflow caused by fouled coils and/or the reduction in heat transfer of a dirty heat exchanger. As well, drain pans near air conditioning coils can be particularly troublesome due to the buildup of moisture which can become a breeding ground for bacteria and fungus. In many cases these components are chemically or mechanically cleaned. Chemical cleaning can degrade and shorten the life of air conditioning components, as well as introduce other hazardous substances into the air stream. By employing UV to help keep these surfaces clean, utility and maintenance costs are reduced while improving the longevity of the equipment and improving the indoor air quality.

The same UV surface irradiation fixtures can also be used to bathe HVAC filter elements. In this application the filter is used to capture the microbes, and the constant UV irradiation disinfects the filter surface. The fixtures that are used for both applications of surface irradiation should be rugged, drip proof and easily installed. They should be designed such that they can be connected in series to fully bathe the target surfaces. It is important that they be designed to meet building codes and certified for use within an HVAC system.

UV Air Purification

The second HVAC type of application is for treatment of a moving air stream. In these applications, the exposure time can be as short as a fraction of a second. For this reason large
amounts of UV energy are required. Typical pathogens found in a moving air stream consist of viruses, bacteria and fungi (including mold and mildew).

In general, airborne virus and bacteria are relatively small (usually less than 1 micron), and therefore difficult to filter and yet relatively easy to disinfect with ultraviolet. Fungi are considerably larger, on the order of one to ten microns, and when airborne, are much more difficult to disinfect with UV. Reasonable systems can be designed for disinfection of virus and bacteria utilizing ultraviolet alone. However, disinfection of airborne fungi by UV alone is much more difficult and generally impractical. As noted above, fungi can be treated on stationary surfaces quite effectively due to the long exposure times; conversely it is very difficult to pack enough UV energy into a system to disinfect fungi in a moving air stream. The good news, however, is that fungi are much larger and therefore can be effectively captured on medium efficiency filtration. The combination of the two technologies, filtration and ultraviolet light placed upstream of the filter, prove to be very effective in capturing and disinfecting the filter surface of fungi.

Considering performance curves of typically available filters, it can be observed that most filters do a good job of arresting large particulates such as fungi. Generally over 90% of the particulates over 1 micron are collected. The smaller particles which are in the range of virus and bacteria pass through the filter more readily. However, these are easily disinfected by ultraviolet radiation. In other words, an air cleaning system using filters and ultraviolet can be very effective. The filter removes a very high percentage of the microbes over 2 microns and properly selected and dosed UV can disinfect a high percentage of the microbes under 2 microns. Together, the overall performance can approach that of a much higher efficiency filter, without the pressure drops normally associated with very high efficiency filters, such as HEPA filters.

To help in applying UV or the combination of UV and filtration to HVAC system applications, mathematical modeling [see W.J. Kowalski and D. Waltham, “UVGI Systems for Air and Surface Disinfection”, IUVA News, 3(5):4-7, 2001] is available to predict the performance of both filtration and ultraviolet disinfection within HVAC systems. Bioassay techniques and protocols have been developed to test microbial removal and UV disinfection within a simulated HVAC system.

**UV and Bioterrorism**

Due to recent events, bioterrorism has become a concern relative to HVAC systems and the introduction of airborne contaminants. This has provided further ultraviolet opportunities in HVAC systems. Some UV equipment manufacturers have claimed high levels of UV disinfection of Anthrax. Obviously, extreme caution should be used in this type of application. The UV rate constants (dose response) for Anthrax are not publicly available. However, data based on a 1986 study indicates that the amount of UV energy required for disinfecting Anthrax in the spore form is extremely high. Dose requirements for Anthrax in this form may be as high as 50 times that for smallpox, legionella or tuberculosis. When designing a system for these types of microbes, it is important to consider the use of UV and filtration in combination, as sufficient UV disinfection alone may be impossible See Editor’s Note below).

The design characteristics of UV moving air fixtures are similar to those of surface irradiation fixtures. They should be rugged, drip-proof and easily installed within an HVAC system. They must be designed to meet local building codes and should be UL approved for use within an HVAC duct. Modular UV systems and fixtures can make the installation of proper UV dosage easier.

**Summary**

In summary, ultraviolet energy, applied properly, with all of the factors considered within an HVAC system can be effective for both surface treatment and treatment of moving air streams. In the first application, the benefits normally are reduced maintenance and energy costs. In treating a moving air stream, indoor air quality can be improved by applying proper high UV dosage and filtration.

