NALMCO Intro | Transcript

Slide 1 (00:00 - 00:09)

This module provides an overview of the Apprentice GUV Technician certification course offered by NALMCO.

Slide 2 (00:10 - 00:35)

The goals of the course are to offer an introduction to NALMCO, understand basic principles of germicidal ultraviolet, cover GUV standards and guidelines, review application examples of GUV fixtures, understand GUV fixture components, GUV equipment maintenance, and safety of GUV fixtures.

Slide 3 (00:36 - 01:16)

The learning objectives for the Apprentice level certification course focus on germicidal ultraviolet fixtures applied to upper rooms, whole rooms, or a combination of these applications.

After this training, the participant will be able to explain to interested parties: NALMCO certifications; which ones are available, the discovery and principal of GUV, GUV standards and guidelines, applications of GUV light, use of ultraviolet light in disease prevention, GUV lamps and fixture components, and GUV fixture maintenance and safety.

Slide 4 (01:17 - 01:48)

NALMCO stands for the International Association of Lighting Management Companies. NALMCO offers certifications for people who want to become qualified installers of germicidal ultraviolet fixtures. What is important is [that] qualified installers promote adequate design, well-designed and performing fixtures, correct installation, GUV safety, and proper maintenance.

Slide 5 (01:49 - 02:10)

The Apprentice GUV Technician Certification course focuses on upper room and whole room GUV fixtures. It is theoretical in nature and there is not a hands-on component for this certification. It includes principles of GUV, applications, GUV standards and guidelines, GUV fixtures and lamp technologies, maintenance, and safety.

Slide 6 (02:10 - 02:31)

NALMCO certification offers several benefits, including: demonstrat[ing] qualified staff, [ensuring that] maintenance of GUV fixtures is well understood, preparation for audits, and validation of safety.

Slide 7 (02:32 - 03:27)

Partners of NALMCO include the University of Maryland School of Public Health, Illuminating Engineering Society (IES), and the International Ultraviolet Association (IUVA).

Germicidal ultraviolet technology has gained significant recognition as an effective method for disinfection of air and surfaces across various industries. With its proven ability to eliminate harmful pathogens, it has become an integral component in maintaining a safe and healthy environment for employees, customers and the public. With that said, it is important to train professionals responsible for the design, installation and maintenance of GUV luminaires. This training and certification program will serve as the first step toward educating the public on the proper and safe use of GUV.

Slide 8 (03:28 - 04:11)

NALMCO's GUV certifications are carefully designed to provide a comprehensive understanding of germicidal ultraviolet technology and its effective implementation in their respective fields. By the end of the training, attendees will possess the knowledge and skills necessary to install, maintain, and utilize GUV equipment safely and effectively.

Our esteemed panel of industry experts who possess extensive experience in GUV technology will facilitate the training sessions. They will share their expertise, insights, and practical guidance to ensure participants gain a thorough understanding of the subject matter.

Slide 9 (04:12 - 04:30)

There are three levels of NALMCO GUV certifications: the Apprentice GUV Technician, which is online; Senior GUV Technician, which includes a hands-on component; and the GUV Management Professional, which includes a hands-on component.

Slide 10 (04:31 - 05:40)

NALMCO firmly believes that this GUV certification program will equip your organization with the necessary skills and knowledge to enhance its disinfection practices and promote a healthier environment. We look forward to your participation.

Resources for additional information about GUV and NALMCO's partnership with IES can be found in IES Committee Report CR-2-20 Frequently Asked Questions (FAQs). The IES site provides a simplified way to quickly read the FAQs contained in the IES Photobiology Committee's report. The full report contains supporting information on this topic as well as an introductory video. These FAQs have been vetted through the IES ANSI-approved standards development process through a consensus of volunteers representing varied viewpoints and interests. The link to the report is shown here: www.nalmco.org/guv-training.

Slide 11 (05:41 - 06:02)

The Apprentice GUV Technician certification online training and exam are accessible 24/7. The program is designed to be affordable, uncomplicated and offers annual online recertification.

We very much look forward to your participation.

Module 1: Course Overview | Transcript

Slide 1 (00:00 - 00:12)

Welcome to the course about Germicidal Ultraviolet. This is module one and an introduction to the course.

Slide 2 (00:12 - 00:41)

This course has the following goals: understand basic principles of germicidal ultraviolet (abbreviated as GUV), GUV standards and guidelines, application examples of GUV fixtures, GUV fixture components, GUV equipment maintenance, and understanding the safe use of GUV fixtures.

Slide 3 (00:41 - 01:26)

The learning objectives of this course are the following. The online training modules focus on germicidal ultraviolet fixtures applied to upper rooms, whole rooms, or a combination of these applications. After this training, the participant will be able to explain to interested parties the following: discovery and principles of GUV, GUV standards and guidelines, applications of GUV light, use of ultraviolet light in disease prevention, GUV lamps and fixture components, GUV fixture maintenance, and safety.

Slide 4 (01:26 - 01:35)

Let's dive in and learn about germicidal ultraviolet: upper room, whole room and their combinations.

Slide 5 (01:35 - 02:10)

New word alert! New words, meaning new vocabulary, will be introduced throughout this training. When the image of a bullhorn appears, a new term will be introduced. The new terms are highlighted in dark red. Then a definition of these new terms, meaning these new words will follow.

Slide 6 (01:58 - 02:29)

So why is it important to improve indoor air quality? It keeps us from getting sick with respiratory issues like asthma or illnesses like the flu. Steps that can be taken to breathe better indoors include: keeping the heat, ventilation and air conditioning (the HVAC system) up-to-date. Germicidal ultraviolet lights can kill germs in the air.

Slide 7 (02:29 - 03:08)

UV-C germ-killing lights are also referred to as “germicidal ultraviolet”, abbreviated as “GUV” in the United States. GUV is a type of germ-killing light. GUV may kill viruses, bacteria [and] tiny mold particles in the air that can make people sick. GUV installed and maintained properly in indoor spaces prevents the spread of airborne illnesses like tuberculosis, flu, measles and COVID-19.

Slide 8 (03:09 - 03:31)

Many different indoor spaces use GUV to make sure air's free from harmful germs. These indoor spaces can include schools, health care, universities, churches, airports and many other areas where people congregate. GUV has been safely used since the 1930s.

