LIGHT PROGRESS

laftech
Contamination Control Solutions

operates in different fields and turns Ultraviolet Technology into real Solutions, providing a Specific Device for every application needed.

LIGHT PROGRESS®

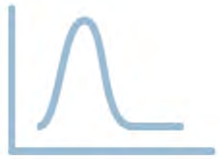
studies, develops, projects and produces

Ultraviolet Germicidal Irradiation

devices, since 1987

UltraViolet Germicidal Irradiation

What does UVGI mean ?

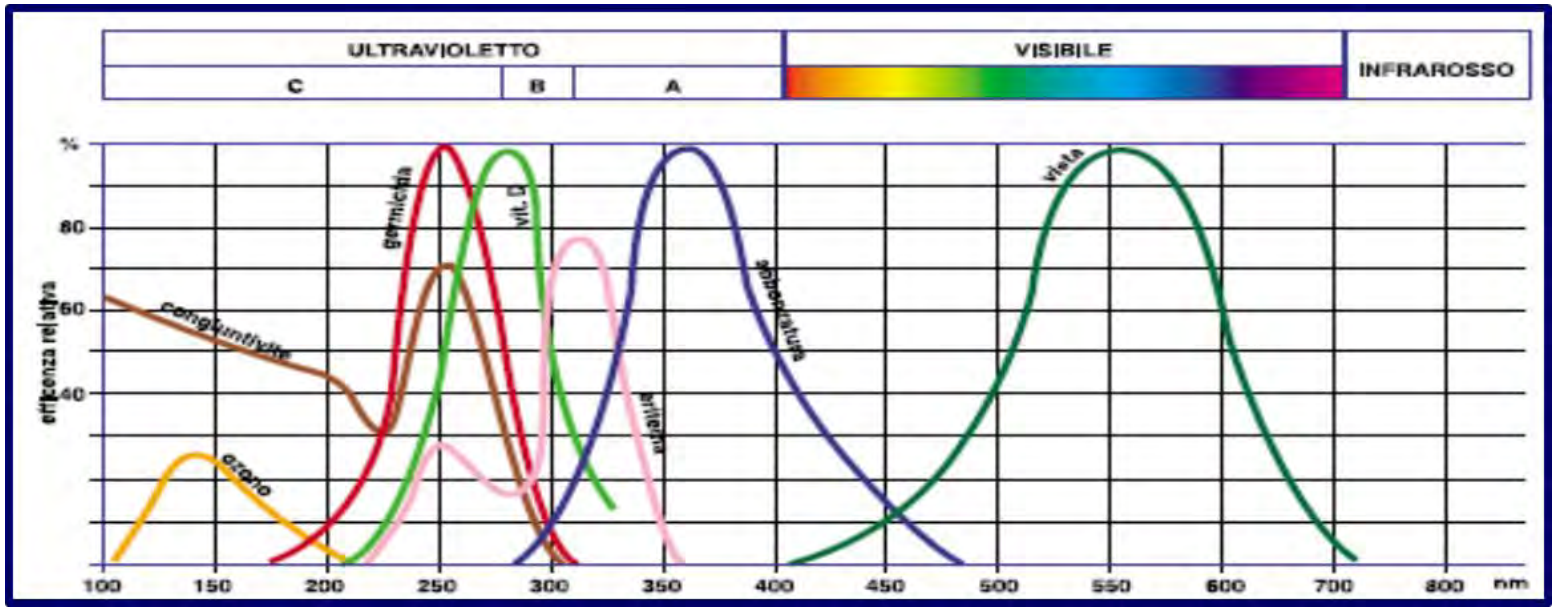


Light in a broad sense can be divided in visible, infra-red and ultraviolet rays.

Ultra-violet rays (invisible) can be classified in:

- UV - A (with tanning properties)
- UV - B (with therapeutic properties)
- **UV – C** (with **germicidal properties**)

Ultraviolet Germicidal Irradiation is known from the 60s as a good physical method to control **growth and distribution of microbial organisms**, **pathogens**, **spores**, **moulds**, etc.