**Editor’s Note added during review, with authors’ permission:**

Anthrax (Bacillus anthracis) is a bacterium whose most resistant form during its life cycle involves a spore stage. It has been shown by many authors [see R.G. Rice, “Ozone and Anthrax – Knowns and Unknowns, Ozone: Sci. & Engrg. 24(3):151-158, 2002 and references cited therein] that relative humidity plays a critical role in the ozone destruction of bacterial spores of any type, but particularly those spores that are accepted simulants for B. anthracis. No bacterial spore inactivation is observed with gaseous ozone when the relative humidity is below 50%, and it is likely that relative humidity also may play a key role in the UV inactivation of anthrax as well.

**Correction Notice**

Regarding the advertisement on page 13 of the 2002 Who's Who in UV and Buyers Guide: “Microwave UV!” the website for this ad was incorrectly printed. The correct website is www.jenael.co.uk Please make that change in your copy.
In a 12 month study carried out at the Leeds General Infirmary, ultraviolet (UV) disinfection systems achieved a 98.9% reduction of *Staphylococcus aureus*, *Mycobacterium tuberculosis* (MTB) and other airborne pathogens within the hospital’s air conditioning system.

It is well-known that infectious diseases such as tuberculosis are spread by airborne transmission. Nosocomial infection (infection originating in hospitals) is now a major problem in many health-care facilities, with about 1 in 10 patients acquiring an infection during a hospital stay [1]. A study in the USA has estimated that in 1985 the total annual cost of nosocomial infection was $4 billion, with 8 million lost bed days [2]. A smaller DHSS study in the UK carried out in 1986 estimated that in acute-care hospitals in England, 950,000 lost bed days, and financial costs of £111 million, were associated with nosocomial infection [3]. Given these statistics, it is not surprising that health care authorities around the world are continuously seeking new ways of controlling the problem.

UV is effective against many pathogenic microorganisms and therefore has the potential for reducing the spread of airborne infections in hospital buildings. Relatively little research, however, has been carried out on into the practical effects of UV disinfection in hospital buildings. Consequently, the 12 month study at Leeds General Infirmary was commissioned by NHS Estates to investigate the practical application of this technology.

In the tests, a range of pathogens associated with nosocomial infection were treated with medium pressure UV lamps -- both within the hospital air ducts and in controlled laboratory settings. All the pathogens tested were found to be very susceptible to UV; in fact, when a four-lamp UV system was used, there was a 98.9% reduction in bacteria levels capable of growth on mannitol salt agar, including both *S. aureus* and *M. tuberculosis*.

Compact and easy to install within existing ductwork, UV systems are silent in operation and can treat up to 4 m³/second of air per lamp. They are virtually maintenance-free, the only regular requirement being the replacement of the UV lamp twice a year, a simple operation that can be carried out by general maintenance staff. UV technology is already widely used within the food, beverage and pharmaceutical industries to destroy spoilage organisms and pathogens.

**References**


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**UV Protects Colgate-Palmolive Laboratories From Airborne Microbial Contamination**

To help protect its biotechnology laboratories from microbial contamination, Colgate-Palmolive has installed several UV disinfection systems within the in-line air ducting of its Salford facility in the United Kingdom. UV is effective against all microorganisms and is now a well-established method for reducing the spread of airborne contaminants in laboratories, hospitals and food manufacturing facilities.

Commenting on the installations, Engineering Services Manager Phil Taylor said, “After considering several alternatives, our engineering department decided that UV was the most suitable technology for our requirements. Since their installation they have been working exactly as intended and have kept microbial contamination in the air ducts within acceptable levels.”

Thanks to Hanovia, Inc., Slough, UK.
2002 Water Quality Technology Conference and Exhibition

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Seattle, Washington

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- Eight in-depth and interactive workshops on analysis of algae, on-line monitoring, taste and odor testing, UV disinfection, vulnerability assessments, applying hazard analysis and critical control point to water, water quality and treatment basics, and water-borne contaminant detection
- Three technical tours that include a water quality laboratory, a treatment facility, and a watershed education center

For more information or to register, visit the Web at www.awwa.org/conferences/wqtc or call us at (800) 926-7337 option 1,1.

American Water Works Association

The Authoritative Resource for Safe Drinking Water℠
Dear Editor –

On the Air Disinfection front, JenAct is developing our microwave UV technology and hope to have it accepted at some future time. Our aim is to persuade experts in the field -- the equipment suppliers -- to power their UV air disinfection units with our 'UV engines'.

Microwave UV gives low pressure efficiency at far higher power levels than previously possible with standard low pressure lamps. If anyone writes to IUVA News criticizing that one, please refer to me! Also, lamps have no electrodes and thus little reason to degrade so really long life. Ten UV lamps can be powered by one power supply thus saving money and the whole microwave cavity can become one with the ducting.

There is patent protection on this so please, nobody copy this simple idea or else when I can afford it I'll chase them!

