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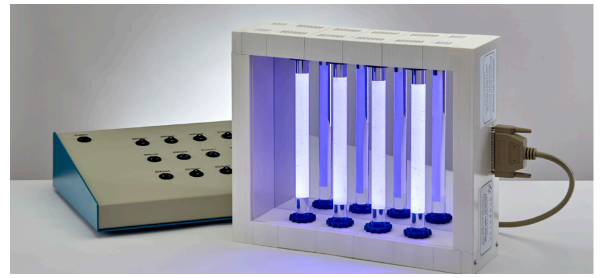

OPTICAL HAZARD ASSESSMENT IN THE ULTRAVIOLET REGION USING LASER SAFETY (60825) AND LAMP SAFETY (62471) GUIDELINES

By Neil Haigh, PhD

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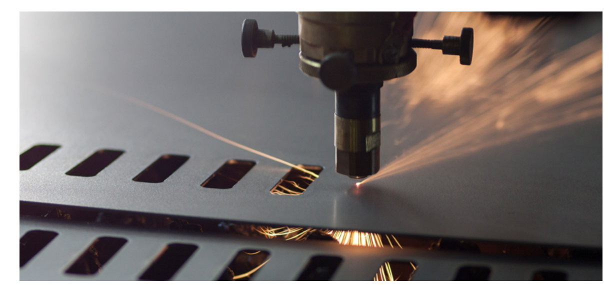
LASER USE IN VETERINARY MEDICINE - BEYOND THE INTRODUCTION

By David S Bradley, DVM, FASLMS

This article will cover the growth of laser use in the veterinary arena. It will review the wide range of applications and the wide range of benefits and improved outcomes lasers provide. It will also highlight the procedures unique to veterinary practice.

U.S. DEPARTMENT OF LABOR ISSUES ENFORCEMENT GUIDANCE FOR RECORDING CASES OF COVID-19

The U.S. Department of Labor has issued interim guidance for enforcing OSHA's recordkeeping requirements as it relates to recording cases of COVID-19.



BLS: LASER SAFETY FOR THE LAYMAN

By Christopher Mordica, CLSO

Certified Laser Safety Officer Christopher Mordica shares his advice and methods on establishing a Laser Safety Program to ensure the safety of all personnel that work on or around high-powered lasers.

FEATURES

BLS NEWSLETTER

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PRESIDENT'S MESSAGE

Gilbert Haas
LIA President 2020

In these challenging times as we all deal with the coronavirus pandemic, I hope you and your family are well and safe. The LIA staff is continuing to work safely through this by working remotely. With your thankful continued support, the state of the organization is doing well. The LIA staff is also investing this time on several new projects which, in the end, will benefit and grow the organization.

To help us through these times, many members are being professionally active by taking time to review educational safety requirements they may need. Please keep in mind that the LIA offers many on-line courses that you can take form your home. LIA on-line proceedings can also be researched for projects or any papers you may need to compose.

Since we are all in this together, emotionally encourage yourself and others to shift from what is fearful to seeing the situation and possibilities from a different perspective. Shine a light on the heroes, good deeds and humility that's emerging during this pandemic. Defocus on misinformation and projections and choose to focus on details that are factual. Misdirection of thinking erodes energy and hope for the future. Fear is contagious, but so is hope.

We all look forward to the days where it will be business as usual.

Be well and safe.

EXECUTIVE DIRECTOR'S MESSAGE

Nat Quick
Executive Director

We hope that you, your families and your communities are healthy and safe as we go through this challenging period created by the COVID-19 (coronavirus) pandemic. We thank all who are providing support on critical LIA projects during this difficult period. Your support has been invaluable.

In response to the COVID-19 pandemic the entire LIA staff has been operating remotely for over three weeks. The transition from our office to a remote virtual workplace has been nearly seamless. I am appreciative and thankful for the resiliency and leadership of the entire staff in innovatively completing critical tasks.

LIA online safety courses show high activity during this challenging period. Many professionals are updating their laser safety knowledge base. The Laser Safety Awareness (LSA) course has been completely revised. The medical laser safety officer (MLSO) and medical laser safety awareness (MLSA) courses have been refreshed and will be available mid-May.

