



January 1, 2004

Dave Witham, VP
UltraViolet Devices, Inc. (UVDI)
26145 Technology Drive
Valencia, CA 91355

Re: UVGI Model Validation

Dave,

This letter is to confirm the validity of the UVGI model currently being used in the proprietary UVDI software package known as V-Smart UVD and its derivations. The core program in this software package, called UVX, is based upon algorithms developed at Penn State and which have been published in various forms (Kowalski and Bahnfleth 2000, Kowalski 2001, Kowalski et al 2000, Kowalski and Bahnfleth 2003, Kowalski 2003). The primary references are given below:

- Kowalski, W. J., and Bahnfleth, W. P. (2000). **"Effective UVGI system design through improved modeling."** *ASHRAE Transactions*, 106v2:4-15.
- Kowalski, W. J. (2001). **"Design and Optimization of UVGI Air Disinfection Systems,"** PhD Thesis, The Pennsylvania State University.
- Kowalski, W. J., W.P. Bahnfleth, D.L. Witham, B.F. Severin, and T.S. Whittam, (2000). **"Mathematical modeling of UVGI air disinfection."** *Quant. Microb.* 2 :249-270.
- Kowalski, W. J. and W. P. Bahnfleth. (2003). **"Immune-Building Technology and Bioterrorism Defense."** *HPAC Engineering*. 75(1)57-62.
- Kowalski, W. J. (2003). **Immune Building Systems Technologies.** McGraw-Hill, New York.

The research into these methods was funded by UVDI and the proprietary software package was developed for UVDI as a work-for-hire by me. The results of the program have been validated in a series of some 30 laboratory tests sponsored by UVDI in which various microbes and UVGI systems were tested in two different laboratories. The results indicated excellent accuracy with a predictive error of less than 15% in 85% of cases. Analysis of these results was provided to UVDI in the following proprietary report:

Bahnfleth, W.P. T.S. Whittam, and W.J. Kowalski (2001), **FINAL REPORT: UVGI System Design and Optimization for Airstream Disinfection**, UVDI.

Technical support was also provided to UVDI for the development of additional software packages, including V-Smart Select™, (Modular Coil Irradiator Selection Guide) and V-Smart Save™ (A Return on Investment Calculator)." These programs are considered validated, state-of-the-art, software packages and they continue to acquire further validation as new test

results and data are provided by academia and by industry. I believe these are the most accurate tools available today for the sizing of UVGI systems and prediction of UVGI system performance. These products will likely continue to be improved upon as new information is developed and new data obtained. At present, the primary factor limiting the use of these algorithms is the shortage of laboratory data on UV irradiation of airborne microorganisms, but as such data is obtained the applicability of the programs will only be increased.

Sincerely Yours

A handwritten signature in cursive script that reads "W.J. Kowalski".

W.J. Kowalski, PE, PhD
The Indoor Environment Center
The Pennsylvania State University
Engineering Unit A
University Park, PA 16802