Designers Lighting Forum

IoT Lighting to improve Education Facilities

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Lighting Solutions for Healthcare

To ensure the current status of this course, including relevant association approvals, please view the course details here.

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The American Institute of Architects
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Purpose and Learning Objectives

Purpose:

Effective lighting in education environments can, and does, contribute to improved student performance, as well as improved safety. Lighting solutions for education facilities must maximize energy efficiency, occupy less space, be flexible and adaptable to different environments, meet life safety requirements, and meet the needs of teaching staff, and students. This course discusses current lighting trends, energy management and education requirements, human centric lighting needs and current legislation affecting lighting design considerations for education facilities. This course will also discuss how the latest IoT trends can be an asset to lighting design in the education space by including Asset tracking and other RTLS technologies. As well as how GUV solutions can help disinfect education spaces and as part of the lighting system be used as a tool to audit disinfection times and contact tracing between disinfection cleanings.

Learning Objectives

At the end of this course, participants will be able to:

1. Describe current lighting and controls trends for education facilities
2. Discuss current regulations and standards impacting building codes and affecting lighting design in education facilities
3. Evaluate GUV solutions for disinfection of education space
4. Evaluate energy savings through controls and current safety trends improve education facilities through implementing IoT and RTLS solutions through connected lighting

Education Facilities Lighting Trends and Requirements

Introduction

The education facility has changed significantly over the past few years. Not only had the teaching methods evolved over this time but also the tools needed to educate the students has evolved.

Lighting is a critical element in the school environment, it can influence behavior, task performance and psychological and emotional responses in the space. Lighting also help with communications, visual comfort and safety and security.

Classroom lighting should support the educational experience and goals by providing and attractive environment that is comfortable and maintains the target illuminances for different task surfaces.

Lighting Solutions

For Education Spaces

Lighting solutions in education facilities must:

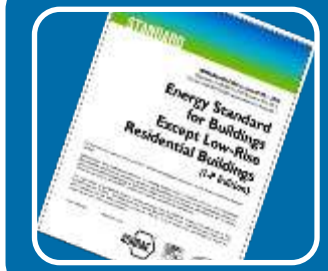
- Meet **specific, unique** to education and energy code requirements
- Be **flexible** and **adaptable** to different types of spaces
- **Meet the needs** of teachers and students
- **Include IoT** capabilities

A Merger between Art and Science of lighting for education facilities

leducation.org

Regulations and Standards

Affecting Lighting Design

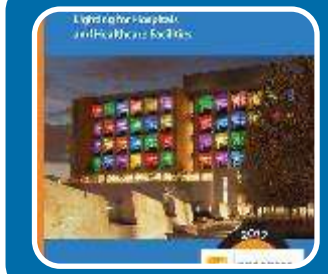


ASHRAE/ANSI/IESNA 90.1-2019

- Minimum DOE standard
- Defines mandatory controls and LPD requirements in Table 9.6.1

IECC 2021

- IECC is more commonly used than ASHRAE
- Defines mandatory controls requirements or Luminaire Level Lighting Controls (LLLC) as methods to meet code



ANSI/IESNA RP-3-20 **Lighting Education Facilities**

- Offers guidelines for good lighting in those areas unique to educations facilities, and is intended for lighting designers

- **ASHRAE** – American Society of Heating, Refrigerating, and Air-Conditioning Engineers, www.ashrae.org
- **ANSI** – American National Standards Institute, www.ansi.org
- **IESNA** – Illuminating Engineering Society of North America, www.ies.org
- **IECC** – International Energy Conservation Code, www.iccsafe.org
- **International Dark-Sky Association**, www.darksky.org

ASHRAE/ANSI/IESNA 90.1 – 2019

Education specific areas

1)	Automatic Receptacle Control	[8.4.2] Power Section
2)	Simplified Building Method for School Buildings	[9.3.1-3]
3)	Automatic full off – Laboratory exception	[9.4.1.1(h)]
4)	Minimum Control Requirements	[Table 9.6.1]
5)	Additional Interior Lighting Power Allowances	[Table 9.6.3]

ASHRAE/ANSI/IESNA 90.1 – 2019

Table 9.6.1 *Lighting Power Density* Allowances Using the Space-by-Space Method and Minimum *Control* Requirements Using Either Method *(Continued)*

Informative Note: This table is divided into two sections; this first section covers *space* types that can be commonly found in multiple *building* types. The second part of this table covers *space* types that are typically found in a single *building* type.			The *control* functions below shall be implemented in accordance with the descriptions found in the referenced paragraphs within Section 9.4.1.1. For each *space* type: (1) All REQs shall be implemented. (2) At least one ADD1 (when present) shall be implemented. (3) At least one ADD2 (when present) shall be implemented.								
			Local *Control* (See Section [a])	Restricted to *Manual* ON (See Section [b])	Restricted to Partial *Automatic* ON (See Section [c])	Bilevel Lighting *Control* (See Section [d])	*Automatic* Daylight Responsive *Controls* for Sidelighting (See Section [e][a])	*Automatic* Daylight Responsive *Controls* for *Toplighting* (See Section [f][a])	*Automatic* Partial OFF (See Section [g] [Full Off complies])	*Automatic* Full OFF (See Section [h])	Scheduled Shutoff (See Section [i])
Building Type Specific/*Space* Types[1]	*LPD* W/ft²	*RCR* Threshold	a	b	c	d	e	f	g	h	i
Classroom/Lecture Hall/Training Room											
Penitentiary	0.89	4	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
All other classrooms/lecture halls/training rooms	0.71	4	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
Computer Room	0.94	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Cafeteria or fast food dining	0.40	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Laboratory											
In or as a classroom	1.11	6	REQ	ADD1	ADD1	REQ	REQ	REQ	REQ	ADD2	ADD2
All other laboratories	1.33	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Locker Room	0.52	6	REQ	ADD1	ADD1	REQ	REQ	REQ		REQ	
Gymnasium/Fitness Center											
Exercise area	0.90	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Playing area	0.85	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2

IECC 2021: Energy code requirements

C405.2 Lighting controls (Mandatory). Lighting systems shall be provided with controls that comply with one of the following:

- Lighting controls as specified in Sections C405.2.1 through C405.2.7.
  - Occupancy Sensor
  - Time switch
  - Daylight Responsive controls
  - Specific Application Controls
  - Manual Controls
  - Exterior Lighting Controls

OR

- Luminaire level lighting controls (LLLC) and lighting controls as specified in Sections C405.2.1, and C405.2.6.

BUILDING TYPE SPECIFIC SPACE TYPES	LPD (watts/sq.ft)
Education Facility	
Classroom/lecture hall/training room	0.71
Computer room	0.94
Corridor	0.41
Cafeteria or fast food dining	0.40
Laboratory classroom	1.11
Locker room	0.52
Restroom	0.63
Gymnasium/ fitness center	0.85

IECC - 2021: Luminaire Level Lighting Controls (LLLC)

LLLC shall be independently capable of:

- Monitoring occupant activity to brighten or dim with occupancy sensor
- Monitoring ambient light (electric and daylight) to maintain desired light level
- Ability for configuration and reconfiguration of performance parameters including:

  - Bright/dim set points
  - Timeouts
  - Dimming fade rates
  - Sensor sensitivity
  - *Wireless* zoning configurations

LEDucation ANSI/IESNA RP-3-20: Design Considerations

Table A-1. Recommended Illuminance Criteria for Spaces Specific to Educational Facilities