We are updating our blog with improved content that better informs our community about laser and photonics developments. We are completing a new conferences website which will make it easier to navigate to both ICALEO 2020 and ILSC 2021 information. Our membership website is also being improved. Website improvements will be launched early May.

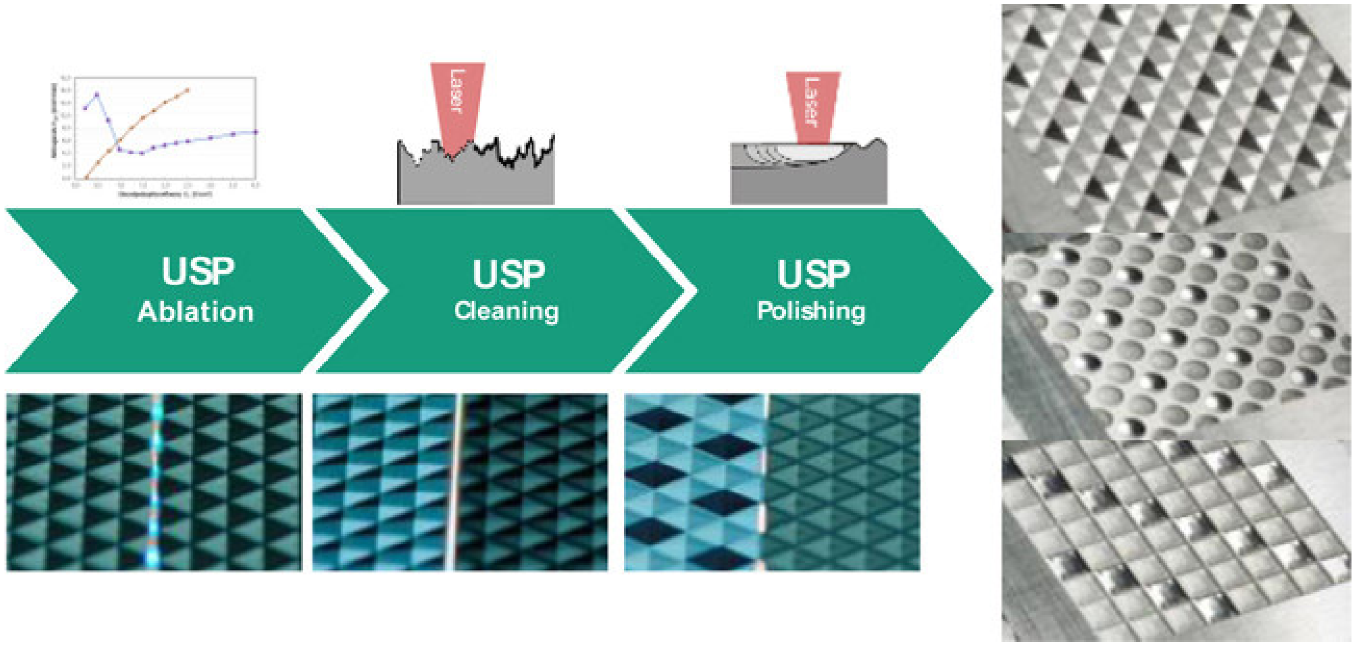
We are exploring contingency plans, particularly for ICALEO 2020 and LIA governance meetings, to provide remote access. We are tracking approaches by other technical societies.

A question asked by engineers and scientists is how can our skills contribute solutions to end the pandemic. Companies involved in additive manufacturing are already fabricating parts for personal protective equipment and ventilators. Specific ultraviolet light wavelengths are being evaluated for destroying the coronavirus particularly on surfaces. Laser technology and other aspects of photonics offer solutions yet to be identified. We have a responsibility to explore new paths that accelerate not only our recovery from the current pandemic but also implementation of new innovations that support the medical/health industry in rapid diagnosis and destruction of existing and new pathogens.

Stay safe and keep others safe.

JLA | EDITOR'S PICK

Strategy of applying a photonic process chain consisting of the steps: USP ablation, USP cleaning, and USP polishing with process images and final results.