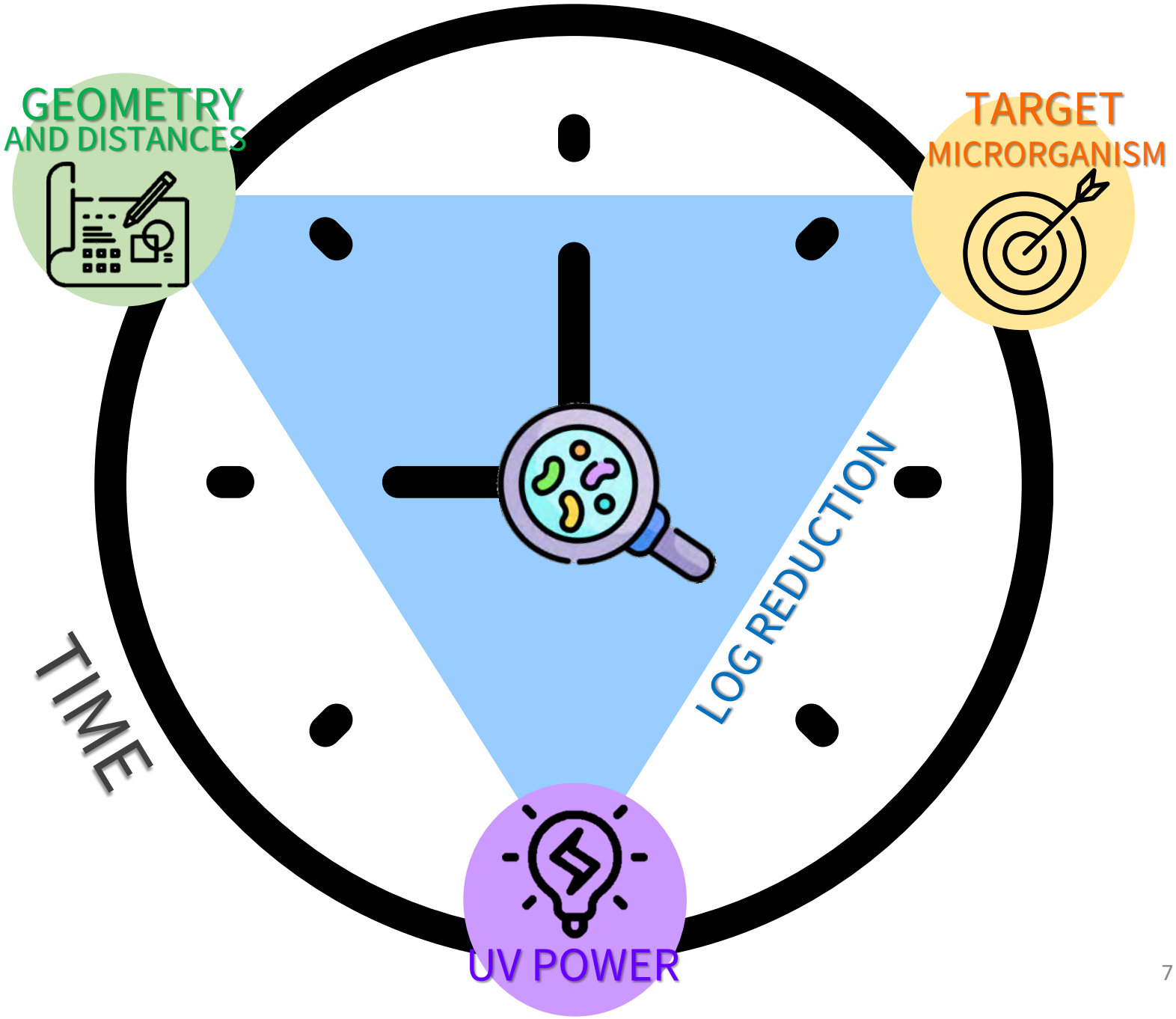
UV-C (short-wave) from 100 to 280 nm

The absorption of a UV photon by the DNA of microrganisms causes a destruction of a link in the DNA chain, and consequently the inhibition of DNA replication.

The germicidal effects of the UV-C radiation **destroy DNA** of **Bacteria**, **Viruses**, **Spores**, **Fungi**, **Moulds** and **Mites** avoiding their growth and proliferation.

UVGI technology is a physic disinfection method with a **great costs/benefits** ratio, it's ecological, and, unlike chemicals, it works against every microorganisms without creating any resistance.

UV Disinfection
Key Factors



SIMPLIFIED CALCULATION OF THE DOSES TO ACHIEVE KILLING OF 90% OF COMMON MICROORGANISMS
NOTE: FOR DESTRUCTIONS OF 99% TO 99.9% - 99.99% OF MICROORGANISMS (AND SO ON),
THE DOSES SHOULD BE INCREASED RESPECTIVELY 2 - 3 - 4 TIMES