Slide 9 (03:32 - 04:03)

Let's review the key points. UV-C germ-killing lights are referred to as germicidal ultraviolet (GUV in the United States). Germicidal ultraviolet lights improve the indoor air quality. Many different indoor environments used GUV lights to make air safer. GUV has been safely used by people since the 1930s.

Module 2: Introduction to UV-C | Transcript

Slide 1 (00:00 - 00:08)

Germicidal Ultraviolet Module two: Introduction to UV-C.

Slide 2 (00:12 - 00:24)

Introduction to GUV light. In this section, we explore: discovery of GUV light, how it works, what it does, and what are photons.

Slide 3 (00:25 - 00:52)

Discovery of ultraviolet light.

In 1801, Johann Ritter experimented with sunlight using a glass prism. All the colors of the rainbow appeared. He noticed an area of energy beyond the visible violet light, but he could not see it. He became curious and designed an experiment to investigate this invisible area.

Slide 4 (00:54 - 01:28)

Johann Ritter's experiment.

He placed a line of silver chloride right beyond the visible violet light region. He used a prism to split the sunlight into rainbow colors. The silver chloride line just beyond the visible violet region began to darken, so he was able to make this invisible area visible. Later, he named this area ultraviolet.

Slide 5 (01:30 - 02:24)

This very busy slide shows the electromagnetic spectrum. It ranges from gamma rays on the left to x-rays, ultraviolet light, visible light, infrared, microwaves and radio waves. So what we see here is that the ultraviolet light is actually composed of UV-A, UV-B, UV-C, and vacuum UV. And, a very small part of the electromagnetic spectrum is actually visible light. So you can see here how small this area actually is. And as an important reminder, the ultraviolet light is not visible light.

Slide 6 (02:25 - 03:03)

The electromagnetic spectrum describes all of the kinds of light. Most of the light in the universe is invisible to our eyes, and humans can only see the rainbow colors. And, they represent a truly very small portion of this electromagnetic spectrum. Other types of light that cannot be seen include radio waves, microwaves, infrared radiation, ultraviolet rays, x-rays and gamma rays.

Slide 7 (03:04 - 03:56)

Light travels in waves like ocean waves. So we have the lower energy region, which has a lower frequency, which is shown on the left here with radio waves, microwaves, infrared. And as you can see, the energy region increases so we have a higher frequency, and the visible light is right in between. Then we have ultraviolet, x-ray, and gamma rays that have the highest frequency.

So as a wave, light has three basic properties that describe it. One is the frequency; it counts the number of waves that pass by a given point in one second. Two is the wavelength, which is the distance from the peak of one wave to the peak of the next. Thirdly, the energy; the higher the frequency of the light wave, the more energy it carries.

Slide 8 (04:04 - 04:35)

Light is made up of lots of photons. So what is a photon? Imagine a shaft of yellow sunlight beaming through a window. This beam is made of zillions of tiny packets of light called photons, and they stream through the air. So a photon is the smallest discrete amount of electromagnetic radiation. It is the basic unit of all light.

Slide 9 (04:36 - 05:39)

So here are some fun facts about photons. The image on the left shows an actual hologram of a single photon, which was reconstructed from raw measurements. And this is actually very close to the theoretically predicted photon shape, which is shown in the image to the right with the blue coloring. This was a very exciting discovery made by scientists.

So not only is light made up of photons, but all electromagnetic energy– for example, microwaves, radio waves, x-rays–they're all made up of photons. Photons are always electrically neutral. They do not decay on their own, and they're always in motion. In a vacuum, photons travel at what is known as the speed of light.

Slide 10 (05:39 - 06:42)

So photons have dual properties, namely a wave and a particle. Einstein was the one who proved that light is a flow of photons, and the energy of these photons is the height of their oscillation frequency. Now, the intensity of the light corresponds to the number of photons. So the more photons, the more intense the light may be. And he explained how a stream of photons can act both as a wave and a particle.

Now, the image on the left shows this dual nature of the light, both as a wave and a particle. Scientists were able, in 2015, to create an image that shows this dual property– this wave, and a particle in a photon. This was a very exciting image discovery by these scientists.

Slide 11 (06:43 - 07:23)

So let's review the key points of this module. Johann Ritter discovered the invisible ultraviolet region. Ultraviolet light is not visible light. The electromagnetic spectrum is made up of different energy regions, mostly invisible to the human eye. Ultraviolet light is part of it, part of this invisible region.

Light is described with three basic properties: frequency, wavelength and energy. Light is made up of lots of photons streaming through the air.

Module 3: GUV References/Standards and Guidelines | Transcript

Slide 1 (00:00 - 00:07)

Module three: GUV references/ standards and guidelines.

Slide 2 (00:08 - 00:34)

In this section, we explore terminology, use of GUV in disease prevention, Centers for Disease Control and Prevention guidelines, Illuminating Engineering Society Standards, the American Society of Heating, Refrigeration and Air Conditioning Engineers handbooks, and ANSI/ASHRAE standards, and guidelines on GUV.

Slide 3 (00:35 - 01:40)

Ultraviolet light can be described with different terms. The ultraviolet industry has no standard language for definitions, and depending on the organization or industry group, terminology for ultraviolet can differ. This creates a lot of confusion. So examples of terminology that are used in industry can include germicidal ultraviolet (abbreviated as GUV), ultraviolet C band (abbreviated as UV-C or UVC), ultraviolet germicidal irradiation (abbreviated as UVGI), or ultraviolet C band specific to wavelength (abbreviated as UV-C_{222},UV-C_{254},UV-C_{265}). In this course we will use germicidal ultraviolet, abbreviated as GUV.

Slide 4 (01:41 - 02:36)

The use of germicidal ultraviolet in disease prevention.

Years of experiments and observations led to the discovery that ultraviolet light can help reduce the transmission of diseases. Specifically, the ultraviolet UV-C region of the electromagnetic spectrum shows the greatest effect on germs in the air. The Centers for Disease Control and Prevention, abbreviated as CDC, began to publish guidelines on the use of UV-C. These guidelines also referred to upper room germicidal ultraviolet, which is abbreviated as UR-GUV. Upper room germicidal ultraviolet is strictly from the UV-C region of the electromagnetic spectrum.