EFFICIENT PRODUCTION OF DESIGN TEXTURES ON LARGE-FORMAT 3D MOLD TOOLS

By: Andreas Brenner, Markus Zecherle, Sven Verpoort, Kersten Schuster, Claus Schnitzler, Markus Kogel-Hollacher, Martin Reisacher, and Benedikt Nohn

Abstract: Laser surface structuring is becoming increasingly important in the industry for tool and mold making. While structured surfaces contribute to minimizing friction in combustion engines or to increasing efficiency of light-emitting diode-based lighting systems, surface texturing is evolving a quality feature of products with regard to optical and haptic properties. Currently used manufacturing processes for tool texturing like photochemical etching are limited in precision and in flexibility. To establish a digital process chain and to increase the design flexibility, laser ablation with (ultra) short pulse laser radiation is becoming an increasingly important technology. In the research project "eVerest," all necessary parts of a laser texture processing are integrated into the machine and operating concept, e.g., the virtual design of the product including unrolling and visualization of the textures. Finally, new process strategies and advanced machine and system technologies are developed.

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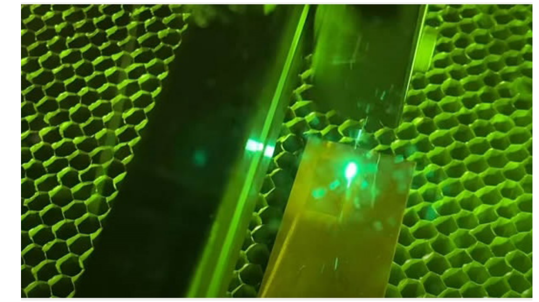
JLA Journal of Laser Applications

TRENDING IN THE NEWS:
LIA'S TOP 4 ARTICLE PICKS

1



LASERS TURN METAL SURFACES INTO BACTERIA KILLERS

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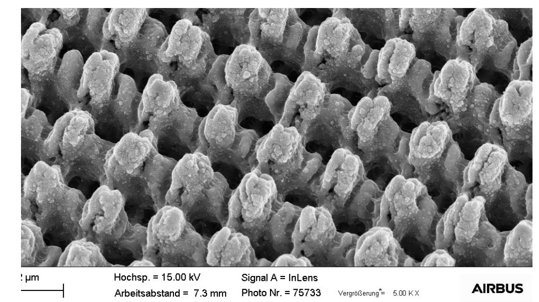

BLASTING AIRPLANES WITH LASERS MAKES IT MUCH HARDER FOR ICE TO STICK TO WINGS

Researchers in Germany have developed a better way to keep planes free of ice and snow using a technology called Direct Laser Interference Patterning (DLIP).

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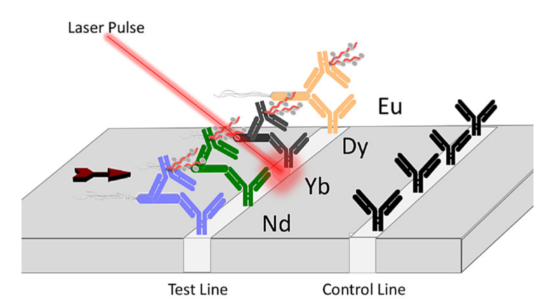

NEW TECHNOLOGY FOR PATHOGEN DETECTION DRIVEN BY LASERS

Researchers at Purdue University use lasers to detect toxins and pathogenic E. coli in food, water, and industrial materials hoping to help stop the spread of foodborne illnesses.

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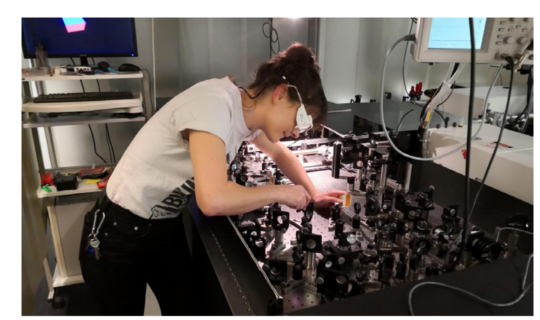

RECORD-BREAKING TERAHERTZ LASER BEAM TURNS AIR INTO GLOWING PLASMA

Scientists at TU Wien (Vienna) have used a laser to turn air into plasma, producing terahertz radiation that can be used for many different applications.