Please see the attached photograph so you can see what I mean.

Richard Little, JenAct Ltd., Whitchurch, Hampshire, UK

volunteered to undertake the formation of this new IUVA Topical Group.

If anyone would be interested in forming a Topical Group on other UV subjects, contact IUVA's Executive Director, Jim Bolton <jbolton@iuva.org>. The process is provided for in the IUVA By-Laws, and is relatively simple, to wit:

1. Establish Draft By-Laws for approval by the IUVA Board of Directors.

2. The Draft Bylaws require a Topical Group Board with a minimum of 6 members (Chair, Chair-Elect, Vice Chair, Treasurer, Secretary and one other Member). The Chair-Elect can remain vacant for now and if desired by the members, IUVA's Executive Director (Dr. Jim Bolton) can serve as Secretary pro-tem until more Members are recruited.

3. Topical Group Members should decide among themselves who should serve as the initial TG Board Members.

4. The Topical Group Chair automatically has a seat on the IUVA Board of Directors, according to the IUVA Bylaws.

**Things to Come**

Our next issue of IUVA News (#5-2002) will feature information on the use of UV and Foods. Articles on Pulsed UV to Sterilize Food Packaging and UV for Sterilization of Juice will be the lead articles. Additionally, abstracts of presentations at the June 2002 Annual Meeting of the Institute of Food Technologists in Anaheim, CA on UV and Foods will be included, along with abstracts of recent publications on the subject.
During the upcoming Aquatech 2002 meeting in Amsterdam, The Netherlands (Oct. 1-3, 2002), a goodly number of papers dealing with UV technologies will be presented at the IOA-sponsored International conference on Ozone in Global Water Sanitation - Integrating also Ultraviolet Light, Catalytic, Synergic & Advanced Oxidation Processes:

Wednesday Oct. 02 SESSION *II*: UV & Advanced Oxidation

09.00-09.30: Dr J.R. Bolton & M.I. Stefan (Canada): Fundamental Photochemical Approach to the Concepts of Fluence Rate and Electrical Energy Efficiency in Photochemical Degradation Reactions.
0.9.30-10.00: Dr Y.A. Lawryshyn & Dr B. Cairns (Canada): UV Disinfection of Water; the Need for UV Reactor Validation.
10.00-10.30: Dr G.F. Ijpelaar, Dr B. van der Veer, Dr G. Medema & Dr J.C. Kruithof (The Netherlands): Byproduct Formation During UV Disinfection of Pretreated Surface Water.

11.00-11.30: M.I. Stefan, Dr J.C. Kruithof, P.C. Kamp & M. Welling (Canada & The Netherlands): Kinetic Parameters of Herbicide Photodegradation in Drinking Water Treatment.
11.30-12.00: J. Sanz, J.I. Lombrana, R. Rodriguez, A. Urkiaga, M. Gutiérrez & L. de las Fuentes (Spain.): UV/H2O2 - Effect on biodegradability.

SESSION *III*: O3-Oxidation-Catalytic Oxidation Processes.

14.00-14.30: Prof. B. Legube, H.X. Fu & Dr N. Karpel Vel Leitner (Fr): Catalytic Ozonation with RU/ CeO2-TiO2 Catalyst.
14.30-15.00: Dr I. Ilisz & Prof. A. Dombi (Hungary): TiO2-based Heterogeneous Photocatalytic Water Treatment Combined with Ozonation.
16.30-17.00: S. Preis, J.L. Falconer, K. Magrini-Bair, F. Wolfrum & J. Kallas (Finland & USA): Gas-phase Photocatalytic Oxidations.
17.00-17.30: Prof. F. J. Beltran, Fr. J. Rivas, R. Montero de Espinosa, P.M. Alvarez & J.F. García-Araya (Spain.): Heterogeneous Catalytic Oxidations (example: oxalic acid in water).
Thursday, Oct. 03 SESSION *IV*: Ozone-Oxidations in Wastewater Treatment.

09.00-09.30: Dr A. Ried, Dr J. Mielke & Ing. H. Stapel (Germany): Integrated Ozone and UV Applications for Additional Process-and-Wastewater Treatment.


Thursday Oct. 03, SESSION *V*: Group Discussions, Conclusions and Outlooks. 14.00-16.00: Announced Contributions by:


And lots of other stuff of general interest to UV people. For registration details, see the Meetings Calendar in this issue.

UV at WQTC

At AWWA’s Water Quality Technology Conference in Seattle, WA (USA) this coming November 10-14, 2002, there will be several sessions devoted to UV technologies for potable water treatment. On Sunday, Nov. 10, there will be an all-day Preconference workshop entitled “Using the UV Guidance Manual: Implementation of UV Disinfection Into Your Disinfection Strategy”.

