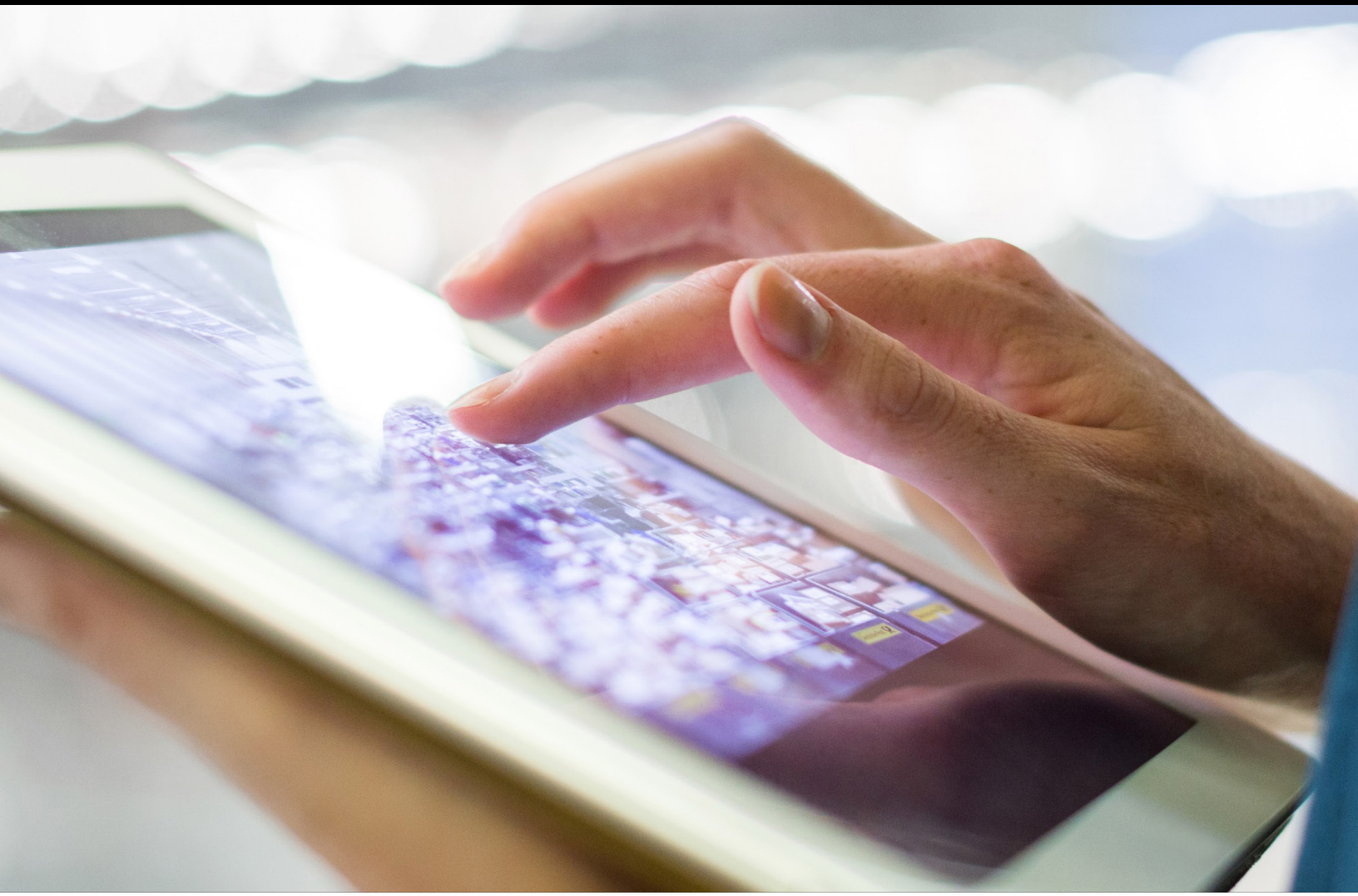


Commissioning and Ongoing Maintenance

Measurement Guidelines

November 30, 2020

Before You Begin:
Read and understand this entire guide, the luminaire installation instructions, and any site-specific documents before attempting to install, commission or operate these luminaires. Failure to read and follow all provided instructions may result in damage or injury.