Slide 5 (02:37 - 03:55)

CDC NIOSH has documents that actually explain how upper room GUV has been used in the past. Since the 1950s, the bulk of the research on GUV has focused on controlling the spread of tuberculosis. CDC published Guidelines For Preventing The Transmission Of Tuberculosis In Health Care Settings, With Special Focus On HIV-Related Issues. Now, these documents were updated to a current guidance document, which, although it seems older, but the most current guidance is from 2009 on the design, installation, testing, and safe operation of upper room GUV systems. So the title specifically is Environmental Control for Tuberculosis: Basic Upper Room Ultraviolet Germicidal Irradiation Guidelines for Health Care Settings, 2009. On CDC’s website, though, you can find updates to some of these guidelines that provide additional information.

Slide 6 (03:56 - 05:10)

The COVID-19 pandemic prompted changes and CDC/NIOSH updated their website in two areas specifically for GUV applications. One, about germicidal ultraviolet, and the quotations are listed here below the websites, so you can find this text as a summary on this website. “New” is about ventilation and respiratory viruses. This area was also updated and it is summarized below the web link.

Slide 7 (04:40 - 05:36)

IES offers two standards on GUV. RP-27.1-22 is focused on background of UV radiation, emission limits and measurements for risk group determination, system safety control measures for manufacturers, labeling, and safety control measures for occupied spaces. RP-44-21 is focused on types of UV radiation, types of GUV equipment and systems, effects of ultraviolet radiation, design and use of UVGI systems for disinfection effectiveness, maintaining systems and verifying performance, safety measures and restrictions, and they provide an overview systems comparison.

Slide 8 (05:37 - 06:33)

ASHRAE has two handbooks that include each, a chapter on GUV. One is the 2024 HVAC Systems and Equipment Handbook, and Chapter 17 contains terminology, GUV fundamentals, germicidal ultraviolet sources and equipment, UV-C photodegradation of materials, maintenance, safety, and installation and commissioning.

The 2023 HVAC Applications Handbook, chapter 62, contains terminology, UVGI air treatment systems, HVAC system surface treatment, energy and economic considerations, room surface treatment, safety, installation, start-up and commissioning, and maintenance.

Slide 9 (06:34 - 07:41)

So let's review the key points of what we just discussed. The ultraviolet industry has no standard language or definitions. And as you could see throughout, just introducing the ASHRAE handbooks or looking at CDC/NIOSH guidelines or the IES standards, the terminology is used interchangeably. Some use UVGI, others UVC, then there's GUV. So the bottom line is, germicidal ultraviolet (GUV) is used to help prevent disease. CDC/NIOSH has guidelines on the use of GUV. IES published recommended practices on GUV applications and safety. And, ASHRAE has 2 published handbooks which each include a chapter on GUV applications and GUV systems and equipment. These guidelines and standards offer a good resource on GUV as needed.

Module 4: Applications of GUV | Transcript

Slide 1 (00:00 - 00:05)

Module four: applications of GUV.

Slide 2 (00:06 - 00:30)

In this module, we will explore taking a closer look at ultraviolet, the differences between UV-A, UV-B and UV-C, common GUV applications, upper room germicidal ultraviolet, and whole room germicidal ultraviolet applications.

Slide 3 (00:31 - 01:06)

You already saw the electromagnetic spectrum in an earlier module. This really serves as a reminder as to where UV-A, UV-B and UV-C lie within the electromagnetic spectrum.

So remember that ultraviolet light is not visible. We cannot see it. And it is important to recognize now that the ultraviolet-C region specifically is known for its germicidal properties.

Slide 4 (01:07 - 02:00)

Let's take a closer look at the ultraviolet-A, -B, and -C region. So here you can see that UV-C has a higher energy as compared to UV-B or UV-A.

So UV-C is responsible for reddening of skin and eye irritation. Now, here's our first word alert. It also inactivates bacteria and viruses. Inactivating bacteria and viruses means they can no longer replicate in their disease-causing state, and it renders an organism harmless. So the UV-B region causes burning, skin aging, and is responsible for skin cancer. UV-A is responsible for tanning.

Slide 5 (02:02 - 02:44)

The sun naturally generates ultraviolet-A, -B, and -C rays. 95% of UV-A reaches the earth, whereas only 5% of UV-B reaches the earth. Now, UV-C is actually completely filtered out by the ozone layer. Imagine if UV-C would not be filtered out. Life on earth would not be possible the way we know it. Artificial UV-C lamps can be made to inactivate unwanted viruses or bacteria, where we then use this UV-C to, as we said earlier, kill those germs in the air.

Slide 6 (02:50 - 03:11)

Applications of artificial UV-A and -B can be found everywhere. They're using curing to detect counterfeit money, EPROMs, detecting scorpions with black light, vitamin D, criminal investigations, and in tanning booths.

Slide 7 (03:12 - 03:44)

Applications of GUV in disease prevention can be found in many different places. For example, GUV can be used in duct systems to treat the air. It can be used in upper room GUV systems where the upper air in a room is treated. It can be found in whole room GUV systems that, in a sense, shine downward and treat air and can also treat surfaces at the same time.

Slide 8 (03:45 - 04:22)

In this image, we see an example of disease prevention using an upper room GUV fixture. So on the left side–and this is a slide from the CDC–they use the terminology UVGI devices, which is the same as upper room GUV. So these devices create a zone in the upper part of a room, and it is called a disinfection zone because the UV-C in that upper part of the room continuously disinfects the air.

Slide 9 (04:23 - 05:26)

This image shows actual applications of this upper room GUV. So in the upper left you can see, and the lights were turned off, how the GUV actually travels. And I know you can see this blue light. Well, that is not GUV. Remember, the ultraviolet region is invisible, but some of these man-made lamps also generate visible light. So here we see the visible light. But at the same time, these lamps generate mostly this germicidal ultraviolet. Now, on the very right hand side, we see an image where one of these GUV fixtures is actually hung and suspended from a ceiling. So this then helps to treat a very large area. So you can see, depending on the application, different fixtures can be manufactured and installed.

Slide 10 (05:26 - 05:53)

In this image, you can see what we call whole room GUV fixtures. So these GUV fixtures treat, so to speak, the whole room. They can be installed on ceilings. They can be mounted on tripods. So depending on the type of fixture, you can find them in different configurations and mountings.

