In-Duct UVGI, Whole Room Air, and Comparison with UVGI

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Grigory V. Volchenkov, MD, Vladimir, Russia
UVGI for airborne infection control

1. Whole room (“Open”) UVGI fixtures (incl. BSCs, sputum collection booths)
2. Upper room (“Shielded”) UVGI fixtures
3. In-duct decontamination of exhaust air from high risk zones
4. UVGI recirculators with fan inside
5. Decontamination of recirculating air in return-air ducts
Exhaust air UVGI decontamination unit
Vladimir Penitentiary MDR TB ward
In-duct UVGI for exhaust air decontamination
State system of sanitary-epidemic normalizing Russian Federation

Prevention of infection diseases

ULTRAVIOLET BACTERICIDAL IRRADIATION FOR DECONTAMINATION OF THE AIR AND SURFACES IN ROOMS

GUIDELINES
P 3.1.683-98

Ministry of Health Russia
Moscow
1998
## Calculation of # of 30W UVGI lamps

<table>
<thead>
<tr>
<th>Object of Decontamination</th>
<th>System of Decontamination</th>
<th>Equations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>Radiators unshielded and shielded</td>
<td>( N = \frac{S \cdot h \cdot H_v}{\sum F \cdot K \cdot t} ), units</td>
</tr>
<tr>
<td>Air</td>
<td>Negative pressure ventilation (UV lamps are in the exhaust chamber)</td>
<td>( N = \frac{S \cdot h \cdot H_v}{F \cdot K \cdot t} ), units</td>
</tr>
<tr>
<td>Surface of the Floor</td>
<td>Radiators Unshielded</td>
<td>( 1.5 ) ( N = 0.56 \cdot S \cdot h \cdot \frac{H_s}{\sum F \cdot \eta \cdot t} ), units</td>
</tr>
</tbody>
</table>
Calculation of # of 30W UVGI lamps

\[ N = \frac{S \cdot h \cdot H_v}{F \cdot K \cdot t} \]

- \( S \cdot h \): Irradiated volume (m\(^3\))
- \( H_v \): Bactericidal volume dose (J/m\(^3\))
- \( F \): Bactericidal flux of lamp (UV Watts)
- \( K \): Coefficient of bacterial flow usage
- \( t \): Conversion h to s (3 600)
Calculation of UVGI lamps per in-duct unit

<table>
<thead>
<tr>
<th>Duct #</th>
<th>Flowrate m3/h</th>
<th>Diameter mm</th>
<th>Area m²</th>
<th>Velocity m/s</th>
<th>Flowrate cfm</th>
<th>Diameter inches</th>
<th>Area ft²</th>
<th>Velocity fpm</th>
<th>UV Watts</th>
<th>Number of 17.5 UV watt lamps</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1400</td>
<td>280</td>
<td>0.0616</td>
<td>6.32</td>
<td>824</td>
<td>11.0</td>
<td>0.6628</td>
<td>1243</td>
<td>24.9</td>
<td>1.42</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>2700</td>
<td>315</td>
<td>0.0779</td>
<td>9.62</td>
<td>1589</td>
<td>12.4</td>
<td>0.8388</td>
<td>1994</td>
<td>42.7</td>
<td>2.44</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>8200</td>
<td>560</td>
<td>0.2463</td>
<td>9.25</td>
<td>4826</td>
<td>22.0</td>
<td>2.6512</td>
<td>1820</td>
<td>73.0</td>
<td>4.17</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>4900</td>
<td>450</td>
<td>0.1590</td>
<td>8.56</td>
<td>2884</td>
<td>17.7</td>
<td>1.7119</td>
<td>1685</td>
<td>54.3</td>
<td>3.10</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>9100</td>
<td>630</td>
<td>0.3117</td>
<td>8.11</td>
<td>5356</td>
<td>24.8</td>
<td>3.3554</td>
<td>1596</td>
<td>72.0</td>
<td>4.11</td>
<td>4</td>
</tr>
</tbody>
</table>

GE BULLETIN LD11 PAGE 26 DATED 1:50
I.J Buttolph, Howard Haynes

Duct air speeds up to 1000 fpm (5.08 m/s) may be disinfected a theoretical 99% by installing germicidal tubes directly in the ducts. The total ultraviolet watts (uww) may be calculated by the empirical formula: UV Watts = \( \frac{Q_{\text{cfm}}}{(3 \times D_{\text{in}})} \), where \( D \) = minor or lessor duct dimension in inches and is not exceed by more than 50% by the major dimension.