MICRORGANISM	DOSE (µW/cm2 SEC)	MICRORGANISM	DOSE (µW/cm2 SEC)	MICRORGANISM	DOSE (µW/cm2 SEC)
BACTERIA		BACTERIA		RNA VIRUS	
Bacillus (vegetative)	3200 (1300-5800)	Proteus vulgaris	2.600		
B. anthracis	4.500	Pseudomonas	3500 (1500-5500)	Picornavirus	7200 (3600-18600)
B. subtilis	5.800	Pseudomonas aeruginosa	5.500	Poliovirus	11.000
B. megatherium	1.300	Pseudomonas fluorescens	3.500	Poliov type 1 Mahoney	6.700
B. paratyphosus	3.200	Salmonella	4300(2100-8000)	Poliov	13.300
Bacillus (spore)	11800 (1100-36500)	Salmonella enteritis (gastroenterite)	4.000	Poliov type 1	3.600
B. Megatherium	2.700	S. typhosa (febbre tifoidea)	4.000	Poliov Mahoney	4.500
B. subtilis	12.000	S. paratyphi (febbre enterica)	3.200	ECBO	8.000
Bacillus anthracis	4.500	S. typhimurium	8.000	Coxsackiev	18.600
B. subtilis spore ATCC6633	15.200	Sarcina lutea	19.700	Reovirus	10200 (4800-16300)
Campylobacter jejuni	2.900	Serratia marcescens	2.400	Reovirus type 1	4.800
Clostridium tetani	13.000	Shigella	1700 (1700-4400)	Reovirus type 1 (Lang. Str.)	16.300
Clorynebact. diphtheria	3.400	Shigella dysenteriae (diarrea)	4.200	Rotavirus	15.900
Citrob. Freundii (ATCC8090)	4.200	Shigella flexneri (diarrea)	1.700	Rotavirus SA11	6.500
Enterobacterium cloaca (ATCC13047)	6.400	Shigella paradysenteriae	1.700	Paramyxovirus	3500 (1500-5500)
Eberthella typhosa	2.100	Staphylococcus	4400 (1800-11000)	Sindbis Virus	5.500
Escherichia coli	4500 (700-5800)	Staphylococcus albus	1.800	Newcastle Disease	1.500
Escherichia coli	3.000	Staphylococcus aureus	2.600	HIV (Lentiv)	143800 (60000-240000)
Escherichia coli (in air)	700	Staphylococcus epidermis	11.000	HIV (HTLVIII)	60.000
Escherichia coli (in water)	5.400	Streptococcus	3600 (1800-6500)	HIV (Sup. T1)	145.000
Escherichia coli ATCC11229	2.500	Streptococcus hemolyticus	2.200	HIV (H9)	240.000
Escherichia coli ATCC 25922	3.000	Streptococcus lactis	6.200	HIV (PHA- stim. PBL)	130.000
Escherichia coli K 12 AB 1157	5.800	Streptococcus viridans	2.000	YEAST	
Escherichia coli B/r ATCC 12407	5.300	Streptococcus faecalis (ATCC29212)	6.500	Comuni lieviti dolciari	6.000
Klebsi. Pneumon. ATCC4352	4.200	Streptococcus faecalis	5.500	Saccharomyces ellips. (panificazione)	6.000
Legionella	1500 (400-2600)	Streptococcus pyogenes	2.200	Saccharomyces cerevisiae (panificaz.)	6.000
Legionella dumoffi	2.400	Streptococcus salivaris	2.000	Torula sphaerica	2.300
Legionella gormanii	2.600	Streptococcus albus	1.800	Lievito di birra	10.000
Legionella micdadei	1.500	Mycobacterium tubercoli	10.000	SPORES OF MOULDS	
Legionella longbeachae 1	1.200	Vibrio comma (Colera)	3400-6500	Aspergillus amstelodami (carne)	66.700
Legionella longbeachae 2	1.000	Yersinia enterocolitica	1.500	Aspergillus flavus (verde / giallastro)	60.000
Legionella oakridgensis	2.200	VIRUS (GEN.)		Aspergillus glaucus (verde / bluastro)	44.000
Legionella jordanis	1.100			Aspergillus niger (panifici) (nero)	132.000
Legionella wadsworthii	400	Batteriofagi	2.600	Cladosporum herbarum (celle frigo)	60.000
Legionella pneumophila	2.500	Virus dell' influenza	6.000	Mucor mucedo (carne, pane, formaggio)	65.000
Legionella bozemanii	2.000	Virus della poliomelite	6.500	Mucor racemosus (A e B) (grigio/bianco)	17.000
Leptospira	2000(800-2800)	Virus dell' epatite A	8.000	Oospora lactis (bianca)	5.000
Leptospira biflexa	2.300	DNA VIRUS		Penicillium digitatum (verde oliva)	44.000
Leptospira illini	800			Penicillium chrysogenum (frutta)	50.000
Leptospira interrogans	2.800	Parvovirus	3500 (3000-4000)	Penicillium roqueforti (verde)	13.000
Leptospira Spp.- Infectious jaundice	3.200	Bov. parvovirus	4.000	Penicillium expansum (verde oliva)	13.000
Leptospira hemorragie (Weil sindr.)	2.000	Kilham rat virus	4.000	Rhizopus nigricans (nero)	111.000
Listeria monocytogenes	9.000	HCC (Dog hepat. Adenov)	26.500	Rhizopus nigericans (formaggio)	300.000
Micrococcus	8000 (6100-10000)	Herpes virus	5700 (1500-16500)	Scopulriopsis brevicaulis (formaggio)	80.000
Micrococcus candidus	6.100	Pseudorabies virus	7.000	ALGAE	
Micrococcus piltonencis	8.100	Herpes simplex MP str.	6.700	Diatoms, green and blue algae	600.000
Micrococcus sphaeroides	10.000	Herpes simplex, type 1	16.500	PROTOZOA	
Mycobacterium tuberculosis (TBC)	6.200	Pseudomonas aeruginosa	5.500	Paramecium	100.000
Neisseria catarrhalis	4.400	Vaccinia	1.800	WORMS	
Phytomonas tumefaciens	4.400			Eggs of Nematodes	40.000

LIGHT PROGRESS

SANITATION means bringing the microbial load into acceptable and optimal hygiene standards that depend on the intended use of the environments concerned. Sanitation is often used to mean “clean” and must however be preceded by cleaning.

DISINFECT means to reduce the microbial load deeply, that is to eliminate at least 1 log (90%) of the bacteria present. Microbial load reduction is a basic value in disinfection and it is expressed in Log Reduction.
A good disinfection level is around 2Logs (99%) a very good disinfection is 3Logs (99,9%), and 4Logs (99,99%) is considered a pretty high standard.

STERILITY is the closest level anyone can get to achieve complete reduction of microbial load, we can talk about sterilization only if reduction is proved to be not less than 6Logs, meaning 99,9999%.

To declare sterility test has to be proved and certified by third parts by law.

SANITATION

DISINFECTION

STERILIZATION

Why LIGHT PROGRESS ?

We offer the **widest product range** of UVGI Devices on the market, providing different solutions, specifically designed for any application.

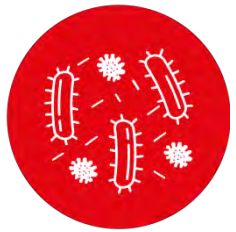
Our Team has the knowledge to consider all the different key factors and the combination between them. With this know-how we size every application achieving **the targets solution** for each specific case.

Our products are born answering **real market issues coming from different Industries**, our first mission is to fit UV-C in already existing environments, satisfaying exactly the clients requests.