Read more

OPTICAL HAZARD ASSESSMENT IN THE ULTRAVIOLET REGION USING LASER SAFETY (60825) AND LAMP SAFETY (62471) GUIDELINES

By: Neil Haigh, Blueside Photonics Ltd.

The advent of the COVID-19 pandemic has led to an increase in interest in the use of ultraviolet light for sterilization purposes. Lamp system suppliers are currently bringing to market a host of UV lamps for potential use in sterilization of the SARS-CoV-2 virus and the world is wide awake to the prospect. Given that there could soon be widespread increase in the use of UV lamps for sterilization then it is appropriate to review how international safety standards can help researchers, workers and users evaluate the potential hazard to the eye and to the skin.

Ultraviolet Lamp Technology

The interest in the use of UV light for health related purposes and treatments is around 100 years old and evolved from the use of natural sunlight to treat certain ailments. Intriguingly the lamp technology that is in predominant use for photobiological applications in the UV region still tends to be centered around the mercury vapor gas discharge lamp, a lighting technology that dates back to this period - Figure 1 shows an original patent for a mercury lamp from 1901! It is worth mentioning here that depending on the construction of the electrical discharge UV lamp, the spectrum may consist of well-established spectral lines such as the well-known 254 nm spectral line in the low-pressure mercury vapor lamp, which is used in germicidal applications. Alternatively, the discharge spectrum could comprise of a host of spectral lines overlaid upon a broadband spectral output – this kind of light spectrum certainly complicates the required photobiological safety hazard assessment.

More recently though, light emitting diode (LED) technology emitting in the deep ultraviolet (UV-B and UV-C) region of the spectrum have shown promise for use in light-based sterilization applications. Figure 2 shows an example of a tuneable spectrum UV-VIS-NIR LED waveguide lamp developed by ColorDyne Ltd in the UK which was presented at ICALEO in 2019 [1]. The spectral output of the next generation of LED based ultraviolet lamps will likely be tuneable, stable and highly repeatable in their nature and represent a great leap forward for workers in the UV field.

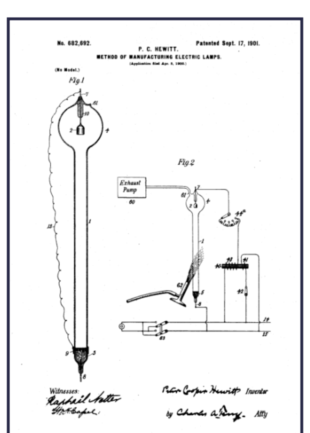

Figure 1 Mercury Lamp Patent – P C Hewitt (1901)

UV Photobiological Safety

Clearly, any light source that can sterilize and kill a living pathogen such as a virus will also be quite capable of causing harm to human eye and skin. The hazard potential is exacerbated by the invisible nature of ultraviolet light implying that there is usually no awareness that a sterilizing UV light beam is present. Furthermore, with many ultraviolet light related injuries there may be no immediate awareness that damage to the skin or eye has occurred until a few hours later. There is also the potential for ultraviolet light to cause a longer-term chronic injury such as cataract to the eye, and skin cancer, decades later.

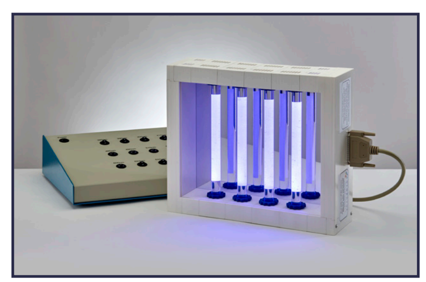

Figure 2 ColorDyne Ltd - Tuneable Spectrum LED Waveguide Lamp – 2019

Due to the widespread and long-term use of conventional ultraviolet (gas-discharge) lamp technology in the workplace, a reasonable body of safety literature has already been established. The textbook by Sliney and Wolbarsht [2] is an essential reference for photobiology safety issues associated with all manner of lamp and laser sources. However due to the pending widespread use of high power UV A, UV B and UV C LEDs for sterilization and other photobiological applications, it is likely that new methodologies and practices will need to be considered [3]. Accordingly, ahead of such developments it is timely to review how the photobiological safety of LEDs and laser sources is currently addressed at the international safety standards level via the respective lamp (62471) and laser (60825) safety standards [4,5]. The purpose being to assist the laser safety officer or optical radiation safety worker in the ways in which the photobiological hazard can be evaluated.