APPLICATION TASK/AREA	Veiling Reflection Risk: Light Level for Task or Area? Task or Area	High Med Low	Recommended Maintained Illuminance Targets[a, b] — TS = Task Surface: Recommended illuminances are at height of task surface above finished floor (AFF) — Horizontal (E_h): Target E_h @ Height AFF			Uniformity Ratio: Max Avg	Ratio	Ratio Basis	Vertical (E_v): Target E_v @ Height AFF			Uniformity Ratio: Max Avg	Ratio	Ratio Basis
			C A T	Lux @ m	(Fc @ Ft)	Min			C A T	Lux @ m	(Fc @ Ft)	Min		
INTERIORS - EDUCATIONAL FACILITIES														
Classrooms														
General Classrooms														
Learning, teaching (interactive)														
AV (dedicated AV viewing)	A	M	K	50 @ 0.76	(5 @ 2.5)	Avg			I	30 @ 1.22	(3 @ 4.0)	Avg	2:1	Avg:Min
Dedicated computer screens	A	M	N	150 @ 0.76	(15 @ 2.5)	Avg	2:1	Avg:Min	K	50 @ 1.22	(5 @ 4.0)	Avg	2:1	Avg:Min
Elementary school	A	L	P	300 @ 0.76	(30 @ 2.5)	Avg	2:1	Avg:Min	N	150 @ 1.22	(15 @ 4.0)	Avg	2:1	Avg:Min
Middle school, high school, higher ed	A	L	Q	400 @ 0.76	(40 @ 2.5)	Avg	2:1	Avg:Min	N	150 @ 1.22	(15 @ 4.0)	Avg	2:1	Avg:Min
Study halls	A	L	P	300 @ TS	(30 @ TS)	Avg	2:1	Avg:Min	O	200 @ TS	(20 @ TS)	Avg	2:1	Avg:Min
Arts														
Art and drafting rooms	A	L	R	500 @ 0.76	(50 @ 2.5)	Avg	3:1	Avg:Min	P	300 @ 1.22	(30 @ 4.0)	Avg	3:1	Avg:Min
Kiln room	A		R	500 @ 0.76	(50 @ 2.5)	Avg	3:1	Avg:Min	P	300 @ 1.22	(30 @ 4.0)	Avg	3:1	Avg:Min
Music room	A	M	P	300 @ 1.22	(30 @ 4.0)	Avg	2:1	Avg:Min	O	200 @ 1.22	(20 @ 4.0)	Avg	2:1	Avg:Min
Home economics														
Food prep, detail work areas	T		R	500 @ TS	(50 @ TS)	Min			O	200 @ TS	(20 @ TS)	Avg		
Science lab														
Bench	T		R	500 @ 0.91	(50 @ 3.0)	Avg			P	300 @ 1.37	(30 @ 4.5)	Avg		
Demonstration area	T	L	S	750 @ 0.91	(75 @ 3.0)	Avg	3:1	Avg:Min	R	500 @ 1.37	(50 @ 4.5)	Avg	3:1	Avg:Min
Shops														
Assembly (difficult process)	T	L	T	1,000 @ TS	(100 @ TS)	Avg			R	500 @ TS	(50 @ TS)	Avg		
Inspection (difficult process)	T	L	T	1,000 @ TS	(100 @ TS)	Avg			R	500 @ TS	(50 @ TS)	Avg		
Machining (medium benchwork)	T	L	T	1,000 @ TS	(100 @ TS)	Avg			R	500 @ TS	(50 @ TS)	Avg		
Woodworking (fine process)	T	L	T	1,000 @ TS	(100 @ TS)	Avg			R	500 @ TS	(50 @ TS)	Avg		
Lecture Hall / Auditoriums[3]														
Audience[4]														
AV and notes	A		K	50 @ 0.76	(5 @ 2.5)	Avg	2:1	Avg:Min	G	15 @ 1.22	(1.5 @ 4.0)	Avg	2:1	Avg:Min
Presentation and no notes	A		F	10 @ 0.00	(1 @ 0.0)	Avg	2:1	Avg:Min	D	6 @ 1.22	(0.6 @ 4.0)	Avg	2:1	Avg:Min
Presentation Area														
Stage	Refer to ANSI/IES RP-41-20: Table A-1													
Speaker or Panel[2]	T		P	300 @ 0.76	(30 @ 2.5)	Avg								
Face(s)	T								O	200 @ 1.52	(20 @ 5.0)	Min	2:1	Avg:Min
Demonstration	T		R	500 @ 0.91	(50 @ 3.0)	Avg	3:1	Avg:Min	O	200 @ 1.37	(20 @ 4.5)	Avg	3:1	Avg:Min
Multipurpose Spaces[5]														
Assembly Areas[6]														
Audience														
AV and notes	A		K	50 @ 0.76	(5 @ 2.5)	Avg	2:1	Avg:Min	G	15 @ 1.22	(1.5 @ 4.0)	Avg	2:1	Avg:Min
Presentation and no notes	A		F	10 @ 0.00	(1 @ 0.0)	Avg	2:1	Avg:Min	D	6 @ 1.22	(0.6 @ 4.0)	Avg	2:1	Avg:Min
Study, testing (typical paper and/or laptop)	A	M	P	300 @ TS	(30 @ TS)	Avg	3:1	Avg:Min	M	100 @ TS	(10 @ TS)	Avg	3:1	Avg:Min
Speaker, faces[2]	T													
Other Areas/Functions														
Access, ramps, stairs	Refer to ANSI/IES RP-10-20: Table A-1													
Gymnatorium, cafetorium[1]	A		P	300 @ 0.00	(30 @ 0.0)	Avg								
Exhibition	A		P	300 @ 0.76	(30 @ 2.5)	Avg	3:1	Avg:Min	M	100 @ 1.52	(10 @ 5.0)	Avg	3:1	Avg:Min
Pre-event, post-event, intermission	A		N	150 @ 0.00	(15 @ 0.0)	Avg	3:1	Avg:Min	L	75 @ 1.52	(7.5 @ 5.0)	Avg	3:1	Avg:Min
Performance	Refer to ANSI/IES RP-41-20: Table A-1													
Transition and Circulation Spaces	Refer to ANSI/IES RP-10-20: Table A-1													
Libraries	Refer to ANSI/IES RP-4-20: Table A-1													
Sports, Indoors	Refer to ANSI/IES RP-6-20: Table A-1													
EXTERIORS - EDUCATIONAL														
Lighting for Pedestrians	Refer to BSR/IES RP-43-20: Tables A-1 through A-4													
Parking and Roadways	Refer to ANSI/IES RP-8-18													
Sports, Outdoors	Refer to ANSI/IES RP-6-20: Table A-2													

APPLICATION TASK/AREA NOTES

1. Flexibility of lighting zones and dimming are recommended.
2. Avg ≤3 times audience task E_h @ 1.22m (4'-0").
3. Dedicated to lectures (fixed or flexible seating).
4. Contrast markings with steps, curbs, and ramps; localized lighting may be deemed appropriate.
5. These spaces require a high degree of flexibility (likely loose seating).
6. Contrast markings with steps, curbs, and ramps; localized lighting may be deemed appropriate.