UV Watts = \( \frac{Q_{\text{cfm}}}{(3 \times D_{\text{in}})} \) = \( \frac{Q_{\text{m}^3/\text{h}}}{(0.2 \times D_{\text{mm}})} \)
In-duct UVGI application in Vladimir, Russia

• Exhaust air decontamination from high risk zones:
  – Bacteriology laboratory “dirty” zone
  – Bronchoscopy unit
  – Sputum collection booths
  – Floors for sputum smear positive patients

• Utilized since 2005 in Vladimir TB Dispensary (Russia)
Serratia marcescens or Bacillus subtilis
Bioaerosol generation upstream of in-duct UVGI units
Bioaerosol sampling before UVGI
Alternative Kclimate UVGI Units
Korf UVGI Unit
Bioaerosol sampling after UVGI
Our on-site laboratory
Results

Upstream UVGI

Downstream UVGI
## Preliminary Results

<table>
<thead>
<tr>
<th>Unit</th>
<th><em>Serratia marcescens</em></th>
<th><em>Bacillus subtilis</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative Klimate</td>
<td>&gt;99.9%</td>
<td>98.7%</td>
</tr>
<tr>
<td>Korf</td>
<td>99.7%</td>
<td>98.3%</td>
</tr>
</tbody>
</table>
Maintenance of in-duct UVGI units

- Cleaning of UVGI lamps with 70% alcohol - quarterly
- Coarse (MERV 4-5) pre-filter replacement - quarterly
- UVGI and air flow measurement - quarterly
- UVGI lamps replacement
  - Annually without a meter
  - 30% drop in irradiance (depends on design)
Two TUV-30 lamps UVGI fixture (OBN-150, Russia)

Courtesy of G.Volchenkov
Whole Room UVGI Unit
6 - 30W lamps
Whole room UVGI fixture
(MDR TB Ward, Dushanbe, Tajikistan)
Impulse Xenon IVGI Unit “Alfa-01”, Russia

- High intensity impulse irradiance
- Wave length - 200 – 800 nm
- Dose (250-400 nm) @ 1m – 100µJ/cm² (1J/m²)
- Frequency of impulses 2,5 Hz
- Cost ~ 20.000 USD
Sputum Collection Booth with Open UVGI Lamp

- Unshielded UVGI fixture installed inside (for fast air decontamination after Pt leaves the booth)

- Negative pressure

- 20 – 24 ACH
TABLE 1. Air changes per hour (ACH) and time required for removal efficiencies of 99% and 99.9% of airborne contaminants*

<table>
<thead>
<tr>
<th>ACH</th>
<th>Minutes required for removal efficiency†</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>99%</td>
</tr>
<tr>
<td>2</td>
<td>138</td>
</tr>
<tr>
<td>4</td>
<td>69</td>
</tr>
<tr>
<td>6</td>
<td>46</td>
</tr>
<tr>
<td>12</td>
<td>23</td>
</tr>
<tr>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>20</td>
<td>14</td>
</tr>
<tr>
<td>50</td>
<td>6</td>
</tr>
<tr>
<td>400</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

* This table can be used to estimate the time necessary to clear the air of airborne *Mycobacterium tuberculosis* after the source patient leaves the area or when aerosol-producing procedures are complete.