Benefits

LIGHT PROGRESS

We eliminate every harmful microorganism, up to 99,99%



We improve Quality

We ensure you safety

We support sustainability

We make you save money

Our team is there to support you

Certificates

LIGHT PROGRESS

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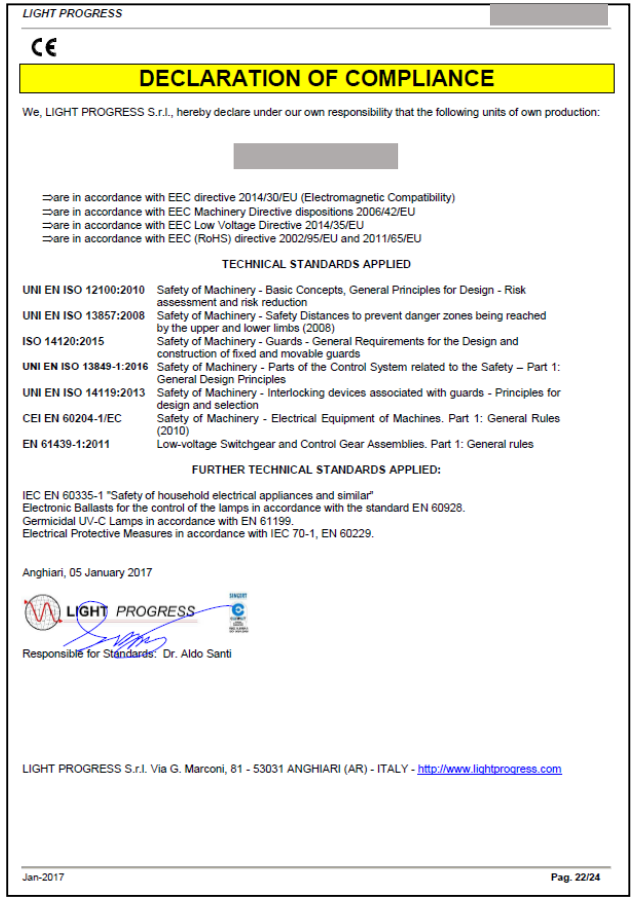
CERTIFIED ISO 9001:2015 COMPANY

UL



LIGHT PROGRESS

CE

DECLARATION OF COMPLIANCE

We, LIGHT PROGRESS S.r.l., hereby declare under our own responsibility that the following units of own production:

[redacted]

⇒are in accordance with EEC directive 2014/30/EU (Electromagnetic Compatibility)
⇒are in accordance with EEC Machinery Directive dispositions 2006/42/EU
⇒are in accordance with EEC Low Voltage Directive 2014/35/EU
⇒are in accordance with EEC (RoHS) directive 2002/95/EU and 2011/65/EU

TECHNICAL STANDARDS APPLIED

UNI EN ISO 12100:2010	Safety of Machinery - Basic Concepts, General Principles for Design - Risk assessment and risk reduction
UNI EN ISO 13857:2008	Safety of Machinery - Safety Distances to prevent danger zones being reached by the upper and lower limbs (2008)
ISO 14120:2015	Safety of Machinery - Guards - General Requirements for the Design and construction of fixed and movable guards
UNI EN ISO 13849-1:2016	Safety of Machinery - Parts of the Control System related to the Safety – Part 1: General Design Principles
UNI EN ISO 14119:2013	Safety of Machinery - Interlocking devices associated with guards - Principles for design and selection
CEI EN 60204-1/EC	Safety of Machinery - Electrical Equipment of Machines. Part 1: General Rules (2010)
EN 61439-1:2011	Low-voltage Switchgear and Control Gear Assemblies. Part 1: General rules

FURTHER TECHNICAL STANDARDS APPLIED:

IEC EN 60335-1 "Safety of household electrical appliances and similar"
Electronic Ballasts for the control of the lamps in accordance with the standard EN 60928.
Germicidal UV-C Lamps in accordance with EN 61199.
Electrical Protective Measures in accordance with IEC 70-1, EN 60229.

Anghiari, 05 January 2017

LIGHT PROGRESS

Responsible for Standards: Dr. Aldo Santi

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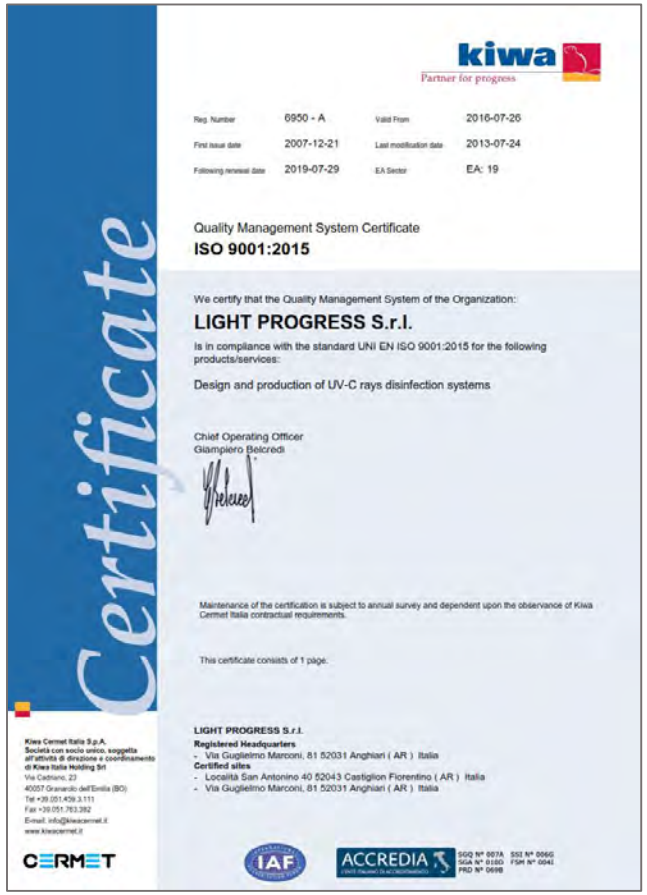
Jan-2017 Pag. 22/24



Certificate

kiwa
Partner for progress

Reg. Number	6950 - A	Valid From	2016-07-26
First issue date	2007-12-21	Last modification date	2013-07-24
Following renewal date	2019-07-29	EA Sector	EA: 19

Quality Management System Certificate
ISO 9001:2015

We certify that the Quality Management System of the Organization:
LIGHT PROGRESS S.r.l.
is in compliance with the standard UNI EN ISO 9001:2015 for the following products/services:
Design and production of UV-C rays disinfection systems

Chief Operating Officer
Giampiero Belcredi

Maintenance of the certification is subject to annual survey and dependent upon the observance of Kiwa Cermet Italia contractual requirements.

This certificate consists of 1 page.

