Workshop—Introduction and Demonstration: Computer Aided Design (CAD) Program for the Design of Complex Upper Room UVGI Systems

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Building Design and Engineering Approaches to Airborne Infection Control
Harvard School of Public Health
Boston MA
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  – Chuck Dunn, Lumalier

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CAD UVGI TOOL Objectives*

- Develop a standardized protocol allowing UVGI equipment manufacturers to define and publish the emission characteristics of their fixtures
- Adapt existing lighting programs for use with germicidal radiation radiometric data by modifying existing electronic data files
- Determine average upper room UVGI intensity and distribution from multiple overlapping fixtures in a wide variety of existing rooms
- Validate the computer design tool using standard radiometers equipped with 360 degree UV

*St. Vincent’s Hospital-HSPH-Acuity Lighting NYSERDA Project 9425
Visual Professional Edition (Released 1999)

- The Professional Edition is comprehensive lighting design software with a 3-D modeling interface for the construction and analysis of interior and exterior lighting designs. It imports DWG/DXF files.

- The Professional Edition generates high-quality construction documents of the lighting design. The final design can be exported to an AutoCAD DWG/DXF file to be transferred to the end customer.

20,000 Active Users

- Specifier: 58%
- Acuity Agents and Employees: 17%
- Contractor: 5%
- Distributor: 6%
- Utility: 14%
- Other Profession: 1%
UVGI Specific Features

• Visual Professional Edition has been modified to calculate UV-C irradiance in addition to visible light.
  – Planar irradiance; for calculating eye exposure.
  – Spherical irradiance, or fluence rate; for calculating germicidal dose.

• Visual can display three-dimensional irradiance webs, which can be set to any desired threshold fluence rate.
  – Useful for initial placement of fixtures.

• Visual can also graphically display the combined total fluence rate due to multiple fixtures and interreflected radiation.
  – Useful for evaluating volumetric coverage of the germicidal zone.
Characterization of Upper Room UV-C Fixture
By Hand

Since the louvers are inclined slightly upwards the emission centerplane rises relative to the horizontal centerplane.
A moving-mirror goniophotometer
Determining radiant intensity

- Testing a luminaire as if it were a point
- $D_{test} > 5 \cdot$ maximum luminaire dimension
IESNA Electronic File Standard

- **IESNA:LM-63-2002**
  - [Keyword 1] Keyword data
  - [Keyword 2] Keyword data
  - [Keyword 3] Keyword data
  - ……
  - [Keyword n] Keyword data

TILT=<filename> or **INCLUDE** or **NONE**
- <lamp to luminaire geometry>
- <number of tilt angles>
- <angles>
- <multiplying factors> Above four lines shall be present if and only if **TILT=INCLUDE**

- <number of lamps> <lumens per lamp> <candela multiplier> <number of vertical angles> <number of horizontal angles>
- <photometric type> <units type> <width> <length> <height>
- <ballast factor> <future use> <input watts>
- <vertical angles>
- <horizontal angles>
- <candela values for all vertical angles at 1st horizontal angle>
- <candela values for all vertical angles as 2nd horizontal angle>
  :<candela values for all vertical angles at last horizontal angle>
A typical photometric report
Developing a similar radiometric report for UVGI
Placement of UVGI Fixtures
TUSS Case Study

Grand Central Drop-In Center
St. Agnes Church Basement
143 E 43rd Street NYC
Applying Upper Air UVGI in Congregate Settings—New York City
Summary requirements driving Designs for TB irradiation.

- UVC source primarily at 254 nm
- UV level measured 1.8 m (6 ft) from floor not to exceed 6000 μJ/cm² over 8 hours*.
- UV Dose = UV irradiance (μW/cm²) * exposure time (seconds)
  - For TB, 10 μW/cm² for 120 seconds = 99% kill (ASHRAE CH-99-12-1)
  - Customary installation: 30 W UV lamp input power per 18.6 m² (200ft²)
    - Model Room Studies are suggesting an average UV fluence be used
    - Key question is how to measure in the field
    - Lamp output power ≅ 25% to 33% input power
    - Lamp efficiency versus lamp temperature and age
- Room vertical airflow rate - TBD (well mixed air is most effective with UVGI)
- Environment temperature (expected system performance in nominal) – 21°C (70°F)
- Environment humidity (expected system performance in nominal) – not greater than 75%
- Lamp life/hours of use ≅ 8,736+ hours (1 year = 24x7x52, + safety factor)
- 100 hours lamp burn-in

*Application of this value should be based on room occupancy usage.
Planning an Installation (continued)

- Walk through the facility verifying room dimensions, usage, floor to ceiling heights, note potential locations of units on plan
- Look at sight lines for maximum uninterrupted flow of UV energy
- Determine wall and ceiling surfacing materials to plan for potential reflectivity into the lower room
- Determine space usage, how frequently occupied, number of occupants and potential contact with infectious persons.
Plan to Disrupt TB Transmission