ANSI/IESNA RP-3-20:

Design Considerations

General Considerations	Lighting Criteria	Design Guidance
Communications	Illuminance	All classrooms are computerized environments
Wall-mounted teaching boards	Task locations	Combination of direct/indirect (based on ceiling height)
Projected images	Uniformity	Indirect should have a wide “batwing” distribution to increase uniformity
Light distribution on surfaces	Luminance, brightness and adaptation	Avoid veiling reflections and discomfort glare
Visual comfort	Room surface luminance	Appropriate lighting/controls for special needs classrooms
Lighting for safety and security	Luminance ratio limits	Speaker’s face must be properly illuminated (hearing & visually impaired)
	Wayfinding	White-tunable to help with behavioral cues
		Continuous dimming
		Daylighting
		Auto On to 50% or Manual On

Concepts

ANSI/IESNA RP-3-20:

Quality of Light

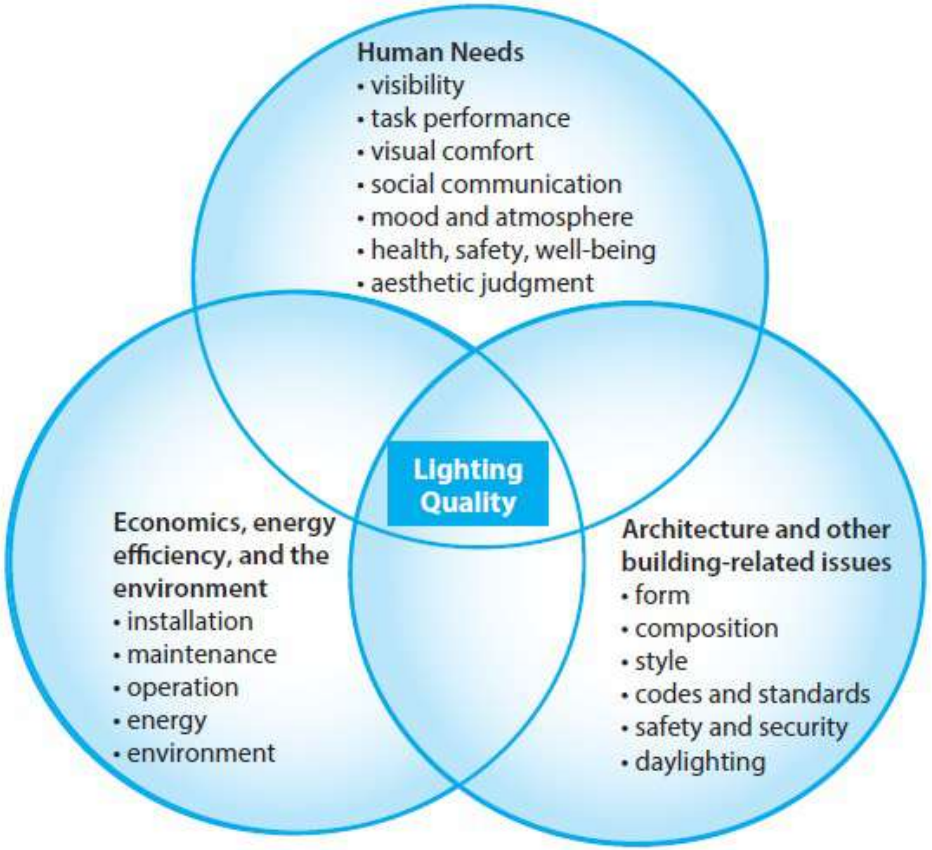


Figure 2-1. Lighting quality: the integration of human needs, architecture and interior design, and economics and the environment. (© Illuminating Engineering Society)

Source: RP-3-20 Lighting Education Facilities

ANSI/IESNA RP-3-20:

Daylighting

Why is daylighting important?

- Impacts people in the space
- Provides connection to nature, time and weather information
- Provides wall and ceiling washing effects

Considerations?

- Views vs daylight (customer expectations)
- Discomfort glare
- Reflection from surrounding buildings, ground, parking

Controls?

- Yes
- Automatic daylighting to raise/lower electric light in response to daylighting
- Open vs closed loop daylighting
- Manual dimming by multiple switches/dimmers limits teachers' ability to adjust lighting (may also violate energy code depending upon location

ANSI/IESNA RP-3-20:

Controls

They are not just for energy savings anymore…

- Controls have traditionally been an energy savings ROI calculation study
- Comfort, flexibility, human needs security all play a factor now

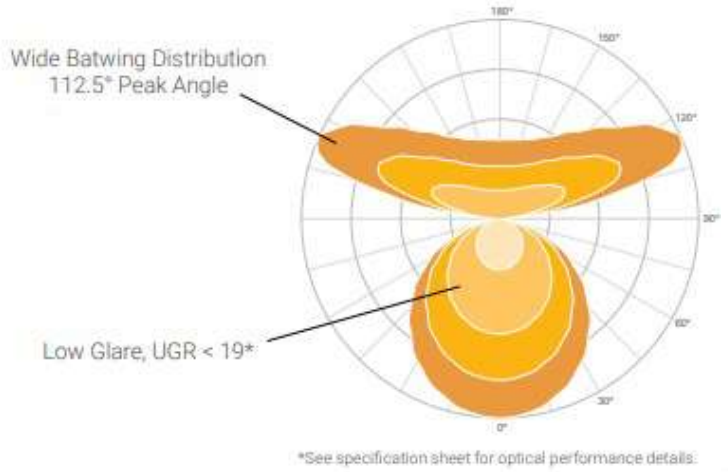
Considerations?

- Minimum dimming levels for each space (0%, 1% or 10%)
- Zoning for daylighting areas
- Use of occupancy or vacancy sensors
  - Auto On to 50%
  - Partial Off
  - Auto Off
- Time schedules vs Sensors
- Check local energy/building codes

Education Spaces

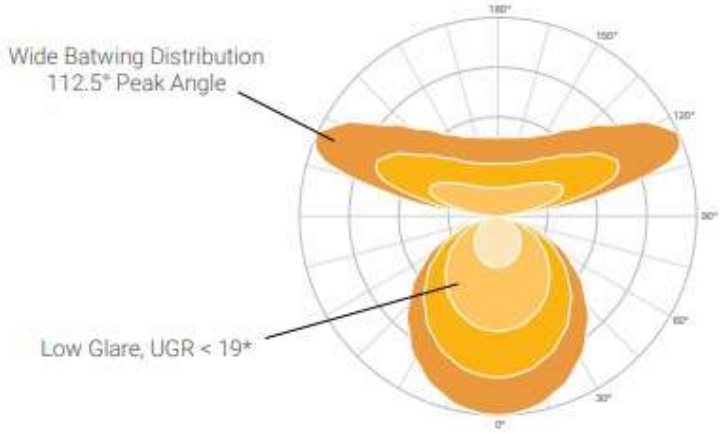
General Purpose Classroom
Design Considerations

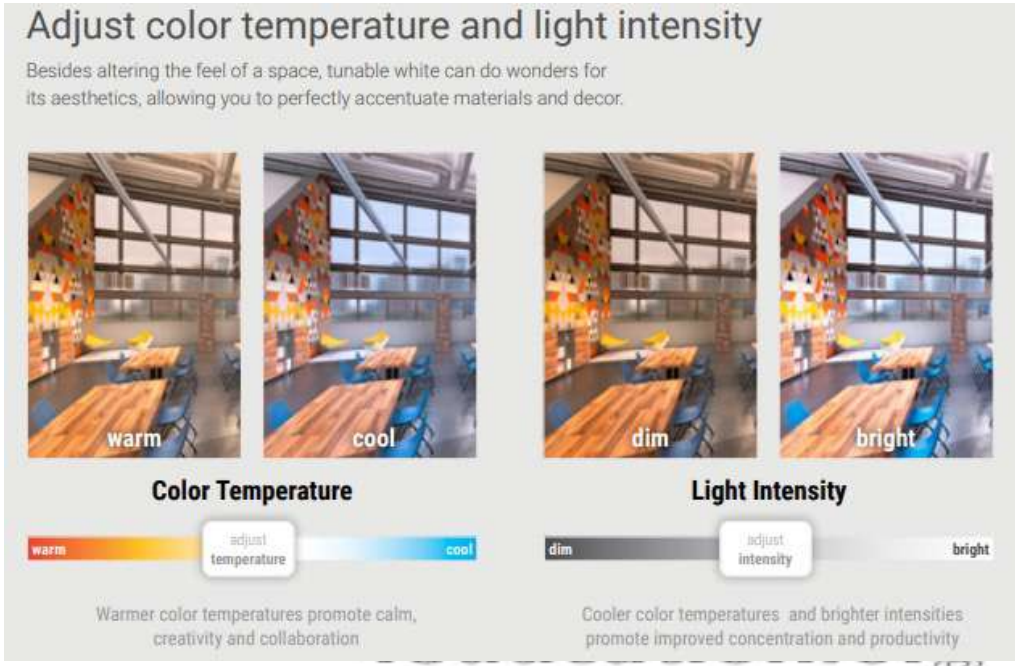
- Every classroom should be considered a **computerized environment** today.
- **Screen visibility** is primary concern
- Most **similar to office** environments
- General lighting is best with **direct/indirect** determined by ceiling height.
- **Use wide "batwing"** distribution to increase uniformity in indirect luminaires.
- **Direct** troffer can be more efficient but products more **discomfort glare** and **veiling reflections**.
- Horizontal
  - 30fc (elementary)
  - 40fc (middle/high school)
- Vertical
  - 15fc @ 4'