Kiwa Cermet Italia S.p.A.
Società con socio unico, soggetta all'attività di direzione e coordinamento di Kiwa Italia Holding Srl
Via Cadriano, 23
40057 Granarolo dell'Emilia (BO)
Tel +39.051.459.3.111
Fax +39.051.783.392
E-mail: info@kiwacermet.it
www.kiwacermet.it

CERMET

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Certified sites
- Località San Antonino 40 52043 Castiglion Fiorentino (AR) Italia
- Via Guglielmo Marconi, 81 52031 Anghiari (AR) Italia

IAF ACCREDIA SQG N° 007A SSI N° 006G SGA N° 016D FSM N° 0041 PRD N° 069B

CERTIFICATE OF COMPLIANCE*

Certificate Number	20130702-E362672
Report Reference	E362672-20130628
Issue Date	2013-JULY-02
Issued to:	LIGHT PROGRESS SRL VIA G. MARCONI 81 52031 ANGHIARI AR ITALY
This is to certify that representative samples of	ACCESSORIES, AIR-DUCT MOUNTED Duct-Mounted UV Lamp Assembly, Models UV-RACK, followed by 3/, 4/ or 6/, followed by 40H, 60H or 90H.
	Have been investigated by UL in accordance with the Standard(s) indicated on this Certificate.
Standard(s) for Safety:	Bi-National Standard for Heating and Cooling Equipment, ANSI/UL 1995-2011 and CAN-CSA C22.2 No. 236-11
Additional Information:	See the UL Online Certifications Directory at www.ul.com/database for additional information

Only those products bearing the UL Classification Mark for the U.S. and Canada should be considered as being covered by UL's Classification and Follow-Up Service and meeting the appropriate U.S. and Canadian requirements.

The UL Classification Mark includes: the UL in a circle symbol: with the word "CLASSIFIED" (as shown); a control number (may be alphanumeric) assigned by UL; a statement to indicate the extent of UL's evaluation of the product; and the product category name (product identity) as indicated in the appropriate UL Directory. The UL Classification Mark for Canada includes: the UL Classification Mark for Canada: with the word "CLASSIFIED" (as shown); a control number (may be alphanumeric) assigned by UL; a statement to indicate the extent of UL's evaluation of the product; and the product category name (product identity) in English, French, or English/French as indicated in the appropriate UL Directory.

Look for the UL Classification Mark on the product.

William R. Carney, Director, North American Certification Programs
UL LLC

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Page 1 of 1

*Available for selected items

University Tests - Air Treatment

Dpt of Physiopathology, Experimental Medicine and Public Health
University of Siena
Via Aldo Moro 1, 53100 - SIENA - ITALY
Tel +39 0577 234134 - Fax +39 0577 234000
e-mail: epidmol@unisi.it

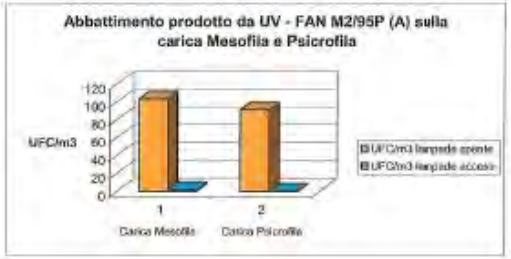
MOLECULAR EPIDEMIOLOGY
Research Division
EpidMol

Valutazione dell'effetto che purificatori d'aria a raggi UV-C prodotti da ***LIGHT* PROGRESS®** hanno sulla carica microbica e fungina presente nell'aria.

University of Siena
Dipartimento di Fisiopatologia
Sperimentale ed Igiene Pubblica
Lab. Molecular Epidemiology
Prof. Emanuele Montomoli

Grafico 1

Grafico 2



University of Siena
Dipartimento di Fisiopatologia
Sperimentale ed Igiene Pubblica
Lab. Molecular Epidemiology
Prof. Emanuele Montomoli

University Tests - Microbial Load Reduction

Dpt of Physiopathology, Experimental Medicine and Public Health
University of Siena
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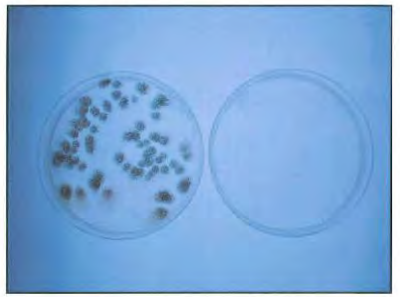
Tel +39 0577 234134 Fax +39 0577 234090
e-mail: epidmol@unisi.it

MOLECULAR EPIDEMIOLOGY
Research Division
EpidMol

Valutazione dell'effetto battericida, sporicida e fungicida dei raggi UV-C emessi da apparecchi *LIGHT* PROGRESS®

University of Siena
Department of Physiopathology, Exp Medicine and Public Health
Lab. Molecular Epidemiology
Prof. Emanuele Montomoli

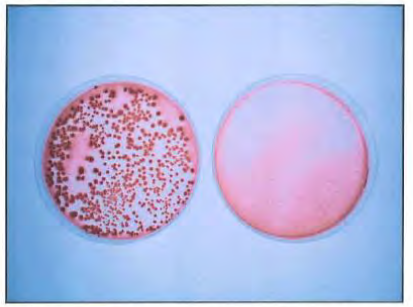
Aspergillus niger



Aspergillus niger su Sabouraud dextrose Agar, a sinistra la piastra non irradiata, a destra la piastra irradiata con UVC

University of Siena
Department of Physiopathology, Exp Medicine and Public Health
Lab. Molecular Epidemiology
Prof. Emanuele Montomoli

Escherichia coli



Escherichia coli su Macconkey Agar n.3, a sinistra la piastra non irradiata, a destra la piastra irradiata con UVC

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Lab. Molecular Epidemiology
Prof. Emanuele Montomoli

Staphylococcus aureus

Staphylococcus aureus su Mannitol salt agar, a sinistra la piastra non irradiata, a destra la piastra irradiata con UVC