Although EPA’s UV Guidance Manual will not be issued formally until the Long Term-2 Enhanced Surface Water Treatment Rule (LT2ESWTR) is promulgated (some time in the future), sufficient drafts of this Guidance Manual have been circulated for review and comment so that this session will be meaningful to those interested in installing UV.

On Monday, Nov. 11, a session on UV Disinfection will be held from 1:00 to 5:00 PM. On Tuesday, Nov. 12, a session on UV Design and applications will be held from 08:30 to 12:00 noon, and from 1:30 to 5:00 PM, a session on UV Dose Delivery and Reactor Validation will be held.

UV at WEFTEC

On Monday, Sept. 3, 2002 a session on UV Disinfection (Wastewater) will be held from 1:30-5:30 PM. The following papers will be presented:

“Addition of UV Disinfection for Kailua Regional Wastewater Treatment Plant, Hawaii”, P. Chan, L. Thallapally, F. Mitchell

“A Comparison of UV Disinfection for Drinking Water, Wastewater, and Reclaimed Wastewater”, H.B. Wright, E. Mackey, R. Cushing, T. Tekippe

“Double-folded, Low-pressure, High-output Ultraviolet Lamp and Enhanced Mixing Reactor Chamber Combine to Disinfect “Selection and Installation of a UV Disinfection system as a Retrofit to an Existing wastewater Treatment Plant”, F.J. Johns, M.A. Lichtwardt, P. Grundeman, D. Gallegos


“Low Pressure-High Output UV: Is it the Wave of the Future”, G. Hunter, T. Cummings


Poster: “UV Reactor Validation: Implications of Non-ideal Reactor Behavior”, Y. Lawryshyn, K.-P. Chiu

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The Second International Congress on Ultraviolet Technologies of the International Ultraviolet Association will bring together experts from all over the world to exchange and discuss latest information on research and development in the field of UV technologies. An exhibition will give the delegates an opportunity to keep up-to-date with latest industry trends, issues and developments.

A pre-congress workshop on "Fundamentals and Advances in UV technology" will be held on 9th July, 2003.

The topics of the congress are:

- terms units and definitions for UV radiation and its application;
- UV disinfection of drinking water, wastewater, and process water;
- UV for ultrapure water applications;
- UV treatment of air;
- inactivation of pathogenic and indicator microorganisms;
- spectral sensitivity of microorganisms;
- formation of by-products;
- performance testing and biodosimetry;
- modeling and computational fluid dynamics (CFD);
- surveillance of disinfection systems;
- measurement of UV irradiance and fluence rate;
- advances in UV sensor technology;
- application of monochromatic and polychromatic UV radiation;
- application of new UV radiation sources (e.g. xenon, excimer, pulsed);
- UV curing;
- application of UV in cosmetics and medicine;
- UV treatment for food, beverages, and packaging;
- regulatory standardization and directives worldwide.

Enhancing the technical and scientific program, the conference participants will have the opportunity to enjoy the flavor, beauty and history of the city of Vienna, the capital of Austria, which is world-famous for music, art, architecture and Viennese hospitality.

For further information please contact:

Icos. Congress Organisation Service Ges.m.b.H.
Congress secretary: Ms. Julia Egermann
Johannesgasse 14, A 1010 Wien, AUSTRIA
Phone: +43 1 512 80 91; Fax: +43 1 512 80 91 80
e-mail: iuva2003@icos.co.at; Web: www.iuva2003.at
Upcoming Meetings

... IUVA Meetings ...

Tampa, FL (USA) September 6, 2002: Southeast Ultraviolet Disinfection: Enhancing Public Health Protection -- a One Day Conference. In this seminar, recognized experts provide a thorough overview of the key issues associated with implementation of UV disinfection. Registration details: Contact: Kathy Harvey at IUVA HQ -- see insert box p. 3.

Singapore, 30 October – 1 November, 2002. Call for Exhibitors: Complete details, space sizes, Exhibition Floor Plan, prices, payment details, etc. are available on the IUVA web site (www. iuva.org). Meeting will be held in the Singapore Swissotel The Stamford, Olivia Room. Contact points: North America and Europe: The IUVA Conference Secretariat Kathy Harvey – see contact information p. 3, insert box; from Asia and the other parts of the world: The ETI Communication Manager, Ms. Tan Kim Suan, Environmental Technology Institute, Innovation Centre (NTU), Block 2, Unit 237, 18 Nanyang Drive, Singapore 637723, Tel: (65) 794-1533; Fax: (65) 792-1291, Email: kstan@eti.org.sg. Hurry!! Time is running out!!

