

3 pages, July 2007.

THE GUIDE FOR WORK with UV-OPAQUE LIQUIDS ON STERIBEAM SYSTEMS.

Also the draft ("white paper") for a congress presentation to be titled

**Sterilization of UV-semi-opaque (5%-25%) liquids
with pulsed and continuous UV systems from SteriBeam.**

Applications:

- pharmaceutical or cosmetic solutions with pulsed UVB+UVA light,
- juices (filtered) ,
- targeted upgrade of drink properties (e.g. artificial aging of brandies),
- sterilization/purification of contaminated waters,
- sterilization of emulsions.

§1. Finding the working distance of a fluid (the effective UV penetration).

The penetration of the UV light, as of any light, is described by the **the Lambert-Beer law**:

$$\frac{I_1}{I_0} = 10^{-A} = 10^{-\alpha l c}, \quad \alpha = \frac{4\pi k}{\lambda}$$

where

A - absorbance

I₀ - the intensity of the incident light,

I₁ - the intensity after passing through the material (liquid),

I₁/I₀ can be directly measured on UV spectrometer,

l - the distance that the light travels through the material (the path length),

c - the concentration of absorbing species in the material,

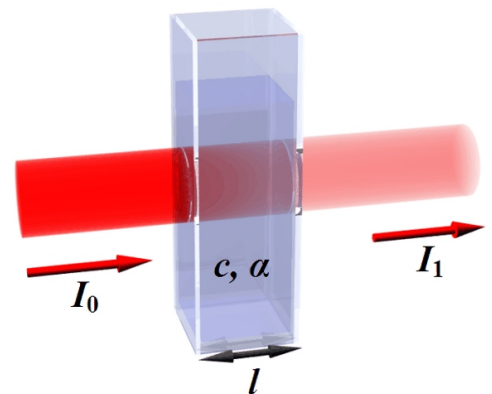
α - the absorption coefficient or the molar absorptivity of the absorber,

λ - the wavelength of the light,

k - the extinction coefficient.

For measurements of **I₁/I₀** one needs a UV transparent (like quartz) cell with a length **l_q** (usually 5 to 10 mm).

Opaque liquids usually pass just a few % of UV light on such a distance, therefore a liquid had to be diluted.



The degree of dilution is invert proportional to the active penetration length and have to be found empirically.

E.g., for the cell with $l_q=5$ mm and a opaque liquid with a concentration C_f , the 10 times dilution $C_d = C_f/10$ improves an average UVC (250-300 nm) transmission I_1/I_0 from 0.03 to 0.3.

Since diluted and non-diluted liquids are correlated as $\alpha l_q C_d = \alpha l_f C_f$, then these measurements allow to accurately find the penetration length of the non-diluted liquid as $l_f = l_q: 10=0.5$ mm.

§2. The UV exposure (and liquid circulation/mixing) for a given UV penetration l_f :

2.a. For CWUV system

displayed on our website, the max flow is 3/min (50 ml/sec), at the flow depth of 5 mm the reactor working volume $20 \times 10 \times 0.5$ cm= 100 ml and the time fo each 1 ml under the lamp is $100 \text{ ml}/50 \text{ ml/sec} = 2$ sec.

If to use the 0.5 mm penetration (as above), then 10 mixing is required (5 mm / 0.5 mm) so to get each layer exposed.

For the given circulated volume of a liquid (batch volume $V_b= 1$ l (1000 ml), the time to do so is $10 \text{ l}/3 \text{ l/min} = 3.3$ min.

The UVC exposure depends on a type of a micro-organism, and a reduction goal. For our CWUV system the UVC intensity is 30 mW/cm^2 , which gives 1 log reduction in 1 sec for many simple micro-organisms. The exposure of 2 sec brings it to 2 logs (60 mJ/cm²).