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Grafico 8

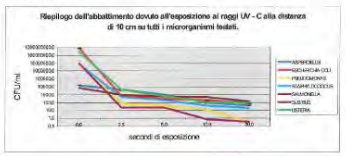
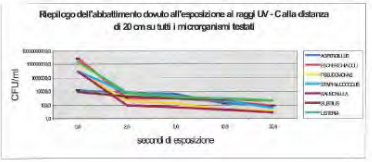


Grafico 9



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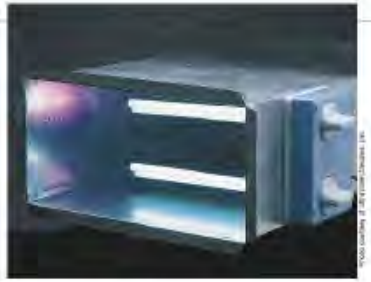
Best Practice

LIGHT PROGRESS

UVGI Design Basics

for Air and Surface Disinfection



Ultraviolet germicidal irradiation lamps can help clean coils and improve indoor air quality

UVGI for Hospital Applications

Dr. Wladyslaw Kowalski
Vice President, Immune Building Systems, Inc., New York, NY, drkowalski@ibsi.com
IUVA Air Treatment Symposium, Los Angeles, 2007

INTRODUCTION

Health Care facilities are subject to microbiological airborne hazards that can cause infections in both patients and health care workers. Hospital-acquired, or nosocomial, infections have been a persistent problem in hospitals and they can have complex multifaceted etiologies. It is possible that as much as a third or more of all nosocomial infections may be the result of airborne transmission at some point, and if so, air disinfection technologies may be able to reduce the nosocomial infection rate.

If the direct contact route predominates, as many experts believe, then surface disinfection technologies could also have a major impact. Combining air and surface disinfection may be an optimum approach to reduce infection rates and may very well be economical to implement. Existing health care guidelines for ventilation system design, pressurization, filtration, and disinfection procedures have historically held the problem at bay, but emerging nosocomial hazards and increasingly complicated etiologies are creating a demand for new control technologies.

This evolving and growing problem has spawned interest in both existing and developmental technologies, especially among engineers and health care professionals. This presentation summarizes applicable codes and standards, examines the epidemiology of airborne nosocomial infections and their aerobiological pathways, and reviews air and surface disinfection technologies such as ultraviolet germicidal irradiation (UVGI), which may offer more effective solutions. A summary of results from implementation of UVGI systems in hospitals is provided which demonstrates average nosocomial infection rate reductions of over 85%.

Guidelines, Codes, and Standards

Various guidelines, codes, and standards exist that offer details for designing health care facility ventilation systems (AIA 2001, ASHRAE 2003a & 2003b, CDC 1994 & 2003). Some guidelines specifically address problems like TB, nosocomial infections, and surgical site infections (CDC 2003, Weber 1981, Mangram et al 1999, Tablan et al 1994). While these guidelines provide adequate design information relating to airflow, air exchange rates, and filtration, they do not contain any specific guidelines for UVGI applications and are not reviewed here. In fact, the only current guidelines that provide any detailed information relating to UVGI air and surface disinfection are the draft IUVA guidelines (IUVA 2005).

The IUVA Guidelines include a description of the operating parameters of UVGI systems intended for effective air treatment, and these are equally applicable to health care applications as well as to commercial buildings and other facilities. The operating characteristics for successful UVGI system implementation do not differ (i.e. are not more stringent) for hospitals since performance criteria are already near a maximum for any UVGI system that meets the suggested guidelines. Included in the operating parameters are a recommended minimum of 0.25 seconds of UV exposure, an air velocity within the range of 500 fpm +/-100 fpm, and a recommended rating of URV 10 or higher, which corresponds to a minimum UV dose of 5 J/m2. Coupled with the requisite filters for hospital applications (per ASHRAE) such combined UVGI/filtration air cleaning systems will provide high removal rates for all nosocomial bacteria, fungi, and viruses.

Airborne levels in hospitals are not routinely monitored or regulated. For hospital air, WHO recommends relatively relaxed limits of 100 cfu/m³ for bacteria and 50 cfu/m³ for fungi, but many facilities would fail to meet these (WHO 1988). Environmental fungal spores should be completely removed per filtration guidelines, and so the presence of any fungal spores in an OR should warrant investigation. According to the criteria of Federal Standard 209E (FD 209E) on cleanrooms, conventionally ventilated operating rooms rank less than class 3.5 (Darmaz et al 2005). A limit of 10 cfu/m3, based on the ISO Class 7 cleanroom limit (EU Grade B) used in the pharmaceutical industry and at a target for ultra clean ventilation (UCV) systems, would probably be a more appropriate criterion for hospital ORs and ICU.

Airborne Nosocomial Epidemiology

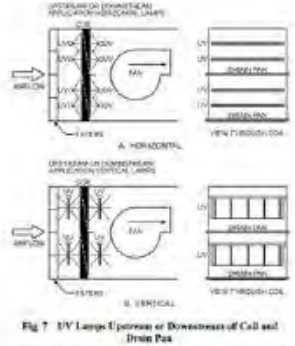
Airborne nosocomial infections are those that transmit directly or indirectly by the airborne route, and they may cause respiratory (primarily pneumonia) and surgical site infections (SSIs). The cost of nosocomial infections in the U.S. is estimated to be about $4-5 billion annually and various sources estimate that they cause between 2 and 4 million nosocomial infections with some 20-80 thousand fatalities annually (Kowalski 2006). It is not known what fraction of these infections are due specifically to airborne microbes, but since many of these microbes are potentially airborne it could be assumed that a large fraction, perhaps 25% or more, involve airborne transmission at some point in the nosocomial etiology.