Special Needs Classroom
Design Considerations

- May need **high quality** and **appropriate quantity** of lighting for those with hearing or vision needs
- Speaker's face should be **properly illuminated**. May need higher illuminances.
- **Avoid flicker, glare** and use light source with SPD **similar to daylight**
- **White-tunable** can have **benefits** for behavioral cues
- General lighting is best with **indirect** determined by ceiling height.
- **Use wide "batwing"** distribution to increase uniformity in indirect luminaires.
- **Direct** troffer can be more efficient but products more **discomfort glare** and **veiling reflections**.
- Horizontal
  - 30fc (elementary)
  - 40fc (middle/high school)
- Vertical
  - 15fc @ 4'

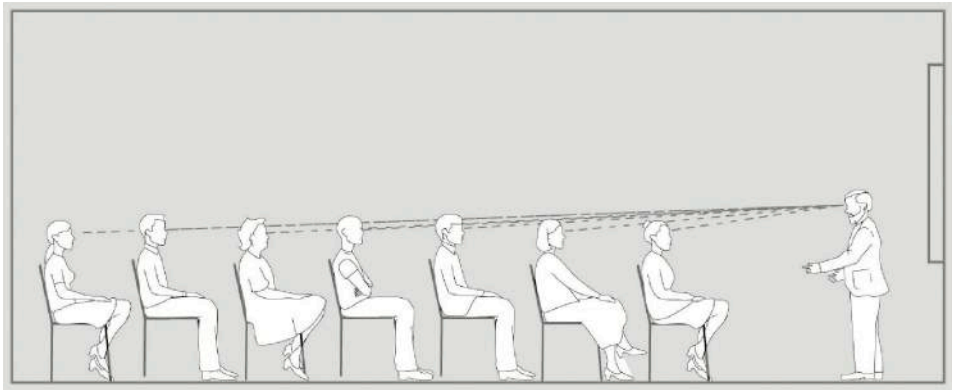


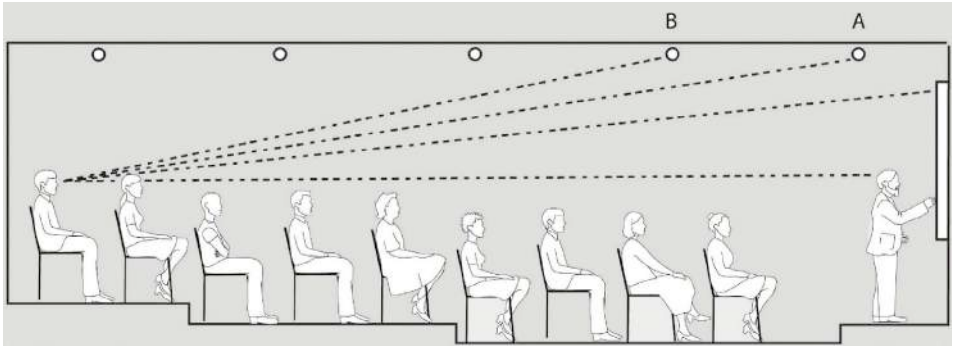


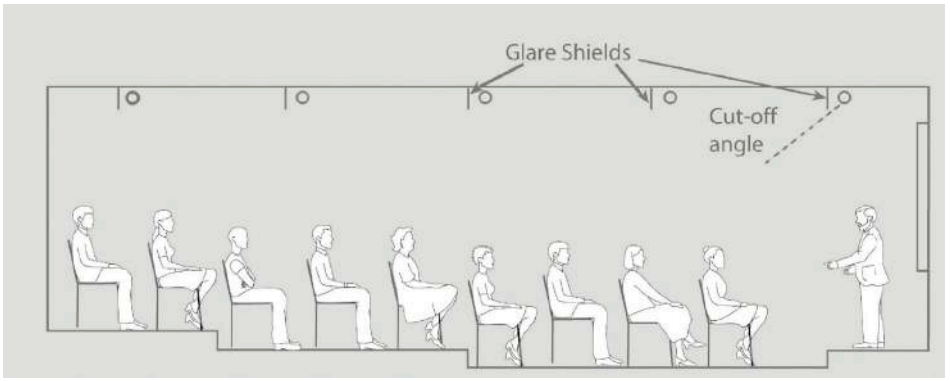
Lecture Halls

Design Considerations

- Typically, larger spaces with **more complex lighting** and fixed learning environment. More instructional and less personal
- May have sloped or tiered floors **requiring walkway/step lighting**
- **Multiple illuminance levels** (A/V, paper-tasks, lectures, etc)
- **Dimming required** for flexibility
- Downlighting should be carefully designed to **avoid glare, veiling reflections and shadows**
- **Directional downlights & track** should be positioned to minimized glare and highlight speaker's face
- Horizontal
  - 5fc (audience A/V)
  - 1fc (audience presentation
  - 30fc (speaker)
- Vertical
  - 1.5fc @ 4' (audience)
  - 20fc @ 5' (speaker)







Source: RP-3-20 Lighting Education Facilities

Cafegymatorium

Design Considerations

- **Common in K-8** educational facilities, they are large spaces used in multiple ways.
- **Full-range dimming** to 0% is recommended.
- **Careful consideration** of theatrical lighting location as it can effect the design of the space.
- **Coordinate controls** with staff
- If the space is a gym consider luminaire **housing and lensing** to reduce likelihood of damage
- Horizontal
  - 30fc
- Vertical
  - N/A