Background to Laser and Lamp Optical Radiation Safety Standards

The contents of the main international safety standards for lamp (62471) and laser (60825) sources are drawn down extensively from underpinning investigative work undertaken by several organizations, including the International Commission on Non-Ionising Radiation Protection (ICNIRP) [6] and the American Conference of Governmental Industrial Hygienists (ACGIH) [7]. Essentially, the advisory limits proposed by the latter organizations are adopted, codified and streamlined for use in associated laser or LED safety standard documents including product safety concerns. There is often a good degree of synergy and subtle overlap in the approaches of both sets of safety standards, however in certain regions of the spectrum, including the ultraviolet, the corresponding safety limits can vary considerably in their numerical value and even their definition [8].

Radiant Exposure & Irradiance UV Safety Limits

In the following discussion, for the sake of brevity, the potential for an ultraviolet light source to pose a retinal hazard at the back of the eye is not included. However such a hazard should not be overlooked and is generally referred to as photoretinitis [2]. The exclusion of a potential photoretinal hazard, allows the ultraviolet photobiological light hazard to be defined in simple terms of radiant power per unit area (irradiance) or radiant energy per unit area (radiant exposure). In either exposure scenario, the typical (minimum) area of exposed human tissue will be of the order of 1 square centimeter, and the peak level of UV radiation over this type of area should be assessed for its hazard potential. The assessment can be made either from a knowledge of the emission properties of the light source or via a practically measurement using suitable radiometric equipment. In the UV region of the spectrum both assessment approaches can soon become fraught with difficulty and uncertainty that arise from a host of issues related to radiometry undertaken in this region of the spectrum.

Another factor for exposures in the UV region of the spectrum is the reciprocity of the relationship between the irradiance, exposure time, and the radiant exposure:

Irradiance x Time = Radiant Exposure (1)

It follows that the limits in the safety standard might be expressed in terms of either irradiance or radiant exposure. This allows a maximum permissible exposure parameter tmax to be defined:

t_{max} (s) = Radiant Exposure Limit / Irradiance of beam (2)

where In equation (2) the radiant exposure limit effectively defines a maximum permissible 'dose' of UV light for exposed tissue in that region of the spectrum, irrespective of the time period over which it is delivered.

It is also worth pointing out here that due to the complex nature of UV- light-to- and human -tissue interactions it is possible to have several 'competing' exposure limits presented for the same region of the UV spectrum, depending upon the which damage mechanisms are of interest and relevance.

IEC 60825 Laser Safety Standard Approach

At a simplistic level, the approach of the IEC 60825 series of laser standards is to treat the UV light source as a 'small', narrowband ($\Delta\lambda < 1$nm) source of UV light.

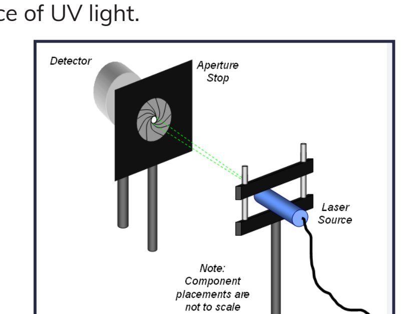

Figure 3 UV Laser Safety Measurement Schematic

Figure 3 shows schematically the measurement setup for an optical radiation safety test performed upon an ultraviolet light source such as a laser pointer. In the figure, the placement of the test setup components is not to scale, and the applicable values of the aperture stop diameter and the measurement distance for the test need to be consulted from the applicable standard. For example, in UV laser safety work the recommended limiting aperture might be 1 mm for an eye exposure and 3.5 mm for the skin. In such irradiance measurements, the laser source is usually treated as a 'small' source in that the physical size of the source itself is irrelevant, and the measurement is usually performed 'open field of view' with no limitation placed upon the extent of the source as seen by the detector. If the wavelength of emission of the laser source is reasonably well-known or fixed by the physical properties of the laser emission process (which it usually is) then it is possible to measure the total level of accessible radiant emission from the laser using a broadband optical power meter such as a thermopile. This might obviate the need to use complex spectro radiometric apparatus such as a double monochromator.