Ultraviolet Germicidal Irradiation

The U.S. General Services Administration requires that UVC be included in cooling coil air-handling units for all new facilities and alteration projects to maintain coil cleanliness

Table 3 Advantages and Disadvantages of UVC Fixture Location Relative to Coil

Location	Advantages	Disadvantages
Downstream	More space to install fixtures. Allows luminaire to better irradiate surface where contaminants is highest. Allows luminaire to irradiate generally most contaminated part of coil and drain pan.	Lamp and fixture must be rated for damp location. Lamp cooling effects may reduce UV output, or require wonderful corrosion or more lamps and fixtures for a given result.
Upstream	Lamp and fixture may be subjected to less moisture. May be the only location to apply fixtures. Fewer lamps and fixtures may be needed (less re-downstream coils).	May not allow enough space to install fixtures. May initially take longer to clean coil and may not. Accident clean pan.



A. HORIZONTAL

B. VERTICAL

Fig. 7 UV Lamps Upstream or Downstream of Coil and Drain Pan

Fig. 8 Horizontal Lamp Placement for Coil Surface Disinfection

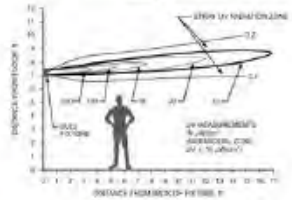


Fig. 9 Typical Elevation View

site to ensure that electrical interlocks are included to disengage the UV system when it is secured. UV systems should operate continuously to maximize UV's benefits and to improve lamp life, and to counteract mold and bacteria growth that occurs when an HVAC system is not operating.

UVGI systems can be installed upstream or downstream of the cooling coil (Figure 7). Both locations have advantages and disadvantages, as shown in Table 3. Figure 8 shows an actual installation at a coil.

Upper-Air UVGI Systems

Upper-air irradiation systems are designed to irradiate only air in the upper part of the room. Their narrow, flat-sided beam is placed parallel to the plane of the ceiling and prevents any ultraviolet rays from impinging on occupants below. Upper-air systems rely on air convection and mixing to move air from the lower to the upper portion of the room, where it can be irradiated and airborne microorganisms inactivated (Kethley and Branch 1972). Many fixtures incorporate a safety switch that breaks the circuit when fixtures are opened for servicing, and should contain baffles or louvers appropriately positioned to direct UV irradiation to the upper air space. Baffles and louvers must never be bent or deformed.

Upper-room UVGI fixtures typically are low-pressure UVC lamps in tubular and compact shapes, and require a variety of electrical wattages. Beyond lamp size, shape, and ballast, fixtures are designed to be open or reflected in distribution, depending on the physical space to be treated.

Ceiling height is above 10 ft allow more for more open fixtures, which are more efficient. For occupied spaces with lower ceilings (less than 10 ft), consult knowledgeable upper-room UVGI fixture (wall, pendant, and corner) are available to be mounted in combinations at least 7 ft from the floor to the bottom of the fixture. Figure 9 shows some typical dimensions and corresponding UV levels, and Figure 10 illustrates distribution in a room.

Indoor Air Quality Guide

Best Practices for Design, Construction, and Commissioning

Developed by:
American Society of Heating, Refrigerating and Air-Conditioning Engineers
The American Institute of Architects
Building Owners and Managers Association International
Sheet Metal and Air Conditioning Contractors' National Association
U.S. Environmental Protection Agency
U.S. Green Building Council

...lly used in buildings: in-duct, ...de a high level of ultraviolet ...y past the lamps. Upper room ...the occupants, shielded from ...rces to create currents that ... rooms with low air turnover. ...n pan in the delivery plenum ...tivates microorganisms that ...This irradiation of stationary ...r intensity requirements than ...moving air stream.

... to provide radiation at the ...microorganisms. The lamps ...rescent lamp but differing in ...nother difference is that UVC ...transmits UVC, rather than

These guidelines deal primarily with issues related to placement of UVC systems in air handling units in the proximity of the cooling coil.

How important is indoor air quality?

Evidence strongly suggests that poor environments in schools, primarily due to the effects of indoor pollutants, adversely influence the health, performance and attendance of students and teachers. This evidence links high concentrations of several air pollutants to reduced school attendance. There is also persuasive evidence that microbiological pollutants are associated with increases in asthma effects and respiratory infections, both of which are related to lower school performance and attendance.[4] UVC lights offer a potentially effective means of both reducing energy use and delivering fresh air to improve classroom air quality.

UVC lamps are designed to clean both the coil and drain pan surfaces in a few hours or a few days[5] and to progressively penetrate between the coil rows and fins with time. Indoor air quality may be improved since the coils that are continuously cleaned by UVC are thus no longer an incubation site for microorganisms. Air flowing through the coils is therefore not contaminated, resulting in cleaner air being delivered to the classroom.

What are the maintenance issues with UVC?

An effective traditional coil cleaning program cleans the coils three to four times per year. Use of UVC lamps can eliminate the need for these costly, tedious cleaning treatments that create system downtime and use chemicals, biocides or pressure washing. Mechanical or chemical washing may also damage coils. Maintenance benefits may accrue from use of UVC lights to keep coils continuously clean, avoiding these laborious coil cleaning actions that will otherwise be required to return coils to a clean condition. UVC lamps should be inspected to see if they are dirty and then cleaned on a regular basis, as needed. Some installations have a view port to permit visual observation of the

Scientific Studies

LIGHT PROGRESS

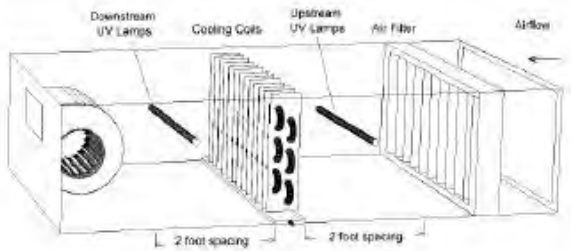


Figure 2.1: Location and spacing for UVGI system in an air handling unit

2.2 Location of UV Lamp Ballasts

UV lamp ballasts should preferably be located external to the ventilation system although this is not currently a strict requirement due to so many systems that have integral lamp ballasts that must be located wherever the lamp is located. One of the problems with lamp ballasts being located inside air handling units is that they may be exposed to temperature and humidity extremes.