Vienna, Austria, July 9-11, 2003. Second World Congress on Ultraviolet Technologies. A pre-congress workshop on "Fundamentals and advances in UV technology" will be held on 9th July, 2003. The technical and scientific program of the congress (July 10-11) will include plenary and parallel sessions as well as poster presentations – see p. 11 of this issue.

Exhibits from companies with products based on ultraviolet technology will be presented.

The first announcement and call for papers and exhibitors will be distributed soon. Contact: Prof. Dr. Regina Sommer, Institute for Hygiene and Medical Microbiology, University of Vienna, Medical Faculty, Kinderspitalgasse 15, A-1095 Vienna, AUSTRIA. Phone 43-1-40490-79452; Fax 43-1-40490-9794; e-mail: regina.sommer@univie.ac.at

"The Ultraviolators" Jazz Band (organized by Rip Rice) will entertain at one or more social functions, provided enough players will be present. Musicians Wanted – esp. piano and/or electric guitar. Please contact Rip Rice (see p. 3 insert) with instrument you play, and whether you can or cannot bring that instrument to Vienna (piano excepted).

... Meetings of Other Organizations – 2002 ...

L'utilisation des UV dans le traitement des eaux (Use of UV in the Treatment of Waters), Limoges, France, 13 Sept. 2002. Contact: Aquatech Limoges, Faculté des Sciences, 123 Avenue Albert Thomas, 87060 Limoges Cedex, France.


WEFTEC 02, Water Environment Federation's 75th Technical Exhibition and Conference, McCormick Place, Chicago, IL, USA, Sept. 28 - Oct 2, 2002. Contact: www.weftec.org


Aquatech Amsterdam 2002, Amsterdam RAI, Amsterdam, The Netherlands, 1-4 October 2002. Contact: Aquatech RAI, P.O. Box 77777, 1070 MS, Amsterdam, The Netherlands, Ph +31 (0)20 549 1212; Fax: +31 (0)20 549 1843; e-mail: aquatech@rai.nl; or visit www.aquatech-rai.com.


Meetings of Other Organizations – 2003

Aquatech Energy, Water & Waste EXPO 2003, Warsaw, Poland, February 12-14, 2003. In order to meet EU standards, huge investments will have to be made in water management and technology within Central and Eastern Europe in the years ahead. Although limited space is available for this groundbreaking event, there are special reduced rates for Aquatech exhibitors. To reserve space or receive more information, please visit http://show-info.nl/ewwexpo2003

Water and Wastewater Europe, Nice, France, 4-6 March 2003. Call: +44 1992 656 631. Companies from around the world will be on the exhibition floor, primed to present their products and services including: Pumps Valves Desalination Equipment Water Treatment Plants UV Disinfection Filtration Systems Engineering Drilling and more. This conference held over two and a half days will feature more than 40 technical and strategic papers on Desalination, Water Re-use, Water Quality, Sludge Treatment, Privatization, Finance and Legislation. http://www.wwueurope.com


Meetings of Other Organizations – 2004

ABSTRACT

The popularity of ultraviolet air disinfection systems is increasing with advances in lamp technology, and more reliable data about the effectiveness of UV. These advances have resulted in more commercial interest of UV for air treatment systems. One of the problems associated with UV air disinfection systems is the fouling of quartz lamps and sleeves that reduces the disinfection efficiency in traditional UV systems. The decrease in the average UV intensity transmitted to the air due to fouling and the necessary cleaning of the quartz lamps and sleeves adds significant cost to a standard UV system. Additionally, due to the fragile properties of quartz lamps and sleeves, the potential for breakage and subsequent air contamination is always present in HVAC systems. Therefore from a cost, maintenance and safety standpoint; it would be best if quartz sleeves and lamps could be protected with non-fouling and non-breaking properties.

INTRODUCTION

Numerous regulatory, process and system design changes have impacted the use and implementation of germicidal ultraviolet (UV) disinfection systems. A wide range of applications has resulted in the use of germicidal UV systems for air disinfection in the United States. Germicidal UV air disinfection systems are receiving increased attention in the HVAC industry, as a non-chemical method that can contribute to the improvement of indoor air quality (IAQ) (4,5,7-13). There has been extensive research on ultraviolet light disinfection technology in air applications (1-3,6) There are several factors that affect ultraviolet light efficiency, such as lamp output, lamp aging, and fouling of contact surfaces.