† Time in minutes to reduce the airborne concentration by 99% or 99.9%.

http://www.cdc.gov/mmwr/PDF/rr/rr5417.pdf
TABLE 1. Air changes per hour (ACH) and time required for removal efficiencies of 99% and 99.9% of airborne contaminants*

<table>
<thead>
<tr>
<th>ACH</th>
<th>99%</th>
<th>99.9%</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>138</td>
<td>207</td>
</tr>
<tr>
<td>4</td>
<td>69</td>
<td>104</td>
</tr>
<tr>
<td>6</td>
<td>46</td>
<td>69</td>
</tr>
<tr>
<td>12</td>
<td>23</td>
<td>35</td>
</tr>
<tr>
<td>15</td>
<td>18</td>
<td>28</td>
</tr>
<tr>
<td>20</td>
<td>14</td>
<td>21</td>
</tr>
<tr>
<td>50</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>400</td>
<td>&lt;1</td>
<td>1</td>
</tr>
</tbody>
</table>

So . . . How long between patients with unshielded UVGI on?

http://www.cdc.gov/mmwr/PDF/rr/rr5417.pdf
 Threshold Limit Value (TLV)

- For UVGI (254 nm) – 6000 μJ/cm² over an 8 hour period

- Upper irradiance level at eye height for exposure:
  - Former Soviet Union countries – ≤0.1 μW/cm²
  - USA, European Union – 0.2 μW/cm² 8-h
  - South Africa – 0.4 μW/cm² 8-h
Eye UVGI over exposure symptoms

- photokeratoconjunctivitis:
  - Pain
  - Sensation of a foreign body
  - Excessive tearing
  - Conjunctival injection
  - Periorbital edema (very rare)

Inflammation of the outer layer of the cornea experienced several hours after overexposure and resides within 24 – 48 hour period in the absence of additional exposure. No residual findings reported.
Skin UVGI over exposure symptoms

Photodermatitis – less common:
- Skin erythema
- Irritation
- Facial skin peeling (rare)

resides within 48 hour – 2 week period in the absence of additional exposure. No residual findings reported.
Upper-room UVGI unit with fan
Modified UVGI Fixture (OBN-150) with Shielded and Open lamps
UVGI Measurement Device

– Gigahertz-Optik model X911 UVC-meter with UV-3718-4 detector (Germany).
Determinants of Effectiveness of Upper Room UVGI

- UVC irradiance in the upper air
- Size of irradiated sector
- Rate of air mixing between upper and lower zones
- Specific susceptibility of a microbe to UVGI

Adapted from First M.W., Nardell E.A., Chaisson W., Riley R. 1999 Guidelines for the Application of Upper Room UVGI for Preventing transmission of Airborn Contagion. Part I and II. *ASHRAE transactions* 105(1)
Louvered Upper Room UVGI Fixtures

(a) Wall-mounted fixture (compact lamps)

(b) Corner-mounted fixture (compact lamps)

(c) Ceiling-mounted fixture (compact lamps)

(d) Wall-mounted fixture (fluorescent style lamps)

Representative commercial upper-room UVGI fixtures. (Photos 2a - 2c courtesy Lumalier; Memphis, Tenn. Figure 2d courtesy Atlantic Ultraviolet Corp., Hauppauge, N.Y.)
Shielded Upper Room UVGI fixture

Courtesy of G. Volchenkov
Use of lower, open lamp for irradiation entire room space while patients and staff are absent

Courtesy of G.Volchenkov
Measurement of UVGI: Operator Tips

– Wear glasses;
– Avoid to look unprotected directly on unshielded lamp;
– Accurately check distance to the UVGI source and direction of sensor;
– Ozone odor is sign of poor lamp quality, subject for immediate replacement.
– Keep records.
Measurement of UVGI: Safety Evaluation

– At bed, standing and sitting eye level,
– Check direct irradiation from lamp,
– and all possible reflective directions (from ceiling, walls, ducts, equipment, polished and shining surfaces, etc).
– “Peak” measurement mode is recommended for “quick search”.
Measuring of UVGI Irradiance at Eye Level

Courtesy of G. Volchenkov
Measurement of UVGI: Safety Evaluation

Maximum exposure limits
- \(6,000 \, \mu J/cm^2 = 6,000 \, \mu W \text{ per sec } /cm^2\)
- \(0.2 \, \mu W/cm^2\) continuous for 8 hours

For UV exposures certain to be less than full day, intensities higher than \(0.2 \, \mu W/cm^2\) may be acceptable.
Measurement of UVGI: Efficiency Evaluation

At the distance of 1m, detector exactly directed to lamp:

- New Phillips TUV-30 lamp – ~280-300 \( \mu \text{W/cm}^2 \)
- Expired lamp: if \( \leq 100 \ \mu \text{W/cm}^2 \) @ 1m – NEEDS TO BE REPLACED
Measurement of UVGI in upper part of patient room

Courtesy of G.Volchenkov
Saving resources by using UVC – meter and routine maintenance

Cost of UVC-meter – 1.500 USD
Cost of TUV-30 lamp 40 USD
Number of lamps - 160
Manufacturer’s guaranty – 8000 h (~ 1 year continuous use)
Average actual lamp life 2,5 – 3,5 years for 90% of lamps
Money saved during 1st year:
(40 x 160 x 90%) – 1500 = 4.260 USD
Upper room UVGI fixture
Installation – in high risk zones

- Patient rooms for hospitalized TB patients and suspects
- Examination rooms
- Indoor congregating areas for patients
- Toilets and smoking rooms
- Waiting areas
- Bronchoscopy rooms
- Sputum collection rooms/booths
- Autopsy rooms
- High risk areas in laboratories
- Homeless shelters
Upper room UVGI fixture: unreasonable installation

Examination room, NTC, Kathmandu, Nepal
Upper room UVGI fixture: unreasonable installation

TB research room in Uganda.
Courtesy of Paul Jensen.
Upper room UVGI fixture: unreasonable installation

Recreation room in Brasil
Courtesy of Paul Jensen.
Upper room UVGI fixture: unreasonable installation

Courtesy of Paul Jensen.
Unsafe Design and Installation

Corridor, MDRTB Ward, TB Dispensery, Almaty, Kazakhstan. Irradiance at eye level up to 4 $\mu$W/cm$^2$
Installation of Upper Room UVGI Fixture

Room factors to consider:
- Level of risk
- Total area
- Shape
- Height of ceiling
- Reflective properties of surfaces
- Accessibility for maintenance
Installation of Upper Room UVGI Fixture

Room factors to consider:

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Installation of Upper Room UVGI Fixture

Room factors to consider:

– Level of risk
– Total area
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– Height of ceiling
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– Accessibility for maintenance

At least one 30W fixture per 18 – 20 m²
Installation of Upper Room UVGI Fixture

Room factors to consider:

– Level of risk
– Total area
– Shape
– Height of ceiling
– Reflective properties of surfaces
– Accessibility for maintenance

Wall-mounted fixture – in the center of longer wall
Ceiling-mounted fixture – in the center
Installation of Upper Room Fixture

Room factors to consider:

– Level of risk
– Total area
– Shape
– Height of ceiling
– Reflective properties of surfaces
– Accessibility for maintenance

With ceiling height less than 220 cm, installation is problematic.

Higher ceilings are better.

SS+ TB floor corridor, Vladimir
Upper room UVGI fixtures in SS+ TB Ward Corridor

- Low and highly reflective ceilings (2.2 m)
- Low occupancy – short exposure time
- UVC – irradiance at 1.5 m height at the opposite wall – 0.4 µW/cm²
- Not any complaints or symptoms of overexposure since 2005
Upper room UVGI fixtures in SS+ TB Ward Corridor

- Low and highly reflective ceilings (2.2 m)
- Low occupancy – short exposure time
- UVC – irradiance at 1.5 m height at the opposite wall – 0.4 µW/cm²
- Not any complaints or symptoms of overexposure since 2005
Installation of Upper Room UVGI Fixture

Room factors to consider:
- Level of risk
- Total area
- Shape
- Height of ceiling
- Reflective properties of surfaces
- Accessibility for maintenance

Reflection of UV:
- White plaster – 40 – 60%
- Oil paints – 3 – 10%
- Water based paint – 10 – 35%