It is the responsibility of the installer to ensure that persons will not be exposed to excessive UV radiation during equipment operation. This will require the installer to conduct an assessment of irradiance levels per the instructions listed in this document in the surrounding occupied spaces prior to occupancy and to repeat assessment whenever relamping is completed.

This document applies to following products:
Fail-Safe GAC - Germicidal UV 2x2 Grid Ceiling Mount
Fail-Safe GAW - Germicidal UV Louvered Wall Mount

Table of Contents

General Instructions and Materials Required

Upper Air Germicidal UV radiation measurements must be taken:

- Upon initial installation
- Whenever new lamps are installed
- Whenever modifications are made to the room or upper air installation conditions
  (e.g. height, position, change of walls or ceiling material, room dimension changes, etc.)
- Whenever any reports or complaints of possible overexposure are received, or is reasonably expected

Required Materials (sold separately)

Personal protective equipment (PPE):

- Safety glasses with side panels
- Long sleeve shirt, long pants and closed toe shoes
- Skin protecting gloves
- Sunblock cream [1]
  (containing either zinc oxide or titanium dioxide for head, neck,face and other areas of exposed skin)

Calibrated X1-5 Optometer - Gigahertz - Optik

- **Step 1:** For output range of 1-50 µW/cm², calibrated at first decimal (0.1 µW/cm²)
- **Step 2:** For measuring safety level at 0.2 µW/cm² calibrated to second decimal (0.01 µW/cm²)

Measuring tape and documentation materials

Ladder and Tripod

UV-3725-4 Radiometric Detector. UV-C 254nm irradiance with cosine corrected field-of-view. Gigahertz -Optik

UV- 3718Z-01 Detector Accy: 80° FOV adapter for UV-3718 detector [2, 3, 4]

1. National Institute for Occupational Safety and Health. Atlanta, GA: National Institute for Occupational Safety and Health; 2009. Environmental control of tuberculosis: basic upper-room ultraviolet germicidal irradiation guidelines for healthcare settings.
2. ICNIRP (2007) Protecting Workers from Ultraviolet Radiation
3. End TB Transmission (ETTI) (2019) Maintenance of Upper-Room Germicidal Ultraviolet (GUV) Air Disinfection Systems for TB Transmission Control, Stop TB Partnership, Geneva, Switzerland. www.stoptb.org/wg/ett/resources.
4. ACGIH. (2017). TLVs® and BEIs®. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

Premeasurement Actions

- Prior to the installation, Cooper Lighting Solutions recommends 100hr burn-in of the lamps. Once the burn-in is complete, the lamps will be stable and considered a baseline for commissioning measurement.[1]

  Failure to complete the 100hr burn-in could result in higher initial readings. The space should never be occupied by humans or pets prior to completing all measurements.
- Make sure you have the latest site documents including latest architectural and electrical drawings, simulated calculation report (if performed), list of surface materials and reflectance values (see Appendix B), site audit notes or previous measurements (if applicable) to compare with the current situation.
- Check if the usage of the space (occupant tasks, hours occupied, etc) is the same as it was when the system was designed. If there is a change, register it.
- Look for obstacles (hanging from the ceiling or higher objects from the floor) that may interfere with the UV-C light, register them.
- Check if there are nearby items (smoke detectors, alarms, projectors, wi-fi routers, etc.) with materials or paint that can be degraded by UV-C and advise the customer.
- Energize luminaires and allow to stabilize for 10 minutes prior to beginning any measurements.
- Thoroughly clean the sensor lens according to sensor manufacturer instructions or with Isopropyl Alcohol before beginning measurements.
- Look for standard luminaires installed in the ceiling directly in the irradiance path that may reflect light into the occupied zone. Cooper Lighting Solutions recommends moving or removing these.

1. ASHRAE GPC 37 (Draft).

Step 01: Establish Baseline

Figure 1: The detector is raised and lowered to find maximum output (irradiance) of the UV beam for recording output. If allowed, permanent marker on the floor would facilitate repeat measurement. Or use a yard/meter stick between the face of the luminaire and the GUV radiometer's detector.