EQUIPMENT OPERATIONAL FACTORS

Ultraviolet lamp efficiencies decline over time. Therefore, it is important when adopting a minimum intensity threshold for ultraviolet light treatment for the standard to state the output of the lamp at its lowest point according to the manufacturer’s suggested effective time of usage. Industry brochures show approximately thirty percent (30%) reduction in light transmission efficiency over a period of 10,000 hours. Operators and maintenance crews need to be adequately trained to service the equipment as recommended by the manufacturer.
EXPERIMENTAL

One possible solution to address the problem of quartz breakage is by studying the properties of a specially engineered sleeve (patent pending), called Fluoro-Safe™ (Figure 2). The non-fouling properties of the material that are used to make the sleeves reduces the need for most physical or chemical cleaning and hence, reduces the cost as well as maintenance time for most UV air disinfection units. In case of impact to the lamp, the Fluoro-Safe™ wrap retains the pieces of glass as well as other contents from the lamp within a sealed environment, therefore helping to prevent contamination to the downstream air flow. The test data presented will show the UV transmittance at 253.7 nm for various types and thicknesses of the Fluoro-Safe™ sleeves as well as data on the improvement of the surface reflectivity in a model UV germicidal air disinfection system. It will be shown that any UV energy loss due to the use of the Fluoro-Safe™ material is recovered fully by the right design, thickness of the sleeve material and lamp type. Additionally, it will be shown that a reflective material placed on the inner walls of the air disinfection unit where the UV lamps are placed, dramatically increases the UV intensity, therefore, achieving adequate disinfection of the air stream.

![Figure 2 Close-up view of the Fluoro-Safe™ sleeved germicidal UV lamps.](image)

TEST SETUP

Various Fluoro-Safe™ sleeves were used made of different types of materials and thicknesses for a comparison of UV transmittance at 254 nm, see Table 1.

For UV energy recovery, a cube was made of mirror-finished aluminum sheets with dimensions of 5 inches x 5 inches x 5 inches with polished sides facing toward the lamp. There are two openings on both sides of the box to accommodate a lamp and sleeve combination with a diameter of 3 inches. The openings are located in the middle and 0.2 inch above the base. The UV irradiance measurements were made through a 0.7-inch diameter port located in the middle of the top plate of the box, directly above the lamp (see Figure 3). The majority of UV disinfection applications use low pressure mercury arc lamps, producing primarily a wavelength of 253.7 nm. The research presented in this study incorporates low-pressure-high-output (LPHO) lamps with a wavelength of 253.7 nm, and the UV irradiance from LPHO lamps was measured with a Spectroline DRC-100X radiometer equipped with a DIX-254A UV-C sensor calibrated by the manufacturer to standards of the National Institute of Standards and Technology (NIST). Tests were performed on four different types of sleeves. Each test was repeated with a different set of sleeves with the same dimensions in order to check consistency. A LPHO lamp was used for this test, and UV lamp output efficiency comparison between the LO lamp and the LPHO lamp was made. Additionally, breakage testing was performed on the sleeved lamps to observe any visible signs of content spill.

![Figure 3. UV Test Box.](image)

RESULTS AND DISCUSSION

All the tests were carried out at room temperature and in air for UV transmittance of the materials mentioned above. Test results are summarized in Figures 4-8. From the results, material D turns out to be the best material in transmitting UV at 253.7 nm, followed by material E, material A, material B, and material C, respectively. The sleeved lamps also were field tested and operated in air for about 2,500 hours with no deterioration of the sleeve. The sleeved lamps were dropped from a height of 3 ft,
Table 1. Fluoro-Safe™ sleeve dimensions

<table>
<thead>
<tr>
<th>Material Type</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>D</th>
<th>D</th>
<th>E</th>
<th>E</th>
<th>E</th>
<th>Quartz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner Diameter (in)</td>
<td>0.875</td>
<td>0.875</td>
<td>0.875</td>
<td>0.875</td>
<td>0.875</td>
<td>0.875</td>
<td>0.875</td>
<td>0.875</td>
<td>0.858</td>
<td></td>
</tr>
<tr>
<td>Thickness T, (in)</td>
<td>0.02</td>
<td>0.017</td>
<td>0.02</td>
<td>0.02</td>
<td>0.04</td>
<td>0.06</td>
<td>0.02</td>
<td>0.04</td>
<td>0.06</td>
<td>0.057</td>
</tr>
</tbody>
</table>

Figure 4. Test # 1, Inner diameter of the sleeves is 0.875 inch.

Figure 5. Test # 2 = Test 1 is repeated with another set of sleeves of the same dimension.

and although the lamp broke in three different places, the contents, as well as the broken quartz were contained within the sleeved environment of the lamp and the overall physical dimensions of the lamp were preserved. Also a thirty percent (30%) drop in irradiance measurements was observed after the bottom of the surface was replaced with a wooden piece. It was observed that LPHO lamps gave an output about 2.5 times greater than those of the LP lamps. From the results, one can conclude that the engineered material definitely shows promise in UV air applications.