Auditoriums

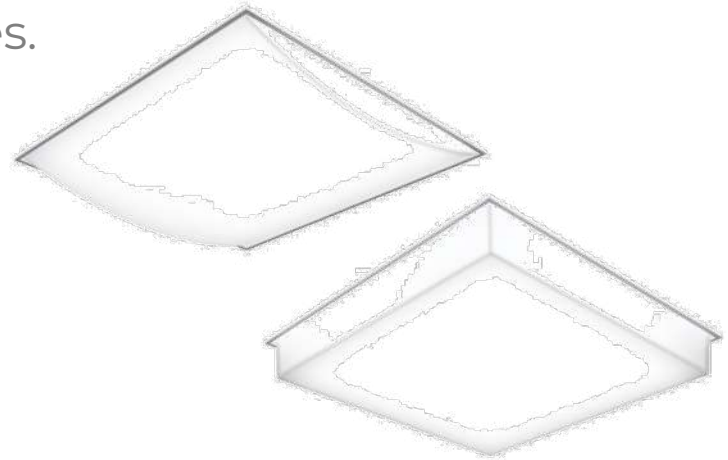
Design Considerations

- Lighting should be planned for audience assembly, intermission and tasks.
- **Dimming to 0%** to create smooth transitions.
- Window-darkening devices if needed
- **Aisle lights** mounted on or in seats, should be **controlled separately** provides adjustable illuminance levels
- Stage lighting embraces the art of lighting with color, shading and 3D composition
- **Multiple systems are needed** for stage lighting (work lighting moveable/flexible theatrical lighting, front, side and bac lighting) are all critical to the show
- All lighting should be **included into a single system** for e operation
- Horizontal
  - 1fc (audience presentation)
  - 30fc (speaker)
- Vertical
  - 1.5fc @ 4' (audience)
  - 20fc @ 5' (speaker)

Science Labs

Design Considerations

- **Higher illuminance** levels are needed
- High **CRI >85** is needed to discern different chemicals
- **May need wet location** luminaires
- General lighting is best with **direct/indirect** determined by ceiling height.
- **Use wide "batwing"** distribution to increase uniformity in indirect luminaires.
- **Task lighting** at work stations
- Horizontal
  - 50fc (@ bench)
  - 75fc (in Demonstration area)
- Vertical
  - 30fc @ 4.5' (@ bench)
  - 50fc @ 4.5' (in Demonstration area)



Shop & Art Rooms

Design Considerations

Art Rooms

- Luminaires need **high CRI >90**
- **Adjustable lighting** may be needed for task or display lighting
- **Adjustability and flexibility** is preferred as spaces and usage varies
- Horizontal
  - 50fc @ 2.5’
- Vertical
  - 30fc @ 4’

Shop

- General lighting should be **supplemented** with fixed and portable **task lighting**
- **Avoid flicker** when rotating machinery is in use, this could produce a stroboscopic effect
- Provide lighting from **multiple sources** when machinery is in use
- Horizontal
  - 100fc @ Task Surface
- Vertical
  - 50fc @ Task Surface

Life Safety
Design Considerations

- **Emergency lighting must be provided** throughout the entire building and property.
- The use of LEDs in today's exit signage **ensures long life** and low maintenance to these wayfinding products.
- An **illuminated path of egress** that directs occupants a safe distance away from the facility is required.

Exterior Spaces

Outdoor Lighting Design Considerations

- Enable **wayfinding, safety and perception of security** with well designed outdoor lighting
- Pedestrians should **feel comfortable** walking around the site at night
- Pedestrians should **recognize facial features** and body language
- Plan for **vertical surface illuminance** around **5ft** above ground level
- Uniformity ratios should be calculated using **minimum maintained FC/LUX**
- **Uniform** lighting perceptions of how good lighting is and how safe people feel reach **high ratings at a much lower light** level than non-uniform lighting
- RP-20-9* recommendations
  - Min light level 2lux
  - Uniformity ratio (max/min) of 20:1
- RP-8-18 recommendations
  - Min light level >4.5lux
  - Uniformity ratio (max/min) of 3:1

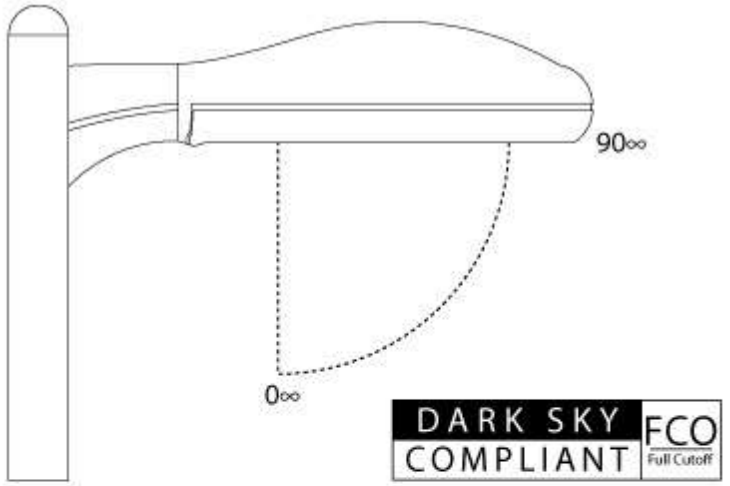
Facility Site and Area

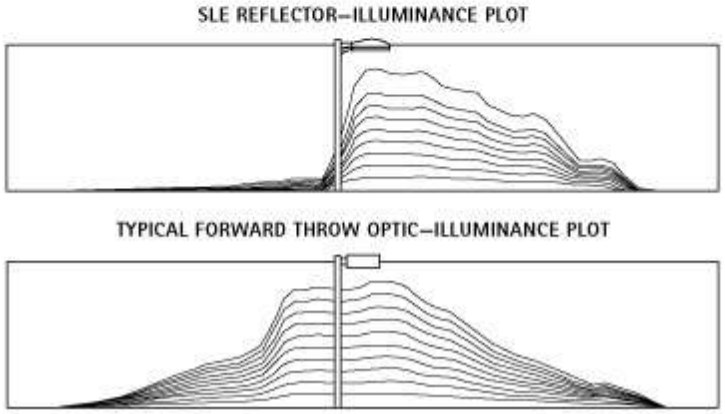
Design Considerations

Energy Code Requirements

- Lighting zones are the same MLO (Model Lighting Ordinance) zones used in ASHRAE
- **Automatically off** during daylight hours
- Façade and landscape **lighting auto off 1 hour after closing** to 1 hour before opening

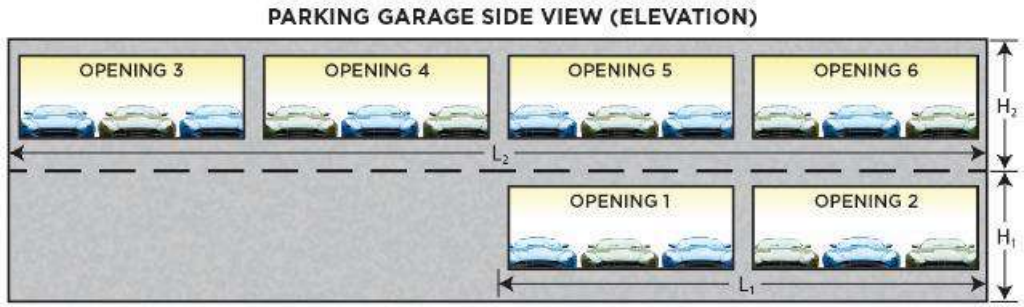
  OR
- **Reduce connected lighting power by at least 30%**
  - from not later than midnight to 6am
  - *or* one hour after business closing to one hour prior to opening
  - *or* when no activity is detected for longer than 15 minutes





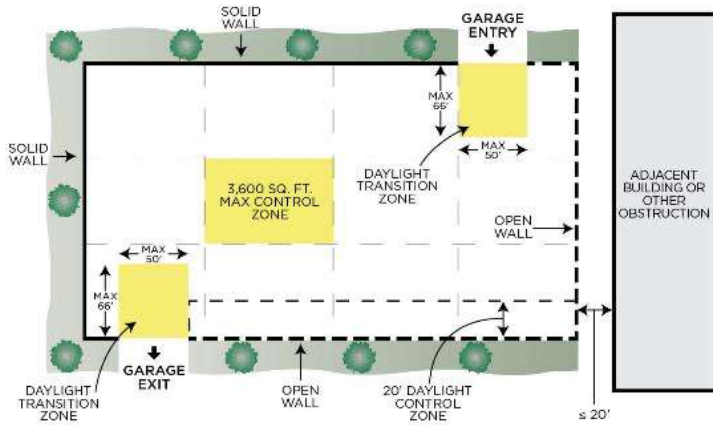
Parking Garage

Design Considerations



Daylighting control required if the total area of all openings in a wall section (i.e. openings 1-2) are greater than or equal to 40% of the total wall area (HxL).