Instructions for Measuring

1. Acquire all necessary PPE.
2. Zero the UV meter according to the meter manufacturer's instructions.
3. Remove the cap and position the sensor 3ft (0.91m) from the center of the upper-room GUV luminaire.[1]
4. Point the sensor probe vertically, aiming in the beam of the luminaire, the center of the sensor should be in the center of the UV-C beam.
5. Record the reading in the log book, this is the initial baseline output to be referenced by all future readings after replacement lamps are installed.
6. Repeat steps 1-6 at 6ft (1.83m) from the center of the upper-room GUV luminaire.
7. Compare results to Appendix A: Dosing Recommendations. If above max permissible UV exposure, disconnect the device and notify Facilities/Owner. [1, 2]

Note: Upon luminaire relamping and/or cleaning, changes to site conditions (painting, installation of new luminaire in the irradiance path, changing or resurfacing reflective surfaces, installation of obstructions in the irradiance path, etc.) and/or changes to site usage, repeat steps 1-7.

1. End TB Transmission (ETTI) (2019) Maintenance of Upper-Room Germicidal Ultraviolet (GUV) Air Disinfection Systems for TB Transmission Control, Stop TB Partnership, Geneva, Switzerland. www.stoptb.org/wg/ett/resources.
2. Nardell EA, Bucher SJ, Brickner PW, Wang C, Vincent RL, Becan-McBride K, James MA, Michael M, Wright JD. Safety of upper-room ultraviolet germicidal air disinfection for room occupants: results from the Tuberculosis Ultraviolet Shelter Study. Public Health Rep. 2008;123:52–60 w.

Step 02: Eye Level Safety measurements

Instructions for Measuring

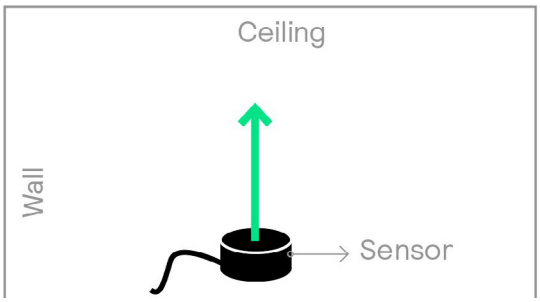
1. Create a grid of measurements on the floor, placing the tripod at an equally-spaced distance (see table to the right).
2. Place the tripod head at the default 6ft (1.83m) or acceptable eye level for the tasks that take place in the space.
3. Make sure to use the 80° field of view adapter on the detector for these measurements.
4. At each grid point, take five measurements.
   - For the first measurement, orient the detector (normal of the detector surface) horizontally (pointed at ceiling).
   - Next, orient the detector vertically, pointing straight ahead along the typical line of sight for measurements in all directions.
5. Record the location of all measured points, clearly highlight if any measurement is higher than the maximum agreed upon value for the application (based on the Maximum Permissible UV-C Exposure guidelines in Appendix A).[1] Corrective action needs to be taken and system should not be energized until measurements are in alignment with Appendix A dosage recommendations.

Measurement Grid

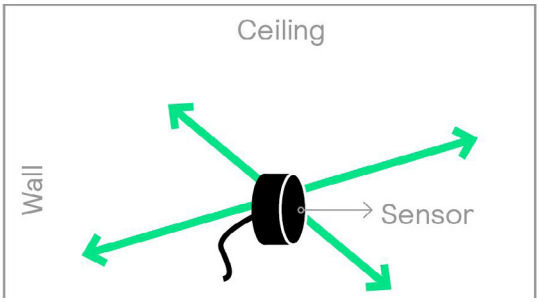
Space Length (ft/m)	Maximum grid spacing (ft/m)	Minimum grid points
<6ft/<1.83m	1.5ft/0.5m	4
6-24ft/2-7.5m	3ft/1m	5
24-65ft/7.5-20m	4.5ft/1.5m	10
>65ft/>20m	6ft/1.83m	15

- The larger the area, the bigger the distance between measurement points.
- Grid should not align with luminaire layout.
- If a simulated calculation of the space has been provided, the measurement grid may follow the simulated grid points for correlation.
- Reduce grid distance:
  - Where multiple luminaire are combining energy [2]
  - Wherever highly reflective surfaces might be found [3]
  - At task areas

Sensor Orientation



Horizontal



Vertical

1. See Appendix A.
2. End TB Transmission (ETTI) (2019) Maintenance of Upper-Room Germicidal Ultraviolet (GUV) Air Disinfection Systems for TB Transmission Control, Stop TB Partnership, Geneva, Switzerland. www.stoptb.org/wg/ett/resources.
3. See Appendix B.