Slide 11 (06:01 - 06:20)

This image offers a nice example of a whole room and upper room GUV installation where you can see, the left side of the image shows the whole room GUV fixture and on the right side it shows the upper room GUV fixture.

Slide 12 (06:21 - 06:43)

Here's a close up look of GUV applications. The one I mentioned earlier, HVAC air disinfection, you can see how the UV-C lamps are installed in the air ducts. And on the right hand side we can use UV-C lamps to disinfect surfaces.

Slide 13 (06:44 - 07:01)

GUV can also be found for drinking water disinfection, which is actually a very common application. And, you can find GUV disinfection in municipal wastewater treatment.

Slide 14 (07:02 - 07:51)

So let's review the key points of what we just covered. The sun naturally generates UV-A, UV-B and UV-C rays. Some of the UV-A and UV-B reach the earth's surface. UV-C is completely filtered out by the ozone layer and does not reach the earth's surface. UV-C has germicidal properties and UV-C inactivates, meaning it kills bacteria and viruses. Man-made germicidal ultraviolet (GUV) lamps are used for disease prevention. GUV lamps are used in many different applications to eliminate unwanted bacteria and viruses from the air, on surfaces, and in water.

Module 5: UR and WR GUV Luminaire Components | Transcript

Slide 1 (00:00 - 00:09)

Module five. Let's have a look at upper room and whole room GUV luminaire components.

Slide 2 (00:10 - 00:37)

Components of GUV luminaires.

And by the way, luminaires is a fancy word for fixtures. So components include lamps, ballasts or driver, optical elements, and luminaire (also called fixtures) housing. Some of the housings have reflectors, baffles and diffusers. They can all be slightly different.

Slide 3 (00:38 - 00:51)

Let's take a look at lamp components. They're similar to a regular light fixture. They can be made of low pressure mercury lamps, light emitting diodes or excimer lamps.

Slide 4 (00:54 - 01:08)

So component 2: ballasts or drivers. It's really, again, the same idea as a regular light fixture. For a low pressure mercury lamp, you find a ballast. And, for example, krypton chloride excimer lamps have certain electronics.

Slide 5 (01:09 - 01:50)

The optical elements also have the same idea as a regular light fixture. So this slide shows the optical elements for a low pressure mercury lamp fixture. So here, the important part is to safely manipulate the lamp’s UVC output upward and prevent exposure. So what this means is an optical element could be a parabolic reflector or refractor, diffuser, louvers, baffles, a lens or a combination.

Slide 6 (01:51 - 02:02)

Optical elements for krypton chloride excimer lamps include diffused optics, or they can be clear optics.

Slide 7 (02:02 - 02:27)

The lamp and the application determines the type of housing. On the left side, we see a typical low pressure mercury lamp housing, and in the middle we see krypton chloride housings, and on the right hand side LED lamp housings. So depending on the application and the size, you can see it greatly varies.

Slide 8 (02:28 - 03:11)

So let's review the key points we just covered. Most upper room and whole room fixtures have four components: a lamp (which can be one lamp or many lamps. What we looked at were low pressure mercury lamps, excimer lamps and LEDs); they can have ballasts or drivers; optical elements; and housing. Different optical elements are used depending on lamp and application. The lamp or lamps and application determine the type of housing that is needed.

Module 6: What Does GUV Light Do and How it Works | Transcript

Slide 1 (00:00 - 00:06)

Module six: what does GUV light do and how does it work?

Slide 2 (00:07 - 00:22)

In this module, we will explore the definition of “pathogen”, definition of “germicide”, CDC’s “upper room GUV” definition, and how GUV works.

Slide 3 (00:23 - 00:47)

GUV inactivates pathogens in the air. So here's a new word alert: pathogens. What is a pathogen? An organism or other agent that causes disease. GUV fixtures inactivate potential pathogens indoors.

Slide 4 (00:49 - 01:22)

What is a germicide? So the definition of germicide is something such as an antiseptic or disinfectant that destroys or inactivates (meaning kills) pathogens such as bacteria or viruses. An agent or preparation that is effective against germs. The result is a loss of ability to replicate, preventing the bacteria or virus from causing infection.

Slide 5 (01:23 - 02:18)

CDC describes GUV in the following way. The upper room– and they refer to GUV as UVGI– refers to a disinfection zone of UV-C energy that is located above people in the rooms they occupy. So the upper room GUV inactivates or kills airborne pathogens in the room where these pathogens are released. GUV fixtures are installed to prevent direct exposure of people in the room. On the left side, you see an image that shows these upper room GUV fixtures mounted above people and the louvers are set so that UV-C rays travel above people's heads so they will not be exposed.

Slide 6 (02:19 - 03:21)

This image shows upper room GUV fixtures that use a 254 nanometer or a low pressure mercury lamp. Now these lamps generate the invisible UV-C, but also generate some visible blue light. And when you turn the lights off in a room, you can actually see how this blue light travels, and the invisible UV-C light travels in the same pattern.

So here the louvers are set to have the UV-C energy travel safely above people's heads. So for airborne viral particles, upper room GUV systems also provide air changes per hour that are similar to the introduction of clean air into space by continuously inactivating potential pathogens in air.

Slide 7 (03:22 - 03:49)

This image shows whole room GUV fixtures. Now whole room GUV fixtures create disinfection zones of UV-C energy that travel throughout the entire room. And here you can see some ceiling mounted fixtures and a fixture that is mounted on a tripod. So different configurations are available.

Slide 8 (03:50 - 04:17)

So how does upper room GUV work? Air passes through the disinfection zone from either airflow, through HVAC system diffusers, fans, convection, and/or open windows. So as the air moves through this disinfection zone, potential pathogens can get inactivated.

Slide 9 (04:18 - 04:39)

The airborne pathogens, viruses for example, are inactivated, meaning killed, once they receive an appropriate amount of UV-C energy. So these viral particles remain in the air but are no longer infectious and will be dying off.

Slide 10 (04:40 - 05:34)

So let's review the key points. GUV fixtures inactivate (meaning kill) potential pathogens (meaning organisms) that can cause disease indoors. A germicide destroys or inactivates pathogens such as bacteria and viruses. Upper room GUV refers to a disinfection zone of UV energy that is located above people in the rooms they occupy. Whole room GUV creates a disinfection zone of UV-C energy throughout the entire room. Upper room and whole room GUV work by air passing through GUV disinfection zones where airborne pathogens are inactivated once they receive an appropriate amount of GUV energy.