Example: $\frac{\text{Opening 1 + Opening 2}}{H_1 \times L_1}$ *Example:* $\frac{\text{Opening 3 + Opening 4 + Opening 5 + Opening 6}}{H_2 \times L_2}$



Energy Code Requirements

- Parking garage lighting must be **automatically controlled including daylighting**
- **Reduce lighting power by 30%** or more when no occupancy detected in a lighting zone (<3,600 sf) for 20 mins.
- **Daylighting transition zone** lighting (66' wide by 50') must be separately controlled for eye adaptation (auto ON at daylight, 50% reduction from sunset to sunrise)
- **Daylight control required for lights within 20' of perimeter wall** with net opening to wall ratio of 40%
- **Exceptions apply**

Germicidal UV (GUV) light as a disinfectant

How does it work?

Complex science, simple answer

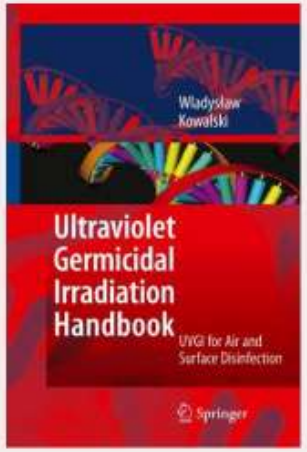
RNA / DNA of a microbe can be altered

A virus is not a living organism – it cannot be killed. It can be inactivated.

GUV wavelengths (254nm) have high energy that alter RNA / DNA in microbes

This energy destroys the nucleic acids altering the structure of RNA and inactivates the virus

Comprehensive source for technical information regarding ultraviolet germicidal irradiation (UVGI).



"UV is highly effective at controlling microbial growth and at achieving sterilization of most types of surfaces."

"One advantage of surface disinfection systems is that it attacks microbial growth at the source."

- Wladyslaw **Kowalski**

Occupied Spaces
4 GUV Lighting Strategies

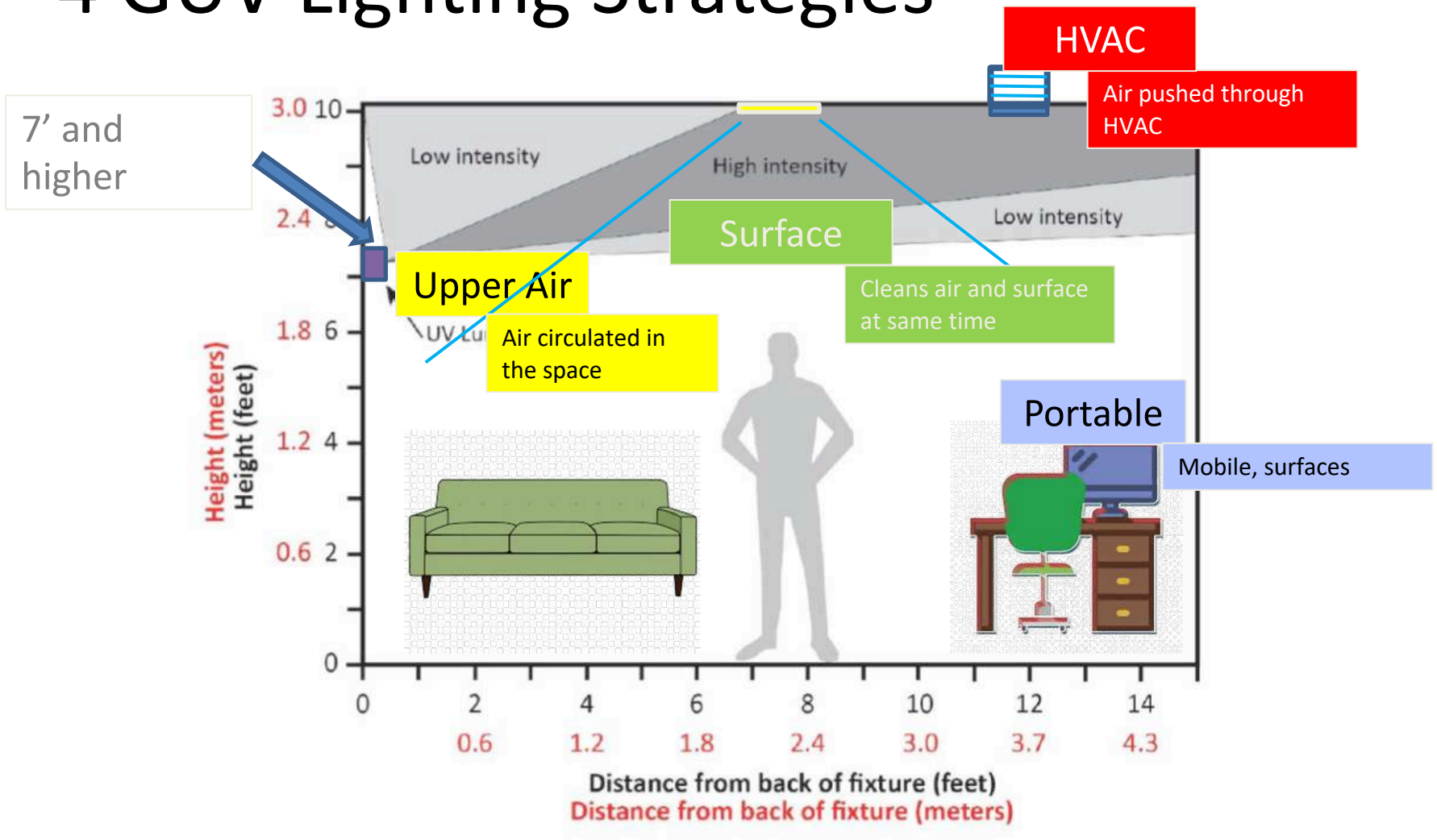


Figure 3-1. Upper-air GUV installation.

What about UL Certification?

The NEC requires that all items permanently installed be tested by a NRTL

UVC germicidal products reference guide

UVC radiation has sanitizing properties, and has many uses in commercial, healthcare and consumer settings. UVC has germicidal benefits, killing bacteria and deactivating viruses depending on the exposure dose (based on source strength, proximity, and time). However, there are serious risks to UVC exposure, so proper safety precautions are essential.

What qualifies as UVC?
Electromagnetic wavelengths shorter than the visible spectrum of light are known as ultraviolet (UV) light (180-400 nm). This reference guide is focused on UVC. Please note that UVA and UVB regions have certain benefits and pose some hazards of their own.

UVC (Short-wave)	UVB (Middle-wave)	UVA (Long-wave)
180-280 nm	280-315 nm	315-400 nm

What are the key risks of UVC?
There are serious risks to UVC exposure. UVC can be dangerous if improperly used. In only moments, UVC exposure can cause serious damage:

- **EYE:** pain, light sensitivity, and gritty sensation on eye can occur, since UVC does not trigger aversion response (blinking squinting, looking away)
- **SKIN (erythema):** similar to a sunburn

What are the dangers of breathing emitted ozone from a UVC device?
Some UVC lamps emit ozone, which enhance germicidal effects but can be hazardous in enclosed spaces:

- **LUNG DAMAGE:** ozone may also worsen underlying respiratory conditions

What if the UVC is contained?
Containment is a set of design criteria that ensures that people are not exposed to excessive UVC. Consumer products that contain the UVC radiation inside the equipment may be safe and eligible for safety certification based on evaluation per the applicable safety Standards.