In terms of the safety limits, the general attitude of the laser safety standard is typically that there is no expectation for a deliberate exposure to UV laser light to occur, so in reality, engineering safety controls such as a light-tight enclosure would be used to protect all personnel from the UV laser beam. Any such direct exposure to the UV laser bean would be treated as a laser accident, with instantaneous harm assumed to have occurred. In this scenario, the assessment of the maximum permissible exposure limit for the UV laser beam hazard is mostly for indicative purposes, with no laser exposure reasonably expected to occur. That said, the potential for a collateral exposure to occur to UV light scattered from within a laser system might need to be considered, even for when shielding of the laser beam is in place. In order to assess the hazard potential for scattered UV laser light, it is best to treat the origin of the scatter as a secondary source of light, and in which case, the safety analysis can the follow the guidelines of the 62471 lamp safety standard as discussed further below.

As an example, for exposure times exceeding 10 seconds, the international laser safety standard defines the ultraviolet hazard using relatively simple formulae as laid out in Table 1 below:

IEC 60825-1:2014 Table A.1 (redrawn)	
Wavelength λ (nm)	Exposure Time t (s) 10 to 3000 s
180 to 320.5 nm	30 $J.m^{-2}$
302.5 to 315 nm	C_2 $J.m^{-2}$
315 to 400 nm	10^4 $J.m^{-2}$

Table 1: UV Laser MPE Values (t > 10 s)

The contents of Table 1 are derived from the laser Maximum Permissible Exposure (MPE) limit Table A.1 in IEC 60825-1:2014.

The coefficient C2 in Table 1 is defined in the 60825-1 standard via the formulae given in Table 2:

IEC 60825-1:2014 Table 9 (redrawn)	
Spectral Region	Parameter
180 to 302.5 nm	$C_2 = 30$
302.5 to 315 nm	$C_2 = 10^{0.2(\lambda-295)}$

Table 2: UV Laser MPE Coefficient C2

The C2 parameter is related to ultraviolet light induced photochemical damage to the cornea – the radiation in this band is often referred to as being 'actinic' in its nature. In the waveband 180 nm to 302.5 nm, the MPE is defined as being constant with a value of H = 30 J.m 2. This represents a significant truncation of the exposure limit compared to the value in the 62471 lamp safety standard. The truncation of the limit is conservative and implies there is no 'relaxation' of the MPE limit below its value at 302.5 nm. In the region 302.5 nm to 315 nm, the coefficient C2 has an exponential form corresponding to a rapid rise (relaxation) in the MPE with increasing wavelength across that zone. Above 315 nm the dominant ultraviolet injury mechanism for a laser is essentially defined by a near-UV light hazard considered to be different to the actinic hazard, and which is associated with UV light penetrating further into human tissue, including the front elements and lens of the eye.

Accordingly, in the near-UV band between 315 nm to 400 nm, a hazardous laser exposure may very well be of the chronic rather than acute type, leading e.g. to cataract formation over the long term, i.e. over years, rather than within several minutes of exposure.

The ultraviolet laser MPE from 180 nm to 400 nm is plotted in Figure 4:

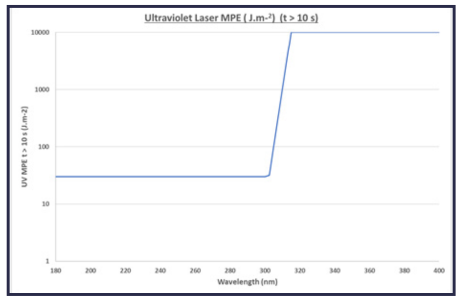

Figure 4 Ultraviolet Laser MPE (60825) t > 10 s)

Note that the (vertical) axis for the UV MPE is necessarily plotted on a logarithmic scale to accommodate the very large change in the MPE that occurs from 302.5 nm. Also note that beyond 315 nm, the UV MPE value might be considered somewhat crude in its form. It does not presently include many potential hazards from several light-tissue interactions that are known to occur in the near UV. However as noted above, it is the expectation of the 60825 laser standard that there will likely not be any need for any eye or skin to be exposed to a UV laser beam.