Module 7: GUV Lamp Technologies | Transcript

Slide 1 (00:00 - 00:04)

Module seven: GUV lamp technologies.

Slide 2 (00:05 - 00:19)

In this section, we explore artificial germicidal lights, definition of photobiology, optimal germicidal wavelength, and GUV lamp technologies.

Slide 3 (00:20 - 01:21)

Germicidal ultraviolet can be created artificially and we want to then create certain wavelengths that are most beneficial to inactivate bacteria and viruses. So here on this image– it is an excerpt from the electromagnetic spectrum– it shows the UV-C energy, the ultraviolet light in the region ranging from 207 to 280 nanometers wavelengths. We know that this region is known for its germicidal property and inactivates bacteria and viruses. So what can be done is, GUV lamp technologies can create these different germicidal wavelengths and depending on the GUV lamp technology, specific wavelengths can then be generated.

Slide 4 (01:22 - 02:13)

Before exploring the GUV lamp technologies, let's have a look at photobiology and its effect on living organisms.

But first, what is photobiology? It is the study of the effects of light on living organisms. So photobiology is broadly defined to include all biological phenomena, involving non-ionizing radiation. It is recognized that photobiological responses are the result of chemical and/or physical changes induced in biological systems by non-ionizing radiation. So germicidal ultraviolet has a photobiological effect on bacteria and viruses.

Slide 5 (02:15 - 03:17)

There is an optimal germicidal wavelength, and the most effective photobiological response is at around 265 nanometers. So the germicidal action spectrum defines relative effectiveness of differing wavelengths in producing a photobiological response. Bacteria and viruses differ in how they respond to germicidal ultraviolet, but most will be inactivated when exposed to enough GUV energy.

Artificial UV-C lamps can generate different wavelengths– for example, 222 nanometers, 254 nanometers, 265 nanometers– where they're all effective in inactivating bacteria and viruses.

Slide 6 (03:18 - 04:11)

Artificial GUV lamps can act as a germicide and create this photobiological response that was just discussed. The most common types of GUV lamps used for upper room and whole rooms GUV fixtures are: 1) low pressure mercury lamps; they generate 253.7 nanometers commonly referred to as 254 nanometers; 2) Excimer lamps, which generate 222 nanometers (often referred to as krypton chloride lamps); and 3) light emitting diodes (LEDs) that can generate various wavelengths, but mostly the 265 nanometers is used for germicidal applications as LED.

Slide 7 (04:14 - 04:46)

Back to the excerpt of our electromagnetic spectrum showing the different lamp technologies under the UV-C energy spectrum. On the left, with the lower energy, we see the krypton chloride or excimer lamps at 222 nanometers, followed by low pressure mercury lamps at 254 nanometers (rounded), and LEDs around 265 nanometers.

Slide 8 (04:48 - 05:35)

Let's look at low pressure mercury lamps. They generate UV-C at 253.7 nanometers– again often rounded to 254 nanometers. They are available in many different lengths and shapes. They're the most efficient method to generate germicidal ultraviolet. And electrically, they're the same as a fluorescent lamp. They're available in various sizes, wattages, and they're equipped with ballasts. They are constructed with a special kind of glass that allows transmission of approximately 80% of the 253.7 nanometer energy, which is generated by mercury discharge.

Slide 9 (05:36 - 06:20)

Excimer lamps are very small compared to the low pressure mercury lamps. They use rare-gas-halogen excimers, mostly krypton chloride for commercial applications, and they produce most of their emissions between 200 to 230 nanometers. Most of the emission is at 222 nanometers. Their advantage is the effect on human skin and eyes. It's much reduced as compared to 253.7 nanometer mercury emissions.Their disadvantage is they have the potential of ozone production.

Slide 10 (06:21 - 07:04)

Light emitting diodes, in comparison, are very small in size and often many are used in one GUV luminare. Typically they have a peak wavelength emission between 260 to 280 nanometers when used for most germicidal applications. They can be designed for germicidal output around the peak efficiency of the standard germicidal response function, which is around 265 nanometers. They're highly customizable, but their specific spectral distribution, peak wavelength, and performance characteristics can differ widely across manufacturers.

Slide 11 (07:05 - 07:43)

These images show examples of various upper room and whole room GUV lamp technology fixtures. On the left we see the 254 nanometer fixtures, which are the low pressure mercury lamp type of fixtures. In the middle we see the krypton chloride fixtures, also known as excimers. And on the right side we see images of LED fixtures. You can see that they vary in size and they have, again, depending on the lamp they contain, they have different housings.

Slide 12 (07:44 - 07:59)

There are many different installation options for upper room and whole room GUV fixtures. These images show various mounting mechanisms including wall mounting, pendant mounts, ceiling mounts and tripods.

Slide 13 (08:00 - 8:43)

Let's review the key points. GUV lamp technologies can create different germicidal wavelengths. Photobiology is the study of the effects of light on living organisms, which can result in chemical and/or physical changes in viruses and bacteria. The germicidal action spectrum defines the photobiological response of the different wavelengths of bacteria and viruses. There are three lamp types used for upper room and whole room GUV applications: low pressure mercury lamps, krypton chloride lamps and light emitting diodes.

Module 8: How does GUV Inactivate - A Detailed Look | Transcript

Slide 1 (00:00 - 00:07)

Module eight: mechanisms of GUV inactivation.

Slide 2 (00:08 - 00:27)

In this section we explore how GUV inactivates bacteria and viruses, [how] photons damage cells, susceptibility of microorganisms and viruses to GUV, and examples of well-studied bacteria and viruses.

Slide 3 (00:28 - 00:56)

GUV inactivates bacteria and viruses differently. [In] bacterial cells, the target molecule for the UV-C photons is the DNA molecule in the nucleus of the bacterial cell. For viruses, they do not have a cell, so RNA is the target of the UV-C photons.