Step 02: Eye Level Safety measurements


Figure 2

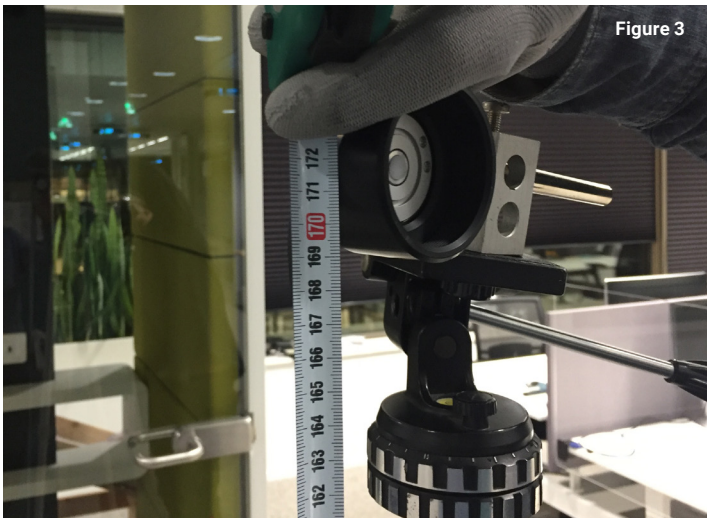


Figure 3

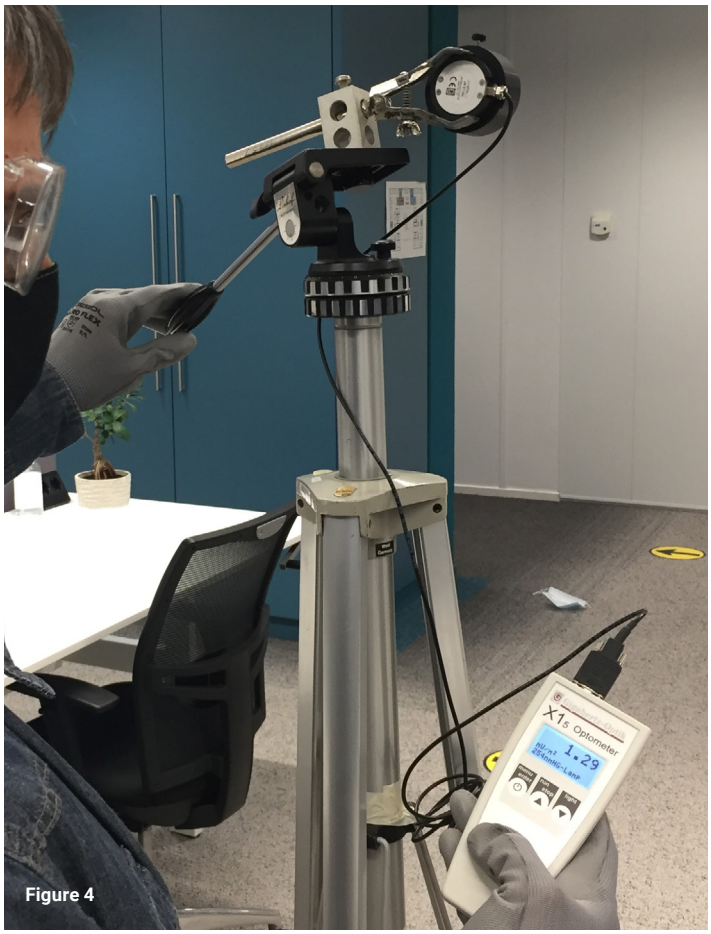


Figure 4


Figure 5

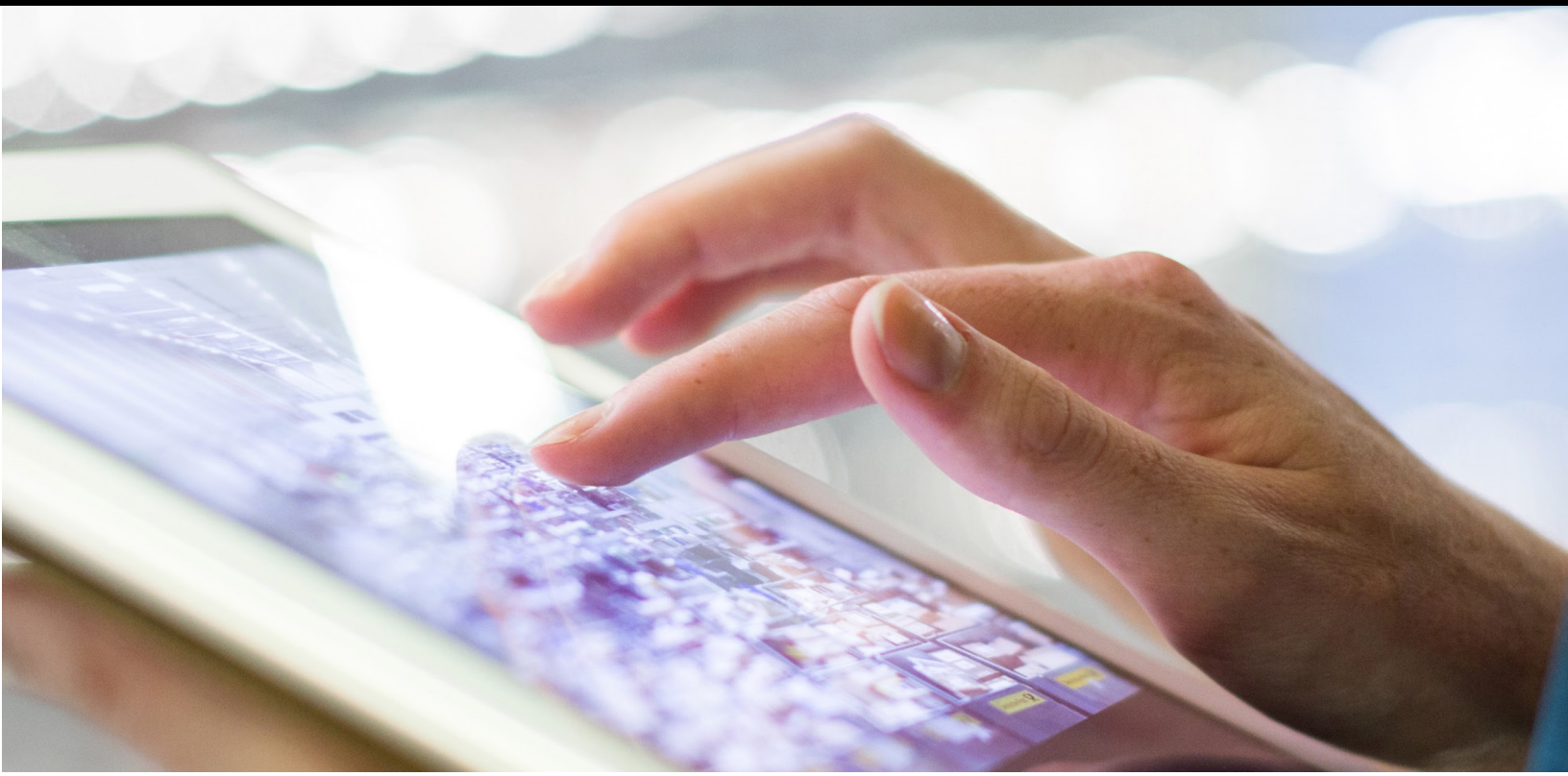
Figure 2: Technician checking eye level safety with GUV radiometer. Searching for the hot-spots at eye level using a hand-held radiometer and sensor with 80 degree field-of-view cover to mimic the structure of the brow and eye.

Figure 3: A tape measure is recommended to set the tripod to 6ft (1.83m).

Figure 4: A tripod is recommended for easy repetitive measurements at 6ft (1.83m) along the grid.

Figure 5: Measuring along the line of eye sight of the occupant.

Step 03: Documentation and Deliverables



1. Mechanical / Electrical Installation report
   (reporting if the luminaires were correctly installed,
   following mounting instructions and design guidance).

2. Visual / photographic inspection
   (confirming if all elements noted during the audit are still valid).

3. Irradiance measurements should be recorded and saved (recorded in
   XLS, PPT or Word – not scanned handwritten values).).