- Most upper room installations are designed to interrupt TB transmission From--Most Important to Least Important
  - Convection--sharing a room or adjacent space
  - Recirculation--anywhere in ventilation circuit
  - Close Proximity--being “coughed on”
- Consider a whole building approach where appropriate
• Fixtures locations are placed on architectural drawings with instructions on installation according to manufacturer’s guidance
• Require key switches to control the UVGI fixtures separate from the general lighting systems
- Large Multi-Purpose/Auditorium
- Open plan office /Conference Room
- Small Office (Security)
- Kitchen
- Toilets, Corridors/Transition Zones
<table>
<thead>
<tr>
<th>Space Usage</th>
<th>Room Dimensions</th>
<th></th>
<th>Mounting Height Above Finished Floor (AFF)</th>
<th>Area m² (ft²)</th>
<th>Volume m³ (ft³)</th>
<th>Number (N) UVGI Fixture Type Wall Mounted (WM)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Multi-purpose/ Auditorium</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>16.2 (53)</td>
<td>12.2 (40)</td>
<td>3.7 (12.1)</td>
<td>199.6 (2148)</td>
<td>519 (18473)</td>
<td>(12) 8.5 W</td>
</tr>
<tr>
<td><strong>Conference Room/ Open Office</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8.9 (29.3)</td>
<td>5.5 (18)</td>
<td>2.6 (8.5)</td>
<td>49 (527)</td>
<td>117.4 (4565)</td>
<td>(3) 8.5 W</td>
</tr>
<tr>
<td><strong>Security Office</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.7 (8.8)</td>
<td>3.7 (12)</td>
<td>2.6 (8.4)</td>
<td>9.7 (104)</td>
<td>25.2 (874)</td>
<td>(1) 8.5 W</td>
</tr>
<tr>
<td><strong>Kitchen</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.7 (8.7)</td>
<td>3.7 (12)</td>
<td>2.6 (8.4)</td>
<td>37.3 (401)</td>
<td>97.0 (3368)</td>
<td>(2) 8.5 W</td>
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</table>
### Conference/Open Office Room

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<tr>
<th>Space Usage</th>
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<th>UVGI Fixture Coverage</th>
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<tbody>
<tr>
<td></td>
<td>L m (ft)</td>
<td>W m (ft)</td>
</tr>
<tr>
<td>Conference/Open Office Room</td>
<td>8.9 (29.3)</td>
<td>5.5 (18)</td>
</tr>
</tbody>
</table>

**Design Concept:** Congregate setting, high occupancy, shared air with adjacent auditorium (multi-purpose room). Dropped ceiling for an open office plan. Look for long path lengths, evenly space fixtures along one wall.

**Key**  
- L = length  
- W = width  
- H = floor to ceiling height  
- A = Area covered  
- V = Room Volume  
- MH = Mounting Height above finished floor  
- N = Number of UVGI Fixtures  
- W = nominal wattage  
- WM = Wall mounted  
- CM = Ceiling Mounted
### Space Usage

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<tr>
<td><strong>L</strong> m (ft)</td>
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<td><strong>V</strong> m³ (ft³)</td>
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<td><strong>(N)</strong> WM</td>
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| Security Office Room | 2.7 (8.8) | 3.7 (12) | 2.6 (8.4) | 2.2 (7.2) | 9.7 (104) | 25.2 (874) | (1) 8.5 W |

**Design Concept:** Small office in high traffic area. Fixture placed on wall which provides the longest path length.

**Key**
- **L** = length
- **W** = width
- **H** = floor to ceiling height
- **A** = Area covered
- **V** = Room Volume
- **MH** = Mounting Height above finished floor
- **(N)** = Number of UVGI Fixtures
- **W** = nominal wattage
- **WM** = Wall mounted
- **CM** = Ceiling Mounted
**Design Concept:** 2 Units in staggered arrangements to avoid reflections from aluminum cooking hoods.

**Key**
- L = length
- W = width
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- A = Area covered
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<th>UVGI Fixture Coverage</th>
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<tbody>
<tr>
<td></td>
<td>L (m (ft))</td>
<td>W (m (ft))</td>
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<tr>
<td>Kitchen</td>
<td>2.7 (8.7)</td>
<td>3.7 (12)</td>
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Cover high occupancy toilets and Showers

Cover Transition Zones
**Multi-Purpose Room/Auditorium**

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<th>Space Usage</th>
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<tr>
<td>Large Multi-purpose</td>
<td>L (m)</td>
<td>W (m)</td>
</tr>
<tr>
<td></td>
<td>16.2 (53)</td>
<td>12.2 (40)</td>
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**Design Concept:** Congregate setting, high occupancy, 24/7 usage. Seek preservation of the room aesthetic, take advantage of above average room height. Look for long path lengths, evenly space fixtures along walls, engineering judgment to provide 2 additional fixtures above standard 1 fixture per 18.6 m² (200 ft²) due to higher density.

**Key**
- L = length
- W = width
- H = floor to ceiling height
- A = Area covered
- V = Room Volume
- MH = Mounting Height above finished floor
- N = Number of UVGI Fixtures
- W = nominal wattage
- WM = Wall mounted
- CM = Ceiling Mounted
Irradiance Webs

- These webs are set to indicate a fluence rate of 10 $\mu$W/cm$^2$. 
Total Fluence Rate

- Fluence rate volumes of 10 µW/cm² and 20 µW/cm².
## Multi-Purpose Room/Auditorium

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**Design Concept:** Congregate setting, high occupancy, 24/7 usage. Seek preservation of the room aesthetic, take advantage of above average room height. Look for long path lengths, evenly space fixtures along walls, engineering judgment to provide 2 additional fixtures above standard 1 fixture per 18.6 m² (200 ft²) due to higher density.

**Key**
- L = length
- W = width
- H = floor to ceiling height
- A = Area covered
- V = Room Volume
- MH = Mounting Height above finished floor
- N = Number of UVGI Fixtures
- W = nominal wattage
- WM = Wall mounted
- CM = Ceiling Mounted
Live Demonstration of Visual 2009 CAD UVGI

• We will now look at an example of how Visual works live.
• For further information on this program please email:
  • Richard.Vincent@MountSinai.Org