Figure 6. Test # 3 = Test 1 is repeated with another set of sleeves of the same dimension.

Figure 7. The percent UV transmittance through the skin of various Fluoro-Safe™ sleeves.

REFERENCES

1. Defining the Effectiveness of UV Lamps Installed in Circulating Air Ductwork, ARTI 21-CR Research Project 610-40030, Air-Conditioning and Refrigeration Technology Institute, the final report is expected to be available in the third quarter of 2002.

Figure 8. The average percent UV transmittance at 253.7 nm.


9. Ultraviolet light (C band) emitters shall be incorporated downstream of all cooling coils and above all drain pans to control airborne and surface microbial growth and transfer, GSA Facilities Standards for Public Buildings Service, section 5.4, Drains and Drain Pans, P 130, November 2000, PBS-P100.
Edmonton’s EPCOR UV Installation – Currently the World’s Largest

Reported by Jim Bolton, Associate Editor, IUVA News

EPCOR, the water utility for the City of Edmonton, Alberta, Canada and surroundings, installed in May, 2002, (currently) the world’s largest UV disinfection system for drinking water treatment at a design flow rate of 360 ML/day (95 mgd) (including one redundant reactor). This UV disinfection system treats filtered water with a percent transmittance (%T) between 90 and 98% (at 254 nm). The primary reason for this installation is to provide protection against Cryptosporidium and Giardia protozoa.

There are three flow lines (see Figure 1), each with a 48 inch diameter Calgon Carbon Sentinel™ UV reactor with six 20 kW medium pressure lamps arranged in three rows perpendicular to the water flow (see Figure 2).

The UV system can be operated in two modes: (1) manual (operator controlled – local and remote) or (2) automatic (PLC controlled). Real time data is being collected on historical UV dose, lamp status, sensor readings, lamp hours and wiper status. The UV dose delivered is calculated on the basis of computational fluid dynamics (CFD) calculations and irradiance modeling, with the lamp power, flow rate and sensor readings and the %T as input parameters.

The operating philosophy is designed to: (1) maintain a UV dose above an “alarm set point” of 40 mJ/cm², a minimum of two reactors on line at any time; (3) a minimum of four lamps on in each reactor at any time; making sure that all water quality parameters (e.g., %T) are met continually.

At present, Alberta Environment has given 1-log credit for Giardia inactivation for this UV system. It is hoped in the near future that they will grant 2.5-log or more credit for both Cryptosporidium and Giardia inactivation.

Further information on this new UV disinfection system can be obtained from Steve Stanley, EPCOR, 10065 Jasper Ave., Edmonton, AB T5J 3B1, Canada; Tel: (780) 412-7755; Email: sstanlev@epcor.ca.

First International Congress on UV Technologies – 14-16 June 2001 – Conference Proceedings

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EQUIPMENT SUPPLIERS: To purchase extra copies of IUVA News issues for distribution to your customers or to handout at your booths, contact Rip Rice (Editor – see p. 3) for prices and timing (e.g., back issues vs new issues).
Members of IUVA have access to the "Member Zone" at the IUVA Web Site (www.iuva.org). Your user ID and Password are on your IUVA Membership Card. If you cannot find your card, contact Kathy Harvey <kharvey@iuva.org>, and she will send you the information.

In the "Member Zone", you have access to:

- online versions of past issues of IUVA News
- a series of "UV Presentations"
- a "Discussion Board" (some very interesting information has been posted there.)
- UV Dose Protocol
- UV Buyer's Guide
- UV Disinfection Reference List.

Come visit us!!

The New York State Energy Research and Development Authority (NYSERDA) announces the availability of $900,000 for cost-shared projects that develop, demonstrate, or increase the use of innovative or underutilized energy-efficient water and wastewater technologies and systems. Projects targeting energy optimization/evaluation of ultraviolet (UV) disinfection systems are specifically encouraged. The proposed work must show energy and environmental benefits for municipal wastewater treatment plants (WWTP) or water treatment plants (WTP) in New York State. NYSERDA anticipates making multiple awards of up to $250,000 per project. Proposals are due on October 17, 2002. For more information, contact Kathleen O'Connor, 518-862-1090, ext. 3422, kno@nyserda.org, or visit NYSERDA's website: www.nyserda.org/23pon.html.

UVCalc is a Software Program for Ultraviolet Reactors Designed to Calculate:
- Average Fluence Rate (Irradiance) and hence the Fluence (UV Dose)
- Fluence Rate (Irradiance) Distributions

The program is based on the Multiple Point Source Summation Method with full accommodation of reflection and refraction at the air/quartz/water interface.