4. Baseline Measurements – in the beam (Step 01).

5. Eye Level Safety and compliance - Out of the beam (Step 02)
   at 6ft (1.83m) or the height used in the design.

6. All documentation should be made available to all parties involved
   (installing/commissioning contractor, distributor, owner)
   and saved in a secure location for future reference.

Dosing Recommendation

Maximum permissible UVC exposure

This international standard adopts the REL[1] maximum permissible UVC exposure values and the maximum permissible UVC exposure shall not exceed the ACGIH TLH and NIOSH REL[1] of 6.0 mJ/cm^2 for an 8 hour day, 40 hour work week exposure to UV radiation at 254 nm.[2, 3]

Maximum permissible UVC exposure for radiation at 254 nm

Permissible UVC exposure time	Effective irradiance µW/cm^2	
24 hours	0.07	
18 hours	0.09	
12 hours	0.14	
10 hours	0.17	**<0.8 µW/cm^3** operating range for TLV assessments
8 hours	0.2	
4 hours	0.4	
2 hours	0.8	
1 hour	1.8	**>0.8 µW/cm^3** is not allowable for design acceptance criteria and commissioning
30 minutes	3.3	
15 minutes	6.7	
10 minutes	10	
5 minutes	20	
1 minutes	100	
30 seconds	200	
15 seconds	400	
5 seconds	1200	
1 second	6000	

Threshold Limit Value® (TLV®) consideration should be based on real-time occupancy of spaces treated by UVGI.[3] This recommendation is supported by recent UV monitoring data from First and Colleagues[4], who founded that peak meter readings poorly predict actual exposure of room occupants.

1. CDC/NIOSH. Recommended Exposure Limit. REL, 2005
2. NIOSH. Criteria for a recommended standard: Occupational exposure to ultraviolet radiation Publication 73-11009. National Institute for Occupational Safety and Health, Washington, D.C, 1972
3. ACGIH. 2007. TLVs® and BEIs®. American Conference of Governmental Industrial Hygienists, Cincinnati, OH
4. First M.W., Weker R.A., Yasui S., Nardell E.A. Monitoring human exposures to upper-room germicidal ultraviolet irradiation. J. Occup. Environ. Hyg. 2005, 2 pp. 285–292

UVC radiation reflectance

Material	Refl. (%)
Aluminium: untreated surface	40-60
Aluminium: treated surface	60-89
Aluminium: sputtered on glass	75-85
"ALZAK" treated aluminium	65-75
"DURALUMIN"	16
Stainless steel /Tin plate	25-30
Chromium plating	39
Various white oil paints	3-10
Various white water paints	10-35
Aluminium paint	40-75
Zinc oxide paint	4-5
Black enamel	5
White baked enamel	5-10
White plastering	40-60
Magnesium oxide	55-60
Calcuim carbonate	75-88
Linen	70-80
Bleached wool	17
Bleached cotton	4
Wallpapers: Ivory	30
Wallpapers: white	31
Wallpapers: white	21-31
Wallpapers: red printed	31
Wallpapers: ivory printed	26
Wallpapers: brown printed	18
White notepaper	25

Reed NG, Wengraitis S, Ultraviolet Spectral Reflectance of Ceiling Tiles, and Implications for the Safe Use of Upper-Room Ultraviolet Germicidal Irradiation Photochemistry & Photobiology 2012, 88: 1480-1488

Ceiling tiles reflectance values

ID	Incl specular	Excl specular
A	0.035±0.001	0.034
B	0.043±0.002	0.041
C	0.048±0.001	0.047
D	0.051±0.001	0.05
E	0.052±0.002	0.047
F	0.055±0.006	0.054
G	0.060±0.002	0.059
H	0.064±0.004	0.062
I	0.070±0.001	0.065
J	0.071±0.005	0.071
K	0.071±0.001	0.069
L	0.074±0.001	0.071
M	0.076±0.003	0.067
N	0.096±0.003	0.041
O	0.106±0.006	0.047
P	0.107±0.024	0.05
Q	0.122±0.007	0.047
R	0.151±0.008	0.054
S	0.152±0.009	0.059
T	0.165±0.021	0.062
U	0.237±0.011	0.065
V	0.240±0.033	0.071
W	0.240±0.063	0.069
X	0.244±0.023	0.071
Y	0.245±0.070	0.067
Z	0.260±0.048	0.288
AA	0.260±0.035	0.243
BB	0.273±0.007	0.274
CC	0.275±0.016	0.28
DD	0.276±0.013	0.283
EE	0.276±0.026	0.29
FF	0.282±0.029	0.306
GG	0.334±0.024	0.333
HH	0.353±0.031	0.363
II	0.362±0.028	0.364
JJ	0.423±0.103	0.41
KK	0.459±0.015	0.438