The total consuming power for this system (60 w lamp) for 1 l (3.3 min or ca. 200 sec, 0.055 h) is 1200 J or 3.3 kwh/m³

2b. For pulsed UV system

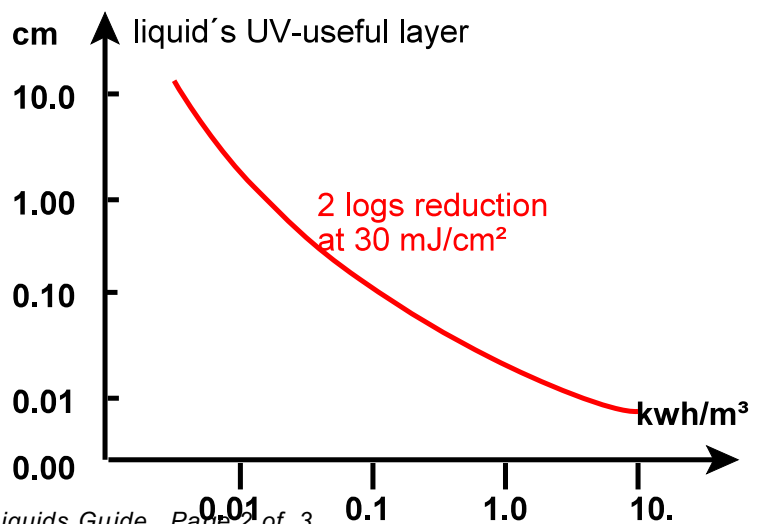
(as in our case) the vessel volume is 80 ml, and the liquid thickness is 2 mm, therefore 4 mixing is require for each exposure. For the same as above exposure for each layer (30 mJ/cm^2) and the total reactor surface of 480 cm, each pulse has to deliver $0.03 \text{ J/c}^2 \times 480 \text{ cm}^2 = 14 \text{ J/pulse}$ in useful UV. At the average lamp efficiency of 20%, that means 72 J/pulse, so 4 pulses are required to treat 80 ml (for 2 logs), or ca. 1 kJ/l. At the productivity of 1 l/sec, it brings the energy cost of 1 kwh/m³.

Both results show that CWUV and PUV have energy costs below those of pasteurisation.

These results can be expressed as a chart, showing the increase of energy costs with a decrease of the working layer (e.i. with the decrease of UV transparency):

NEW DATA CHARTS are planned to be build both for CWUV and PUV for LIQUIDS OFa market value.

(planned for this fall)



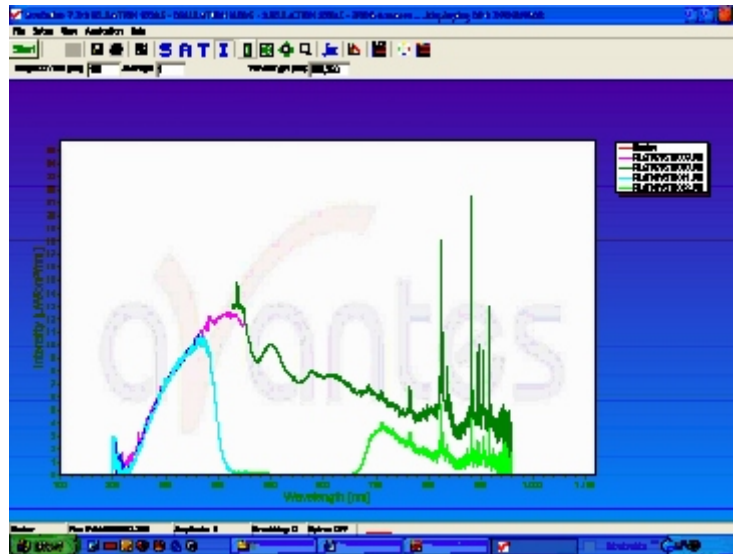
The usage of filters taking out all the unnecessary heat load by visible and IR light is shown below and highly recommended for sensitive liquids (since visible light bleaches colours).

Spectra of the flash lamp:

top curve - non-filtered light,

bottom with a U filter:-

(From SteriBeam marketing presentations for the lamp of the PUV station, proprietary, please, do not reproduce this and above charts without our permission!).



NOTE:

We highly recommend to use our Guide to Sterility Tests (see INFO at our website) for all the sampling and its bio-evaluation so to avoid common pitfalls, leading to unclear or negative results.

§3. Invitation to take joint data on liquids of interest to a customer

We plan to complete this report after taking data in the fall -winter 2007 as our self-financed effort or jointly with to be interested customers so to report it on one of related Congresses in 2008.

We invite our potential customers and/or academic collaborators to take part in such an evaluation and to participate in this congress report.

If interested please contact us at info@steribeam.com

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