Consider repainting with non-reflective materials (containing titanium dioxide)
<table>
<thead>
<tr>
<th>Material</th>
<th>Reflectance %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium: untreated surface</td>
<td>40-60</td>
</tr>
<tr>
<td>treated surface</td>
<td>60-89</td>
</tr>
<tr>
<td>Sputtered on glass</td>
<td>75-85</td>
</tr>
<tr>
<td>‘ALZAK’ – treated aluminium</td>
<td>65-75</td>
</tr>
<tr>
<td>‘DURALUMIN’</td>
<td>16</td>
</tr>
<tr>
<td>Stainless steel/Tin plate</td>
<td>25-30</td>
</tr>
<tr>
<td>Chromium plating</td>
<td>39</td>
</tr>
<tr>
<td>Various white oil paints</td>
<td>3-10</td>
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<tr>
<td>Various white water paints</td>
<td>10-35</td>
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<tr>
<td>Aluminium paint</td>
<td>40-75</td>
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<tr>
<td>Zinc oxide paint</td>
<td>4-5</td>
</tr>
<tr>
<td>Black enamel</td>
<td>5</td>
</tr>
<tr>
<td>White baked enamel</td>
<td>5-10</td>
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<tr>
<td>White plastering</td>
<td>40-60</td>
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<tr>
<td>New plaster</td>
<td>55-60</td>
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<tr>
<td>Magnesium oxide</td>
<td>75-88</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>70-80</td>
</tr>
<tr>
<td>Linen</td>
<td>17</td>
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<tr>
<td>Bleached wool</td>
<td>4</td>
</tr>
<tr>
<td>Bleached cotton</td>
<td>30</td>
</tr>
<tr>
<td>Wallpapers: ivory</td>
<td>31</td>
</tr>
<tr>
<td>white</td>
<td>21-31</td>
</tr>
<tr>
<td>red printed</td>
<td>31</td>
</tr>
<tr>
<td>ivory printed</td>
<td>26</td>
</tr>
<tr>
<td>brown printed</td>
<td>18</td>
</tr>
<tr>
<td>White notepaper</td>
<td>25</td>
</tr>
</tbody>
</table>

Table 3. Reflectance of various materials to UV-254 nm radiation.
<table>
<thead>
<tr>
<th>МАТЕРИАЛ</th>
<th>ОТРАЖАЮЩИЕ УФБИ СВОЙСТВА (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Алюминий: необработанный</td>
<td>40 - 60</td>
</tr>
<tr>
<td>полированный</td>
<td>60 – 89</td>
</tr>
<tr>
<td>напыление на стекло</td>
<td>75 - 85</td>
</tr>
<tr>
<td>Дюралюмин</td>
<td>16</td>
</tr>
<tr>
<td>Нержавеющая сталь, жесть</td>
<td>25 - 30</td>
</tr>
<tr>
<td>Хромированная поверхность</td>
<td>39</td>
</tr>
<tr>
<td>Белая масляная краска</td>
<td>3 - 10</td>
</tr>
<tr>
<td>Белая водоэмульсионная краска</td>
<td>10 – 35</td>
</tr>
<tr>
<td>Алюминиевая краска</td>
<td>40 – 75</td>
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<tr>
<td>Цинковые белила</td>
<td>4 – 5</td>
</tr>
<tr>
<td>Черная эмаль</td>
<td>5</td>
</tr>
<tr>
<td>Белая эмаль</td>
<td>5 – 10</td>
</tr>
<tr>
<td>Штукатурка</td>
<td>40 - 60</td>
</tr>
<tr>
<td>Оксид магния (магнезия)</td>
<td>75 - 88</td>
</tr>
<tr>
<td>Карбонат кальция (известь)</td>
<td>70 - 80</td>
</tr>
<tr>
<td>Постельное белье</td>
<td>17</td>
</tr>
<tr>
<td>Отбеленная шерсть</td>
<td>4</td>
</tr>
<tr>
<td>Отбеленная хлопчатобумажная ткань</td>
<td>30</td>
</tr>
<tr>
<td>Обои</td>
<td>18 - 31</td>
</tr>
<tr>
<td>Писчая бумага</td>
<td>25</td>
</tr>
</tbody>
</table>
Installation of Upper Room UVGI Fixture

Room factors to consider:

– Level of risk
– Total area
– Shape
– Height of ceiling
– Reflective properties of surfaces
– Accessibility for maintenance
Basic principles:

• provide maximal UVGI irradiance in the upper portion of the room and safe level of UVGI (below 0.2 μW/cm²) in occupied area.