Ceiling tile information

Manufacturer	Item Name	Item No.	Materials	Notable surface features	ID
Armstrong	Armatuff	860	Wet-formed high-density mineral fiber	Latex paint	R
Armstrong	Ceramagurad	605	Ceramic and mineral fiber composite	Scrubbable plastic finish	KK
Armstrong	Cirrus	574	Wet-formed mineral fiber	Latex paint	HH
Armstrong	Cirrus (camel)	589	Wet-formed mineral fiber	Latex paint	S
Armstrong	Cirrus (platinum)	589	Wet-formed mineral fiber	Latex paint	X
Armstrong	Clean Room Mylar	1721	Wet-formed mineral fiber	Soil-resistant polyester film	G
Armstrong	Clean Room VL	870	Wet-formed mineral fiber	Vinyl-faced membrane	K
Armstrong	Cortega	769	Wet-formed mineral fiber	Latex paint	V
Armstrong	Crossgate	2625	Wet-formed mineral fiber	Latex paint	AA
Armstrong	Dune	1772	Wet-formed mineral fiber	Latex paint	U
Armstrong	Endura	639	Wet-formed high-density mineral fiber	Vinyl latex paint	GG
Armstrong	Fine Fissured School Zone	1714	Wet-formed mineral fiber	Latex paint	FF
Armstrong	Fine Fissured (camel)	1729	Wet-formed mineral fiber	Latex paint	T
Armstrong	Fine Fissured (haze)	1729	Wet-formed mineral fiber	Latex paint	DD
Armstrong	Fine Fissured (techblack)	1729	Wet-formed mineral fiber	Latex paint	D
Armstrong	Fine Fissured (white)	1729	Wet-formed mineral fiber	Latex paint	Z
Armstrong	Fine Fissured Open Plan	1754	Wet-formed mineral fiber	Latex paint	II
Armstrong	Georgian	17	Wet-formed mineral fiber	Latex paint	CC
Armstrong	Graphis	1753	Wet-formed mineral fiber	Latex paint	J
Armstrong	Latitudes	8005	Wet-formed mineral fiber	Latex paint	W
Armstrong	Ledges	8011	Wet-formed mineral fiber	Latex paint	P
Armstrong	Mesa	680	Wet-formed mineral fiber	Latex paint	E
Armstrong	Optima	3151	Fiberglass with acoustically transparent membrane	Acoustically transparent membrane and latex paint	B
Armstrong	Painted Nubby	3101	Fiberglass	Latex paint	EE
Armstrong	Pebble	2989	Fiberglass	Latex paint	N
Armstrong	Random Fissured	2910	Fiberglass	Scrubbable vinyl film facing	F
Armstrong	Sansera	573	Embossed wet-formed mineral fiber	Latex paint	Y
Armstrong	Shasta	2906	Fiberglass	Scrubbable vinyl film facing	H
Armstrong	Stratus	531	Wet-formed mineral fiber	Latex paint	JJ
Armstrong	VL	871	Wet-formed mineral fiber	Vinyl-faced membrane	L
Certain-Teed	Ecophon Gedina E	—	Fiberglass	Sound-resistant coating	BB
Certain-Teed	Fine Fissured High NRC	454	Wet-felted mineral fiber	Latex paint	M
Certain-Teed	Symphony F	134,2,4	Fiberglass	Laminate	C
Certain-Teed	Theatre Black F	1910,2	Fiberglass	Laminate	A
Certain-Teed	Vinyl Rock	1140,2-CRF-1	Gypsum	Scrubbable vinyl film facing	I
USG	Astro Climaplus	—	Mineral fiber	—	Q
USG	Brio Climaplus	—	Mineral fiber	—	Q

Note: All tiles are white unless noted in parentheses next to the model, or in the model name itself; ID used to identify specific tiles in Figures, Tables, and text.

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Publication No. IB519137EN
January 28, 2021 7:54 AM