If lamp ballasts are located in an internal lamp housing, the housing should be of drip-proof construction or other approved housing method. If lamp ballasts are located external to the air handling unit or ductwork, the wiring must be run through conduit such that there is no exposed wiring inside the air handling unit. Exposed wiring may be subject to deterioration inside and air handling unit and may also be exposed to UV irradiation, which may cause photodegradation over time and thus pose a fire hazard.

2.3 Operating Conditions

Both the UV lamp and the ballast should be located such that the ambient operating conditions (i.e. temperature and relative humidity) are within the component design or operating limits. Refer to manufacturer's information for design operating conditions. In general, both UVGI and filters are designed to operate at an air velocity of 500 fpm, although some lamps may be suitable for operation at higher velocities. Variations in air velocity (i.e. +/- 100 fpm) may be acceptable depending on the manufacturer's lamp but such variations should be evaluated to include or assess the impact on UV output. See IUVA-G01A-2005, "General Guideline for UVGI Air and Surface Disinfection Systems," for

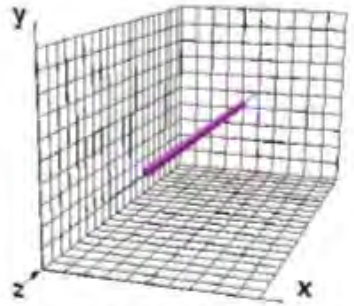


Figure 6.1: Grid for a 9x9x20 Matrix and Coordinate System, shown with a lamp in an axial configuration.

6.2 Operation of the Program

The program takes the input data from an input text file, performs the analysis and outputs results in a text file. Intermediate results can be extracted and graphed in spreadsheets.

Input data requires definition of the coordinate system. The lamp coordinates are based on the lower left front corner of the matrix being at (0, 0, 0). The indices for both the large and small matrices are also based on this (0, 0, 0) point.

Using the input the enclosure intensity field is determined by evaluating the direct intensity field of the lamp, the first reflection intensity field, and the total inter-reflected intensity field. These are summed to produce the total intensity field of the enclosure. This process is shown by the flow chart in Figure 6.2.

As mentioned previously, the inter-reflections are only computed for three iterations, after which the total bulk average intensity is determined mathematically for the remaining inter-reflections. Each of the first three inter-reflection calculations involves computing the exchange of radiative energy from each of the blocks on the other three sides, for all four walls. The summed result produces the wall intensity contours for the next set of inter-reflection calculations. This is the most calculation-intensive portion of the program and takes up the most operating time. In comparison, the direct and first reflection calculations proceed relatively rapidly.

Because two different size matrices are used for the computations, it is necessary to scale up the smaller matrix to match the size of the larger matrix prior to adding them. This is

MN-00-11-1

Effective UVGI System Design Through Improved Modeling

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ABSTRACT

This paper summarizes an improved methodology for predicting the rate of microorganism inactivation for UVGI systems that will enable effective designs and lower energy costs. This approach uses radiative view factors to define the three-dimensional intensity field for lamps and reflective surfaces inside enclosures. Lamp photometric data for a variety of lamps are shown to agree more closely with the view factor model than with models using the Inverse Square Law. The intensity field due to reflectivity from common surfaces is determined by assuming diffuse reflectivity. An analytical method is used to determine the inter-reflected component of intensity due to multiple internal reflections. The superposition of these components yields a three-dimensional intensity field source that can be used to calculate disinfection rates for any given microbial rate constant. Results from laboratory bioassays using S. marcescens *to various dose configurations have corroborated useful predictions within a UV fluence of 10% in most cases.*

INTRODUCTION

Currently available design information has not guaranteed predictable performance for UVGI air disinfection systems. Some of today's design practices can overdesign systems, leading to prohibitive costs and high energy consumption. Other design practices lead to undersized and ineffective systems. Design practices have not changed in decades, and it is worthwhile to review the history of UVGI applications to discover how this situation has come to be.

Although the first UVGI water disinfection system was implemented in 1909 (AWWA 1971), the first UVGI systems designed for air-stream disinfection were not implemented until the 1930s (Hiatt 1940). Based on limited laboratory data and using newly available UVGI lamps, these systems were sized without the benefit of generating criteria. Tests, either on sampling or epidemiological, were used to determine their efficacy. Some of these systems were highly successful, such as those used to control measles in schools, and one used by Riley to eliminate TB bacilli from hospital ward exhaust air (Riley and O'Grady 1961).

Other designs appeared to be ineffective, with the result that the initial glowing reviews of this technology became tempered. Guidelines were issued that cautioned the use of UVGI only in combination with HEPA filters (Luciano 1977; ASHRAE 1991). No studies were ever undertaken to determine the root cause for any UVGI system failure. Apart from improvements in lamp designs, applications technology for air-stream disinfection has remained almost stagnant for decades.

The first design guidelines for UVGI air-stream disinfection systems were developed in the 1940s (Luckiesh and Holladay 1942; Luckiesh 1946). Versions appeared in catalogs that continue to be reproduced and used today (Philips 1985). These guidelines offer procedures, charts, and tables to size lamps and reflective surfaces so as to obtain a desired disinfection rate. These sizing methods, though admirably detailed for the period, suffer from a number of deficiencies:

1. They fail to define the intensity field, instead merely using the lamp rating or else relying on photometric data for lamp midpoints.
2. Lamps are specified without regard to lamp location or type.
3. The correction factor for rectangular ducts ignores the intensity field variations due to surface reflectivity.

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Thank you

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