• take into account importance of adequate air mixing (fan, ventilation, heat radiators)
UVGI fixture maintenance

• Monthly cleaning of lamps and fixture surfaces by 70% Spirit (no soap or detergent solutions!). In dusty conditions – two times per month, after renovations etc. – extra cleaning.

• Twice a year measurement of UVGI level in occupied zone (eye level) and in upper portion of the room at distance of 1m

• Replacement of lamps:
  – if UVGI meter is not available – after 8000 h use according to usage records (?)
  – if UVGI meter is available – when lamp decreases irradiation below 100 μW/cm² at distance of 1 m
Administrative support (1)

• Education of HCW
  – Basic principles of UVGI systems, mechanism and limitations;
  – Potential hazardous effects of UVGI if overexposure occurs;
  – Potential for photosensitivity associated with certain medical conditions or use of certain medications;
  – The importance of maintenance procedures and record-keeping

• Education of patients and visitors
CAUTION

Ultraviolet Energy

Turn off lamps before entering the upper part of the room.
(The upper part of the room is the space above the UVGI fixtures.)
Administrative support (2)

- Trained technician for UVGI measurement and fixture maintenance
- Policies (SOPs) for use, regular cleaning, maintenance and record keeping
- Distribution of 70% Spirit to responsible persons (3 g / lamp / month)
- Procurement of certified TUV-30 lamps for replacement
- Identification of other high risk zones for new installations
“Upper room germicidal system should be left on continuously, day and night, as frequent switching, especially with operating intervals of three hours or less, materially reduces lamp life.”

From First M.W., Nardell E.A., Chaisson W., Riley R. 1999 Guidelines for the Application of Upper Room UVGI for Preventing transmission of Airborn Contagion. Part I and II. ASHRAE transactions 105(1)
## Routine Maintenance

<table>
<thead>
<tr>
<th>Distance from UVGI</th>
<th>Before Cleaning</th>
<th>After 1st Cleaning</th>
<th>After 2nd Cleaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 m</td>
<td>30 μW/cm²</td>
<td>10 μW/cm²</td>
<td>100 μW/cm²</td>
</tr>
<tr>
<td>2 m</td>
<td>20 μW/cm²</td>
<td>10 μW/cm²</td>
<td>31 μW/cm²</td>
</tr>
<tr>
<td>3 m</td>
<td>19 μW/cm²</td>
<td>11 μW/cm²</td>
<td>25 μW/cm²</td>
</tr>
<tr>
<td>4 m</td>
<td>13 μW/cm²</td>
<td>9 μW/cm²</td>
<td>15 μW/cm²</td>
</tr>
<tr>
<td>5 m</td>
<td>9 μW/cm²</td>
<td>6 μW/cm²</td>
<td>10 μW/cm²</td>
</tr>
<tr>
<td>6 m</td>
<td>7 μW/cm²</td>
<td>5 μW/cm²</td>
<td>7 μW/cm²</td>
</tr>
<tr>
<td>7 m</td>
<td>4 μW/cm²</td>
<td>5 μW/cm²</td>
<td>6 μW/cm²</td>
</tr>
</tbody>
</table>

Autoclave Room – Installed 1998, Measured 2001, No maintenance record

Courtesy of Paul Jensen
UVGI Fixture Cleaning

Courtesy of Paul Jensen
UVGI Fixture Cleaning

Courtesy of Paul Jensen
Records of UVGI irradiance, semiannual check

<table>
<thead>
<tr>
<th>Этаж</th>
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<th>Исправность</th>
<th>Причина неисправности</th>
<th>Дата устранения</th>
<th>Облученность (mW/cm²) на расстоянии 1 м</th>
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<td>15</td>
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<td>поменять стартёр</td>
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</table>

Courtesy of G.Volchenkov
Акт проверки

С применением ультрафиолетового радиометра «Lumalier» проведена плановая проверка с измерением мощности бактерицидного ультрафиолетового излучения ламп, установленных в бактерицидных устройствах в здании стационара ГУЗ ВО ОПТД для определения возможности их дальнейшего использования или необходимости замены.