The use of the simple formulaic MPE approach adopted by 60825 allows for the ultraviolet laser safety limit to be determined reasonably quickly. In principle all that are needed are the laser wavelength and the associated beam divergence, alternatively the beam irradiance with distance from the laser can be estimated or measured. Also, for a laser source whose wavelength is intrinsically defined by the stimulated emission process, there might be less concern with the MPE lookup in the 300 nm to 315 nm region compared to the equivalent concern for a complex UV lamp spectrum spanning this region.

UV-A Laser Exposure Example

Consider the case of a Helium Cadmium laser with a wavelength of λ = 325 nm, a CW radiant emission of P_o = 1 mW and a beam divergence of ϕ < 1 mrad. What would be the maximum exposure time for an exposure to the skin? For a laser source of very low divergence it would usually be assumed that all the radiant laser emission would be collected by the limiting aperture over a reasonably long distance (meters) from the source. Accordingly, the irradiance at the limiting aperture can be calculated as follows:

Power through Aperture: P_o = 1 mW

Diameter of Limiting Aperture: $d_{\_LA\_skin}$ = 3.5 mm

Area of Limiting Aperture: $A_{\_LA\_skin} = 9.6 \times 10^{-6}\ m^2$

Beam Irradiance = $E_{\_LA\_skin}$ = 104 $W.m^{-2}$ (3)

The corresponding skin MPE for the laser can be determined via Table 1 as

$MPE_{325nm,t>10s}$ = 10000 $J.m^{-2}$ (4)

The corresponding maximum exposure time t_{max} can be determined from equation (2) to be:

t_{max} = 10000 / 104 = 96 seconds (5)

A similar analysis for an exposure using a limiting aperture of $d_{\_LA\_eye}$ = 1.0 mm for the human eye indicates that the corresponding maximum permissible exposure time to be t_{max} < 10 seconds.

IEC 62471 Lamp Safety Standard Approach

In contrast to the laser standard that assumes a laser to be a narrowband source, the lamp standard assumes the source spectrum of a lamp or LED to be broadband in nature e.g. of the order of 10s to 100s of nm wide. In this case, rather than consult a lookup table for an individual wavelength based MPE limit value, the lamp standard requires a spectral 'overlap integral' methodology to be adopted. In this method, the source spectrum is compared mathematically to a corresponding hazard spectrum referred to as the hazard 'action' spectrum. The action spectrum is weighted in accordance with the wavelength dependent nature of the specific photobiological eye or skin hazard of concern. The various action spectra corresponding to differing photobiological hazard mechanisms are listed in the 62471 lamp safety standard. The approach of the 62471 safety standard can be considered to be flexible in that additional hazard action spectra can be incorporated in line with new lamp and LED related safety studies. This situation is almost certain to occur as experience and expertise increases in the UV LED field and new applications proliferate for UV LED technology.

The action spectra in the lamp safety standard are dimensionless functions that are usually normalized to a peak hazard efficacy value of 1.0, where the peak of the function identifies the wavelength of peak hazard for a specific photobiological damage mechanism. In contrast to this, in the laser safety standard, the MPE values and their related safety coefficients tend to increase numerically with a decreasing laser beam hazard. In other words, the safety coefficients in the laser standard might be thought of as being 'upside down' compared to their equivalent parameter in the lamp safety standard. In this regard therefore the action spectra in the lamp standard tend to provide a more intuitive grasp of the wavelength dependent nature of a UV lamp hazard, in that the peak of the action spectrum corresponds to the peak of the hazard.

An example of a lamp safety hazard action spectrum is given in Figure 5.