Slide 4 (00:57 - 01:54)

Germicidal ultraviolet inactivates microorganisms by damaging their structure. So GUV inactivates bacteria and viruses by damaging the structure of their nucleic acids and proteins at the molecular level. UV-C photons are absorbed by these structures and then damage the DNA or RNA in various ways. The more of the UV-C photons a lamp can generate, the higher the intensity and the greater the inactivation of the bacteria or viruses. The higher the lamp intensity, the faster the inactivation.

So this image shows an unharmed DNA RNA strand. So all of the nucleic acids are still intact.

Slide 5 (01:55 - 02:50)

Incoming UV-C photons get absorbed, destroying the adenine-thymine bonds. What happens then is what we call a “dimer formation”. Specifically, thymine-thymine dimers form. Now these dimers create an error in the DNA or RNA, depending on which structure is getting hit. This then leads to microorganisms and viruses no longer being able to reproduce in their pathogenic state. The cell then becomes sterile. What is noteworthy is that the excimer lamps–the krypton chloride lamps generating 222 nanometers– specifically caused protein damage.

Slide 6 (02:51 - 04:06)

Microorganisms and viruses have different structures, so they also then have different susceptibility to germicidal ultraviolet. What is shown here is that fungal spores are the least susceptible, meaning it takes a lot of germicidal ultraviolet to inactivate fungal spores. On the other hand, looking on the right, viruses are much more susceptible to germicidal ultraviolet. And so, it's much easier to inactivate viruses than fungal spores. In-between, we see bacterial spores, mycobacteria, vegetative bacteria. So these are ordered from least susceptible to most susceptible. So again, it is not one size fits all, but depending on the microorganism or virus, the level or amount of germicidal ultraviolet delivered really then determines the speed of inactivation of the respective microorganism or virus.

Slide 7 (04:07 - 04:41)

Here we see some examples of well-studied bacteria and viruses. There's much research on these disease-causing bacteria and viruses. For example SARS-CoV-2, measles, influenza virus, chicken pox virus and mycobacterium tuberculosis (in short, TB) are very well studied and understood, and the effect of germicidal ultraviolet and the amount needed to inactivate them is fairly well understood.

Slide 8 (04:42 - 05:40)

So in summary, let's review the key points.

Bacterial cells have a different makeup as compared to viruses. So here in bacterial cells, the target molecule for the UV-C photons is the DNA molecule in the nucleus of the bacterial cell. Viruses do not have a cell, so RNA is the UV-C photon target. Now GUV inactivates bacteria and viruses by damaging their structure of either the nucleic acids or the proteins at the molecular level. The more UV-C photons a GUV lamp generates, the greater the inactivation of the bacterial virus, and the cell will die off, meaning it will be inactivated. Viruses generally need fewer UV-C photons as compared to bacteria to be inactivated.

Module 9: Fixture Maintenance | Transcript

Slide 1 (00:00 - 00:07)

Module nine: upper room and whole room guv fixture maintenance.

Slide 2 (00:08 - 00:27)

In this section we explore upper room GUV maintenance as described by CDC, upper room and whole room GUV luminaire’s six maintenance steps, upper room GUV maintenance examples, and when to change GUV lamps.

Slide 3 (00:28 - 01:39)

The CDC has its own section where they describe how to maintain upper room GUV systems. Again, CDC refers to GUV as UVGI just to have clarity here.

So upper room UVGI systems generally are custom designed for the spaces in which they will be used. So systems should be designed, installed and tested with the help of qualified professionals. These professionals have tools and experience to provide effective and safe systems, including proper installation and positioning of the fixtures. They're code compliant to the electrical connections needed and offer training on correct use.

Now, once installed, the systems should require little maintenance. Maintenance usually includes regular lamp cleaning or lamp replacement per manufacturer's recommendations. So let's have a look at what maintenance is needed.

Slide 4 (01:40 - 02:25)

There's six steps that are required to maintain upper room and whole room GUV fixtures. Step one: most importantly, use proper personal protective equipment, PPE. Step two: have all required tools and meters available. Step three: take a witness point measurement. Step four: turn off the power to upper room or whole room GUV fixtures. Step five: clean UVC lamps, or step six: replace the lamps per manufacturer's recommendations.

Slide 5 (02:26 - 02:54)

So step one is one of the most important steps, which is adhering to proper safety. Now, how can you adhere to proper safety? It is by wearing proper personal protective equipment. So what is needed? PPE includes UV safety glasses, appropriate footwear, gloves, and all skin should be covered with clothing.

Slide 6 (02:55 - 03:35)

Step two: have all required tools at hand. Be prepared. This can include a ladder or ladders, the appropriate screwdrivers (it is important to consult with the fixture manual so that you know what tools you need), gloves (which can be lint-free nitrile [or] latex– any gloves allowing safe handling of GUV lamps), commercial glass cleaner or isopropyl alcohol, wavelength-appropriate calibrated radiometers, a maintenance log, and manufacturer's instructions.

Slide 7 (03:36 - 04:20)

Maintenance step three includes the measurement at a witness point. A witness point is a consistent point of measurement within the space. This is taken with a calibrated radiometer. On the image to the left, you can see literally an "X marks the spot" where a witness point is then used to measure the upper room GUV or whole room GUV output with a calibrated radiometer. This is then always consistent and we can then compare measurements during installation to measurements taken in certain intervals.

Slide 8 (04:21 - 05:10)

So when taking the witness point measurement, it is important to wear proper PPE. What is needed is [to] take note of the witness point in the notebook. Remember where this spot/point was located at. Measure output pre- and post-maintenance to verify the output at this witness point. Compare the values to previous measurements that you recorded in your maintenance log. The measurement should be around 70% of the initial value at installation. So is the value less than 70%? Investigate if–is the lamp dirty? Does it need to be cleaned? Is it time for replacement? Or perhaps is there another issue?

Slide 9 (05:11 - 05:36)

Step four of the maintenance process includes turning the power off to the GUV luminaire. So, this fixture could be an upper room or a whole room fixture, and it is important to never perform any maintenance on a GUV luminaire with lamps on. This step is so important. That's why it has its own slide.