В результате проверки заменена одна сгоревшая лампа (коридор ЛХО, №1), выявлен ряд неисправностей в бактерицидных устройствах в связи с отсутствием электрического контакта (см. протокол), которые подлежат немедленному устранению.

В результате инструментальных измерений установлено, что на расстоянии 1 м для всех ламп мощность УФ излучения превышает допустимый минимум — 100 μW/cm², таким образом лампы могут в дальнейшем использоваться для обеспечения эффективного обеззараживания воздуха и поверхностей в помещениях.

Срок следующей проверки годности ламп — 4 квартал 2008 года.

Приложение: протокол проверки на 5 листах.

Электрик

Главная медицинская сестра

Главный врач

Копылов Н.В.

Большакова Т.Н.

Волченков Г.В.
## Equivalent Efficiency

<table>
<thead>
<tr>
<th>Control</th>
<th>Equivalent ACH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical ventilation</td>
<td>2.45</td>
</tr>
<tr>
<td>Upper room UVGI</td>
<td>6.56</td>
</tr>
<tr>
<td>Upper room UVGI + Ventilation</td>
<td>7.55</td>
</tr>
<tr>
<td>Upper room UVGI + Mixing fan</td>
<td>7.61</td>
</tr>
</tbody>
</table>
UVGI Air Cleaners - Recirculators
UVGI air cleaner - recirculator

Front cover removed for cleaning and demonstration
UVGI Air Cleaner – Recirculator
UVGI air cleaner - recirculator

Decontaminated (?) air

Fan

UVGI - lamps

Harsh filter

Contaminated air
UVGI - lamp

Fan

Coarse filter

Decontaminated (?) air

Contaminated air

Exposure = L / Air velocity (sec)

UVGI Dose = Mean irradiance x Exposure (µJ/cm²)

Unit capacity = Air velocity x Opening area (m³/hour)

Equivalent ACH = Unit(s) capacity / Room volume, given UVGI dose ≥ 17600 µJ/cm² (?) and perfect room air mixing
UVGI air cleaner – recirculator: weakness

1. Low capacity
   1. Fan
   2. UVGI lamps
2. Possible air short circuit
   1. External
   2. Internal
3. Maintenance
   1. Cleaning of coarse filter
   2. Disassembling and cleaning of lamps
4. Need for good air mixing
5. Difficult to check effectiveness
6. Cost per room volume
Press Release-
Bacticlean
August 2006

Ultra-violet disinfection effective in tests

Hospital tests have shown that the Bacticlean ultra-violet disinfection system from Victory Lighting will effectively reduce air-borne contamination.

Hospital tests have shown that the Bacticlean ultra-violet disinfection system from Victory Lighting will effectively reduce air-borne contamination in hospital theatre and ward situations within minutes.

Methicillin resistant staphylococcus aureus contamination counts were significantly reduced after just 10 minutes from the system being switched on. These controlled laboratory tests gave a Log10 reduction 3, which was cut to 1.33 when the Bacticlean unit was switched off.
So . . . How much UVGI will go through this???
Efficiency of UVGI Recirculators
Efficiency of UVGI Recirculators

**Graph:**

- **Y-axis:** КОЕ/м³
- **X-axis:** Время, ч

- **Red line:** без рециркулятора
- **Blue line:** с рециркулятором
Efficiency of UVGI Recirculators

Concentration (CFU/m³) vs. Elapsed Time (h)

Equation:

\[ y = 217.3e^{-0.2474x} \]

ACH = 0.25
Conclusions

• Upper Room UVGI is a cost-effective environmental control
• HCWs (and patients) have to be educated to understand the principles of UVGI.
• A public health manager/specialist is expected to understand the principles of UVGI and make some basic measurements as part of the routine maintenance.
• A qualified technical expert is responsible for the installation of the devices and maintenance according to the standards provided by the producers and in line with existing international and country regulations.
References

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• CDC, 2005 Guidelines for Preventing the Transmission of Mycobacterium tuberculosis in Health-Care Settings. MMWR Vol.54 No.RR-17

• Francis J. Curry National Tuberculosis Center, 2006 Tuberculosis Infection Control. A Practical Manual for Preventing TB

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Questions?

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