Now for a limited time, you can submit parameters online for a Free Calculation. Two Versions are available:
- Version 1 is designed for 1 UV lamp in an annular type reactor.
- Version 2 can handle up to 45 lamps in a reactor with a circular, rectangular or square cross section.
- The output data from UVCalc has been validated by the use of spherical actinometry.
- To access the online submission form, go to http://www.boltonuv.com and click on UVCalc 2.


For further information contact Jim Bolton at Bolton Photosciences Inc.
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The IUVA takes great pleasure in extending a heartfelt "welcome!!" to the following new members.

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Fountain Valley, CA — The California Department of Water Resources (DWR) awarded $30 million in grant funding to the Groundwater Replenishment System (GWR). This grant represents the single largest DWR award from the $91 million in Groundwater Storage Program funds available statewide, according to an Orange County Water District (OCWD) news release.

DWR recognized the GWR System for its potential to lessen overall impact on the Bay-Delta system in Northern California by reducing imported water demands an estimated 75,000 acre-feet per year and for its ability to compensate for future cutbacks in California's supply of the Colorado River by having a new local source of water available, OCWD said.

Once completed, the GWR System will take highly treated sewer water currently released into the ocean, and purify it through microfiltration, reverse osmosis and ultraviolet light with hydrogen peroxide advanced oxidation treatment, producing water similar in quality to bottled water. The purified water will become part of a seawater barrier and be pumped through a 13-mile pipeline to spreading basins in Anaheim where it will percolate into deep aquifers and blend with Orange County's other sources of groundwater, following the same natural filtering path rainwater takes through the ground, OCWD said.

The $30 million grant specifically provides funds for construction of water treatment facilities and pumping stations and the 13-mile pipeline from the treatment facilities to existing spreading basins. The project, OCWD, said, is scheduled to produce purified water by 2006.

From: WATER TECH ON-LINE, 18 July, 2002
Abstract: In order to better estimate the distribution of germicidal radiation in a room (20 x 20 ft) equipped to disinfect upper-room air, quartz tubes, 18 inches in length, were filled with an iodide/iodate actinometric solution and suspended vertically (i.e. along the z-axis) from the ceiling. Radiation is confined to the upper portion of the room (above 6 feet) by means of louvers in front of each lamp, which results in a beam 9 inches in height leaving the fixture. The tubes (3 mm ID) span the space in the upper room within which the radiation, generated by low-pressure mercury lamps located at 5 positions, is confined. Hence, this dosimetry system, referred to as longitudinal actinometry, integrates the radiation over the z-axis for a given x-y coordinate. Simultaneous measurements were made using 24 tubes evenly spaced 4 to 6 feet apart. At the same time, 24 spherical actinometers (quartz spheres, 0.9 cm ID filled with same actinometric solution) were also exposed; these were located at the same x-y coordinates 9 inches below the ceiling, i.e. in the middle of the beam. Hence, comparisons could be made between spherical actinometry and longitudinal actinometry. After 15 minutes of exposure the contents of the tubes and spheres were removed and the absorbance read at 352 nm using a spectrophotometer. The fluence was determined from the absorbance change using a quantum yield of 0.75. The results can be summarized as follows: (a) tubes provide a more self-consistent set of fluence data than spheres; (b) at positions closest to the lamp fixtures, the fluence measured by the spheres is twice that obtained using tubes, this difference decreases at greater distances as the beam depth increases but never reaches unity. (c) Using longitudinal actinometry, a volume-weighted fluence rate for each of the 24 sites was determined, and from this an average volume-weighted value of −18 microwatts per cm sq. for the upper 18 inches of the room. For the whole room this metric becomes 3.4 microwatts per cm sq, a figure that can be used to estimate the exposure time necessary to inactivate airborne pathogens, assuming an equal probability distribution within the room.
CATGON CARBON Corporation
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UV Disinfection

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• Treating drinking water for over 40 years
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COMMITTMENT
• Continuous R&D and product development investments
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VALIDATION
• Eight operating systems in drinking water disinfection against cryptosporidium
• Real world results treating over 90 mgd
• Validation using biodosimetry
• Installed testing and validation

ECONOMICS
• Cost effective control of cryptosporidium
• Simple installation
• Proven maintenance savings
• Flexible payment options

PROTECTION
• Uninterrupted treatment for protozoans, bacteria and viruses
• Sentinel combined with activated carbon treatment provides multiple barriers against accidental or intentional surface water contamination

Sentinel - largest installed UV reactors (48" at 95 mgd) for prevention of infection from cryptosporidium oocysts in drinking water.

For more information about the technology license or the Sentinel system, contact us at 1-800-422-7266 or visit our website: www.calgoncarbon.com