Slide 10 (05:37 - 06:31)

Step five: clean GUV luminaires and lamps per manufacturer's instructions. Be sure to wear the proper gloves. This can include nitrile or latex gloves, or lint-free gloves, to avoid depositing oils from your hands on the bulb envelope. A dirty lamp should be cleaned with a lint-free cloth and commercial glass cleaner or isopropyl alcohol. Do not use soap! Clean reflectors and UVC lamps with more than 70% alcohol, and lint-free cloths should be used. Before activation, lamps should be wiped down with isopropanol after installation to remove any contaminants which could include fingerprints. Then, measure the output before and after maintenance.

Slide 11 (06:32 - 07:11)

Step six: lamp replacement per manufacturer's recommendations may be necessary. So when servicing upper room GUV luminaires, be sure to wear UV protective gloves, clothing and a face shield. Turn off the GUV luminaire [and] confirm the proper lamp needed for replacement. Take care not to break the lamp. Wipe off any fingerprints as oil from fingers can be harmful to a lamp's life. Then, verify the GUV lamp output after installation using a radiometer.

Slide 12 (07:12 - 08:11)

Here we have an example of an upper room GUV fixture that uses a 254 nanometer lamp. This is a semi-open luminaire which was installed one year ago. At the witness point, the measurement during installation was 20 microwatts per centimeter squared. Now the average lamp depreciation for these 254 nanometer lamps is approximately 15% at about one year runtime. The measurement we took today was only ten microwatts per centimeter squared. So there was a 50% drop.

Now, after a closer look, the problem was revealed. The image on the lower right shows that the lamp and the fixture itself is full of bugs. So cleaning is necessary to maintain the best lamp performance.

Slide 13 (08:12 - 08:48)

So when to change a GUV lamp? Well, it depends on the type of fixture. It depends on the type of lamp. Do I have a low pressure mercury lamp, do I have an excimer lamp, or perhaps an LED? So, follow manufacturer commendations. If not sure, contact the manufacturer. Perhaps they use chronological hours, operational hours. And if there is a reduction in output, that could be another measurement. But be sure: if unsure, contact the manufacturer.

Slide 14 (08:49 - 09:28)

Here's a review of the key points that were just covered. The six maintenance steps are the following. Step one: wear PPE. Step two: be sure to have all required tools and radiometers available. Step three: take a witness point measurement and record that witnessed point. Step four: turn off power to upper room or whole room GUV luminaires. Step five: clean the UVC lamps or, step six: replace the lamps per manufacturer’s recommendations.

Module 10: GUV Safety | Transcript

Slide 1 (00:00 - 00:05)

Module ten: upper room and whole room GUV safety.

Slide 2 (00:06 - 00:28)

In this section we explore upper room and whole room GUV safety rules, how to know what level of GUV exposure is safe, National and international organizations promoting GUV safety, and upper room and whole room GUV safety exposure limits.

Slide 3 (00:29 - 01:08)

So here are some of the safety rules when considering upper room GUV fixtures. Fixtures need to be installed correctly to prevent unwanted exposures. Only authorized personnel should install fixtures to keep building occupants safe from exposure. Occupant safety is verified by installers and maintenance personnel who validate that exposure to GUV does not exceed safety guidelines. Several organizations developed safety guidelines to help prevent overexposure to GUV.

Slide 4 (01:09 - 01:49)

There are several organizations, national and international, that promote germicidal ultraviolet safety. They include the International Commission on Non-ionizing Radiation Protection (ICNIRP), International Organization of Standards (ISO), International Electrotechnical Commission (IEC) and National Institute for Occupational Safety and Health (NIOSH). These organizations mostly relate to harmful sunlight exposure, meaning to the dangerous UV-B wavelengths, but they also offer safety guidelines on UV-C.

Slide 5 (01:58 - 03:19)

The previously named organizations all provide certain information on how to determine what GUV level is safe. So in 1972, CDC and NIOSH published Recommended Exposure Limits (abbreviated REL) for occupational exposure to UV radiation. So REL is intended to protect workers from the acute effects of UV overexposure. The American Conference of Governmental Industrial Hygienists (ACGIH) issued similar values, which are called Threshold Limit Values for occupational exposure to ultraviolet radiation.

The RELs and TLVs for occupational exposure to UV incident on skin or eye are based on the irradiance and time of exposure. So these values, TLVs and RELs, have guidance on occupational limits which are limited to direct exposure of the eyes but considered goals regarding skin exposure. So the TLV and REL values are actually the same for 254 nanometers.

Slide 6 (03:20 - 03:57)

Let's have a look at ACGIH's threshold limit values, TLVs. In the US, our widely used professional exposure guidelines are known as TLVs. They're based on occupancy use of spaces treated by upper room and whole room GUV systems. GUV inspection, maintenance and repair workers typically do not remain in one location. They move around, so during their eight hour workday, [they] are not overexposed to GUV.

Slide 7 (03:58 - 04:36)

CDC/NIOSH requires PPE if exposures are exceeded. So here, the REL is calculated as a time-weighted average at a steady state of continuous exposure for that duration. So this average value is then taken. Now, time-weighted average takes the average GUV exposure that a person may receive while standing, sitting or walking through an area with upper room GUV luminaires in a period of 8 hours, assuming a workday length.

Slide 8 (04:38 - 05:42)

Here we see an example of a time-weighted average to assess the risk of germicidal ultraviolet irradiation overexposure. This image shows that depending on the height a person may be in a room (i.e., sitting [or] standing), the intensity or the exposure can vary greatly. During [the] day, most individuals do not remain in a fixed position. They move around. Properly installed and commissioned upper room GUV luminaires will not exceed the exposure guidelines. A time-weighted average is calculated at a steady state continuous GUV exposure for the duration of the exposure to upper room and whole room, or their combination. So determining a time-weighted average is important for occupant safety because that really will help us understand if a person may become overexposed in an eight hour work day.

Slide 9 (05:43 - 06:35)

Let's review the key points. Occupant safety is verified by installers and maintenance personnel who validate that exposure to GUV does not exceed safety guidelines. CDC and NIOSH published a recommended exposure limit for occupational exposure to UV radiation to keep workers safe. The American Conference of Governmental Industrial Hygienists issued similar threshold limit values for occupational exposure to ultraviolet radiation.

Time-weighted average takes the average GUV exposure a person may receive while standing, sitting or walking through an area with upper room and/or whole room GUV luminaires in a period of 8 hours.

Module 11: Over-Exposure to GUV | Transcript

Slide 1 (00:00 - 00:05)

Module eleven: over-exposure to GUV.