What if you are a trained professional in a controlled setting taking safety precautions?
Commercial and healthcare related UVC products may have uncontained UVC sources. They are intended for use by trained professionals based on product and site safeguards. Such equipment may be safe and eligible for safety certification based on evaluation per the applicable safety Standards.

Warning labels are not enough!
Some consumer products without UVC source containment have warning labels or timers - this is not enough! Children and pets cannot be expected to follow written warnings, and home environments have too many variables that could result in misuse. Remember that UVC disrupts DNA; in a home environment, devices without containment pose a hazard to the residents, pets, and plants.

What will UL Certify?
UL will certify eligible UVC devices for safety using UL Standards for the product type (see following page for examples). Where the Standard does not already include personal injury requirements for UVC, ANSI RP-27 or IEC 62471 for photobiological assessments will apply. Safety certifications address risks of electric shock, fire and personal injury; safety certifications do not address efficacy claims.

Safety Testing

1. Consumer products with contained UVC sources
2. Commercial and healthcare related products with UVC sources
3. Components integrated inside UVC equipment (Ballasts, LED drivers, UVC light sources, Controls & Sensors)
4. Commercial lighting products (Upper Room UVGI, Hybrid lighting systems, UVA & 405 nm systems

Performance Assessments
Photobiologic, photometric testing to determine risk category, exposure dose, and light output. Performance can be assessed as an independent service with or without a safety certification. Performance evaluation will not result in a UL safety Mark.

Risk Categories for UVC
UVC lamps and lamp systems are classified into risk groups based on UVC exposure limits and the relative photobiological risk of the radiation source. The criteria for each risk group designation is based on the type of UVC light, the length of exposure under normal conditions, and other factors.

UL can help you understand what risk group your product/design falls into and the corresponding safety implications.

Learn more at UL.com/uvlighting

Why does it matter?

"Before you install these systems, you better understand OSHA requirements." – EC&M

"The National Electrical Code requires that all items installed in a building be tested by an NRTL, generally that means UL listed. This does not apply to your personal use items, but does apply to any fixed appliances or electrical equipment that is installed within your home or commercial facility." – EC&M

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Examples of current germicidal UVC devices

Products that UL will certify for safety.

Products that UL is unwilling to certify for safety due to high risk.

Type of UVC Device	Sample Image	Environment	Assessing the risks	Safety Certification(s)
Home use portable sterilizer Marketed to clean a room in the home		Consumer	UVC is NOT contained - not safe for a home setting There is too great a risk that people and pets could accidentally be exposed to UVC and be injured, and ozone may be emitted. The exposure dose to people can be far above accepted levels and can cause injury. Integral timers or proximity and orientation sensors pose concerns with accuracy and reliability of these safeguards, as well as opportunities for misuse or bypass	NOT eligible for certification for consumer use
Personal portable sterilizer/wand Marketed to be hand held and moved over surfaces to sterilize		Consumer		NOT eligible for certification for consumer use; for commercial and healthcare applications contact UL to discuss
Home use air cleaners with internal (contained) UVC Marketed to homes and offices		Consumer	UVC is contained The UVC source is inside the product enclosure and a safeguard disables the UVC when an access door is opened	UL 507 for electrical investigation; standard includes personal injury requirements for UVC based on ANSI/IES RP-27 for photobiological assessment
Portable and stationary UVC sterilization boxes		Consumer and Commercial	UVC is contained The UVC source is inside the enclosure; opening the door will disable the UV source. Testing would ensure that any 'UV leakage' will be within safe exposure dose limits	UL 73 for electrical investigation; includes personal injury requirements for UVC based on ANSI/IES RP-27 for photobiological assessment. UL 62368-1 (or 60950-1) may also apply.
Upper room (UVGI) Mounted out of easy reach, typically 2.1m (7 feet) from floor		Commercial	Permanently mounted (i.e. fixed) equipment intended to be installed and operated in non-residential locations. UVC containment is achieved based on product design features, please site safegaurds	UL 1598 for electrical investigation IEC 62471 for photobiological assessment
Commercial/industrial heating & ventilation May also be found in home settings		Commercial	UVC is contained inside the air duct and not visible Access is restricted to qualified personnel during installation and service. The design also includes other product safeguards such as ON/ OFF switch and interlock switch	UL 1598 (or UL 153) and UL 1995 for electrical investigation; UL 1995 includes personal injury requirements for UVC based on ANSI/IES RP-27 for photobiological assessment
Water treatment UVC disinfects the water as an alternative to chlorination		Commercial	UVC is contained inside a water vessel and not visible Access is restricted to qualified personnel during installation and service	UL 979 for water treatment equipment ANSI/IES RP-27 for photobiological assessment
Mobile UVC sterilizer/ equipment sterilization		Healthcare and Commercial	UVC containment is achieved by product safeguards, trained operator and limiting access to the space so people are not present during operation In addition, the equipment includes reliable safeguards and is operated by staff with training for its proper use	In healthcare facility and laboratory settings - UL 61010 for electrical investigation; the standard references IEC 62471 for photobiological assessment to address personal injury concerns for UVC In commercial settings - UL 73 for electrical investigation; standard includes personal injury requirements for UVC based on ANSI/IES RP-27 for photobiological assessment
Germicidal Systems (may have regular lights in addition to UV emitters)		Healthcare and Commercial	Permanently mounted (i.e. fixed) equipment intended to be installed and operated in non-residential locations. UVC containment is achieved based on product safeguards, trained staff and site safeguards	UL 8802 Outline of Investigatio IEC 62471 for photobiological assessment
UVC lamps, ballasts, LED drivers, UVC emitters, controls, sensors, etc.		Components	Components for use in UVC equipment and germicidal systems; contact UL to discuss the specific use and design, and intended operation (within luminaires or only within equipment designed specifically for germicidal applications)	Various, as applicable

Always follow device labeling and manufacturer recommendations for appropriate settings, use restrictions, recommended PPE (if applicable), and required training. Don't see your product type here? We can help. Contact us today.

Empowering Trust®

Room Disinfection = UL8802
Unoccupied spaces with site safeguards

Upper Air GUV = UL 1598 Risk Group 0
Optical design and onsite confirmation

UL CERTIFIED SAFETY

Look for the "Enhanced Mark" for UL Certified Safety

Germicidal UV System

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Smart IoT Education Facility
RTLS Opportunities

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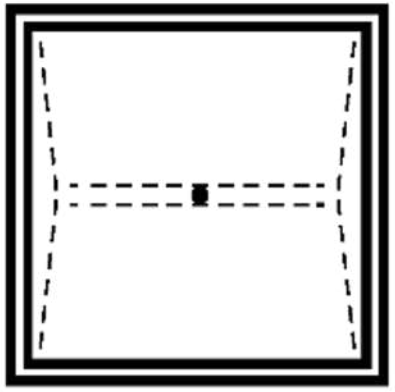
Smart School

Connected Lighting



Digital Sensors

Upgrade to LED lighting with integrated sensing

- Future proof
- Code compliant
- Up to 70% energy savings
- Dense network
- ROI <2 years

Granular Data

Use sensor network to activate

- Real-Time Location
- Space utilization
- Lighting control
- Energy optimization