Slide 2 (00:06 - 00:24)

In this section, we will explore accidental over-exposures from faulty installations, what happens when overexposed to GUV, strategies to avoid overexposure, and upper room and whole room GUV fixture safety.

Slide 3 (00:25 - 00:55)

In this image, we can see how quickly an accidental overexposure can occur from a faulty installation. This GUV luminaire was installed upside down, so this means that the baffles that should aim upward are actually now aiming downward, potentially causing overexposure to persons standing too long or sitting too long in front of this Luminaire.

Slide 4 (00:56 - 01:28)

This image shows an upper room GUV fixture correctly installed. However, the installer missed that persons walking down the staircase are directly exposed to the germicidal ultraviolet rays coming out of the fixture. This can then potentially lead to an overexposure if the person remains on the staircase looking directly at the fixture, perhaps out of simple curiosity. Installers must always be mindful when choosing installation locations.

Slide 5 (01:29 - 01:56)

This picture shows an example of a correct upper room GUV installation. Competent installation is important to prevent overexposure. Upper room GUV fixtures are validated to not overexpose people even when sitting for several hours. The image clearly shows that the installers adhered to safety standards.

Slide 6 (01:57 - 02:22)

What actually happens when overexposed to germicidal ultraviolet? While overexposure affects plants, they will not survive overexposure to GUV.

Additionally, overexposure may have non permanent effects on our skin and eyes. But let's take a closer look and explore overexposure to GUV and what it means.

Slide 7 (02:23 - 02:51)

Overexposure to GUV can cause skin reddening, also called erythema. Now erythema is an abnormal redness of the skin or mucous membranes due to capillary congestion. Erythema is like a mild sunburn-like effect without tanning. It results in itching skin and occurs when exposed to at least 2 to 3 times of GUV above the safety limit.

Slide 8 (02:52 - 03:47)

How does germicidal ultraviolet affect the skin? GUV scattered and absorbed in the stratum corneum, which is the outer dead layer of human skin. GUV is not transmitted through the epidermis. However, there are different wavelengths that, when we talk about GUV, we may find, which can be the 222 nanometers we discussed earlier, or 254 nanometers.

Now you can see on this image here that the 222 nanometer is much less penetrating into the skin as compared to the 254 nanometer wavelength. 222 nanometer actually stops before entering the epidermis and has much less potential to cause damage to the skin.

Slide 9 (03:48 - 04:27)

It is important to note that wavelengths above 300 nanometers will enter the dermis. However, GUV wavelengths are below 300 and we usually are looking at wavelengths that are 220, 254 and 265 nanometers which will not enter the dermis.

GUV wavelengths have a shallow penetration depth into the skin. Repeated overexposure to GUV is rare. [In terms of] long term effects, skin cancer has not been linked with GUV.

Slide 10 (04:28 - 05:06)

Overexposure to germicidal ultraviolet can cause eye irritation, namely photokeratitis. Keratitis is the inflammation of the cornea of the eye. Eyes in general are well adapted to the UV in outdoor sunlight. But when the ground surface is highly reflective with eyes exposed,reflection produces an irritation on the eyes surface, the cornea. This irritation is termed photokeratitis. It is also known as snow blindness or welder's flash.

Slide 11 (05:07 - 05:43)

Overexposure can also cause conjunctivitis, which is the inflammation of the ocular lining. The symptoms may not be evident right out of the gate /right at exposure. However, they usually become evident 6 to 12 hours after exposure. Symptoms include the sensation of having sand in your eyes, tearing eyes and eye pain, which can possibly be severe. Usually these symptoms resolve within 24 to 48 hours.

Slide 12 (05:45 - 06:09)

This image shows that GUV, shown on the image as UVC, is completely absorbed in the cornea. GUV does not penetrate past the cornea as compared to UVB. Hence, inside tissues are protected from UVC, also called GUV.

Slide 13 (06:10 - 06:48)

So since we talk about radiation, at times people wonder, well, can GUV penetrate walls? Well, the answer is GUV energy usually does not penetrate through any solid substances and cannot penetrate walls.

GUV is attenuated by most materials and it does not penetrate through regular glass. But what it can penetrate is quartz glass and sodium barium glass, which is used specifically for GUV lamps. Also, PTFE Plastics have a very high transmission for GUV.

Slide 14 (06:49 - 07:42)

Some of the strategies to avoid overexposure to GUV can include well-designed and commissioned GUV installation, education of maintenance personnel, proper signs, and safety switches, which all can avoid overexposure.

During commissioning and before operating of the GUV installation, a handheld radiometer that has specific wavelengths for the installed fixtures (which may be 222, 254 or 265 nanometers) can be used to verify the safe installation.

Further, validation that there is no stray GUV reflecting from walls, ceilings and other objects in a room can be further strategies to avoid overexposure.

Slide 15 (07:43 - 08:26)

GUV measurements for upper room and whole room systems should always be taken during the initial installation. Also, whenever new lamps are installed, it is critical to verify that GUV levels are still safe and that they did not increase, perhaps with a lamp that has a higher intensity. Also, whenever modifications are made to the GUV fixture or the system– so in the room, for example, adjusting the fixture height or location or positioning of the louvers– this may completely change how much GUV is being put into a room environment.

Slide 16 (08:29 - 09:13)

Let's discuss GUV fixture safety. All upper room and whole room GUV fixtures should have an on and off switch and/or electrical disconnectors. If upper room and whole room GUV measurements taken at initial installation exceed recommended exposure limits, all highly UV-reflecting materials in a room should be removed, replaced or covered. Ultraviolet absorbing paints can be used on ceilings and walls to minimize reflections into occupied spaces. It is noteworthy that most ceiling tiles have a relatively low reflectance.

Slide 17 (09:19 - 10:05)

Review of the key points. Accidental overexposures can occur, but they can also be prevented. GUV overexposure can cause photokeratitis or conjunctivitis, which will heal and leave no lasting effects. Overexposure can cause erythema, which is like a mild sunburn-like effect, which subsides generally within 24 to 48 hours. GUV Wavelengths 222, 254 and 265 nanometers do not enter the skin's dermis, nor do they penetrate past the eye’s cornea. Strategies can be set in place to prevent accidental overexposure as we just learned.