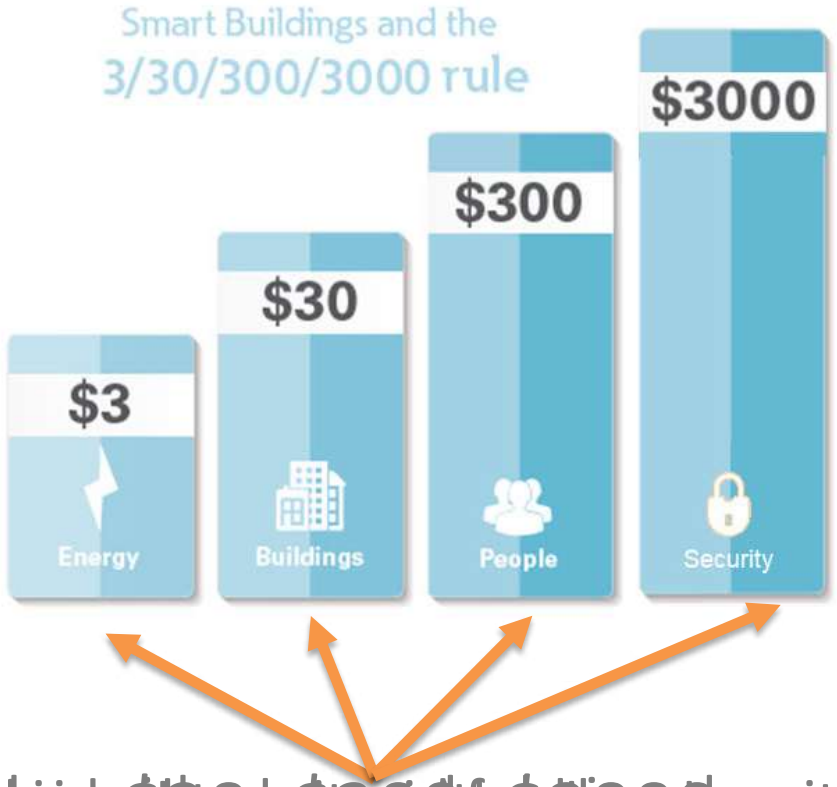
Smart Buildings

Use data from sensors to make impactful changes

- Student location safety/ security
- Improved asset utilization
- Contact tracing

The Connected Problem

Operational Costs key to better ROI



Integrated Sensors

Solve $30, $300, $3000 problems with the same $3/ft² hardware solution

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What is UL2900?

- UL2900 is a series of standards published by UL (formerly Underwriters Laboratories), a global safety consulting and certification company.
- The standards present general software cyber security requirements for:
  - **UL2900-1 Network-connectable products**
  - UL2900-2-1 medical and healthcare systems
  - UL2900-2-2 industrial control systems
  - UL2900-2-3 security and life safety signaling systems

American National Standards Institute (ANSI) and USFDA adoption

Subtle wording – major differences?

Compliant	Compliant
"Our products fully adhere to the requirements of the standard."	*"Our products were designed to the standard which entails requirements from design to testing."*

Demand CERTIFICATION

Legacy indoor positioning/RTLS

New approach needs for location services in school

Traditional RTLS Systems pose difficult tradeoffs

- Accuracy and data reliability
- High Costs
- Purpose-built for specific use cases
- Require significant ongoing battery maintenance
- Do not meet the latest cyber security standards

A new approach is needed for Real-Time Location Services in **Schools**

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Legacy indoor positioning/RTLS

New approach needs for Location services

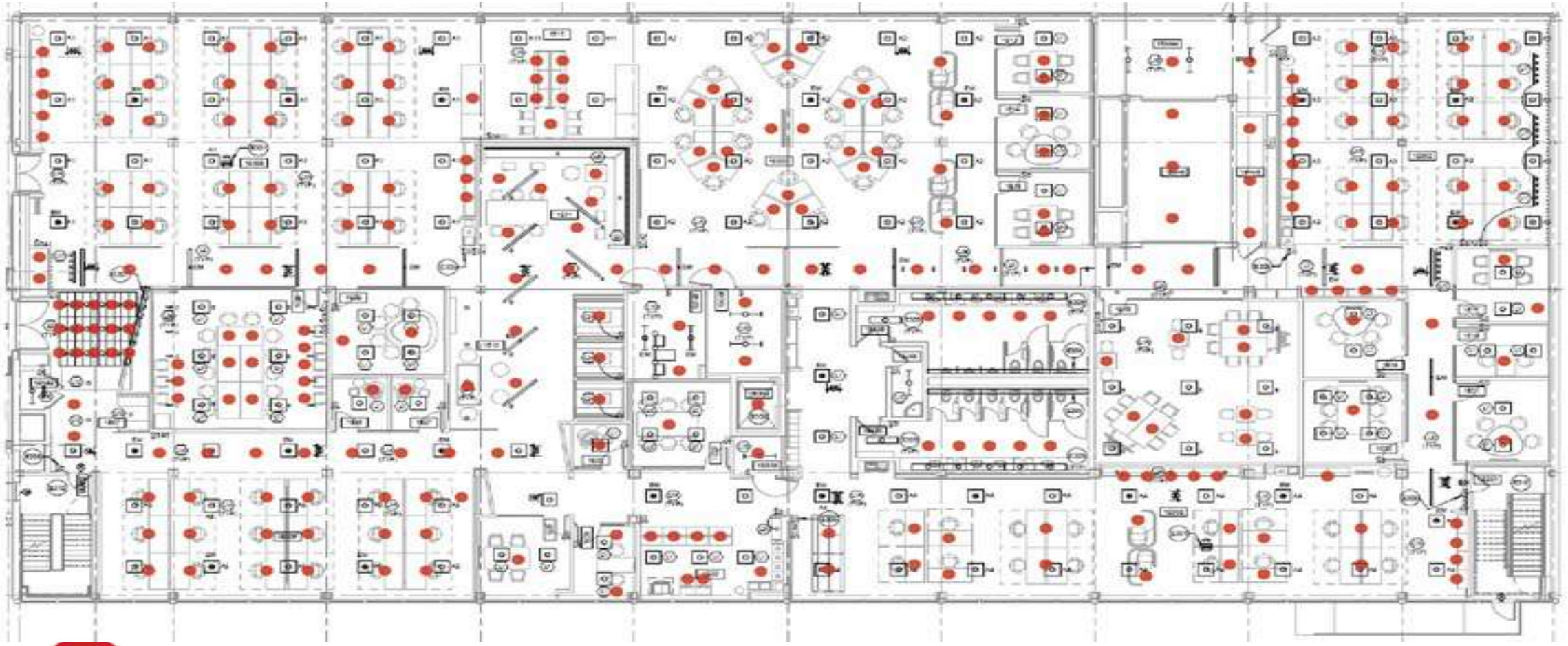
RFID
- Gated

Wi-Fi
- Low Density

Independent BLE Beacons
- Batteries & Maintenance

Connected lighting indoor positioning/RTLS

Scalable Location services



Powered by infrastructure, Ubiquitous, Scalable location services

Connected lighting indoor positioning/RTLS

Scalable Location services

School safety is a paramount issue in education. **Real-time location systems are key** to any emergency preparedness plan.

Course Summary

- Describe current lighting and controls trends for education facilities.
  - Daylighting, white-tuning, indirect lighting, low glare, RTLS
- Discuss current regulations and standards impacting building codes and affecting lighting design in education facilities
  - ASHRAE, IECC
  - Make life easy but using LLLC
- Evaluate GUV solutions for disinfection of education space
  - Upper Air use is best along with HVAC updates
- Evaluate energy savings through controls and current safety trends improve education facilities through implementing IoT and RTLS solutions through connected lighting
  - LLLC allows you to gain the benefits without extra cost

Questions?

This concludes The American Institute of Architects Continuing Education Systems Course

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