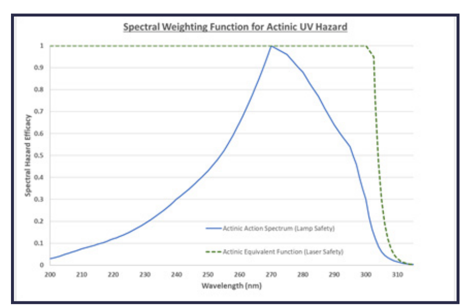

Figure 5: Actinic Ultraviolet Hazard (after 62471)

The solid curve in Figure 5 shows the normalized actinic action spectrum from the 62471 standard; when plotted on a linear scale it has the appearance of a 'shark-fin' that usefully warns of a hazard whose peak occurrs at the tip of the 'fin' at 270 nm. Workers in the field of UV safety will recognize that the peak of this function is close to the known peak value for 'germicidal' UV light that is commonly used to destroy viruses, bacteria and other living pathogens. In the case of the human eye, the peak value of the actinic function at 270 nm corresponds to the wavelength of peak damage to the cornea at the front of the human eye. The damage mechanism here is referred to as UV photokeratitis, more commonly known as 'snow blindness' or 'arc eye'. Because of its photochemical nature, painful evidence of damage to the human eye via actinic UV photokeratitis may not present until several hours following the exposure.

Figure 5 also shows a dotted line curve that is representative of the actinic eye hazard defined via the MPE and safety coefficient C2 in the 60825 laser safety standard. Notice that the equivalent laser safety MPE plot in Figure 4 is 'upside down' compared to the action spectrum curve in Figure 5. It can also be seen in Figure 5 that the C2 laser safety coefficient is held constant below wavelengths of 302.5 nm. Compared to this, the actinic action spectrum values in the lamp standard are seen to decrease either side of the peak value at 270 nm.

Spectral Overlap Analysis

Rather than use single valued wavelength dependent exposure limit values, the 62471 approach requires a spectral overlap assessment to be adopted. In this, the ultraviolet spectral radiant exposure or spectral irradiance is weighted by corresponding values in the action spectrum. For example, where the values in the action spectrum are equal to 1.0, the corresponding source related spectral exposure values are left unchanged. Whereas, for action spectrum values less than 1.0, the source spectral exposure values are diminished accordingly, reflecting that they are less 'effective' in causing the specific hazard. In this way, any wavelengths of light in the source spectrum lying outside of an action spectrum of interest are to be excluded from the analysis and they are deemed to be 'ineffective' for that particular hazard band. The spectrum values lying within the boundaries of the given action spectrum are thus weighted to yield an 'effective' hazard spectrum for the source. In the ultraviolet region of the spectrum, certain aspects of a UV source spectrum might be 'effective' in one hazard band, but 'ineffective' in another, or the spectrum might be effective in two or more hazard bands at the same time.

UV-C Lamp Exposure Example

Consider the case of a germicidal UV-C LED emitting at a wavelength of 265 nm considered potentially ideal for sterilisation of the SARS CoV 2 virus. If a total spectral radiant emission of the LED is determined to be 5 mW, with a peak emission at 265 nm, and a full width half maximum (FWHM) linewidth of 15 nm, the spectral output of the LED source might be as shown in Figure 6.

In order to assess the corresponding actinic eye hazard, the spectral irradiance produced by the usually highly divergent LED (or an array of such LEDs) will need to be determined as a function of distance, either by measurement or estimation from LED emission properties.

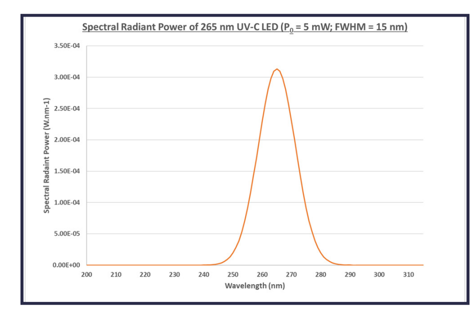

Figure 6: Example of UVC LED Spectral Emission at 265 nm

Consider the situation where the total spectral irradiance at a distance of 100 mm from the LED is determined to be 10 $mW.cm^{-2}$. This might be measured as an 'integrated' power reading using a blackbody type detector, or the spectrum might best be measured using a double monochromator to ensure that spectrum is fully evaluated across the actinic action spectrum. The total spectral irradiance must also be converted to the required units of radiant power per square metre rather the given values per square cm – this leads to

Total Irradiance E_{265nm_LED} = 100 $W.m^{-2}$ (5)

The irradiance spectrum then needs to be weighted ('overlapped') with actinic UV hazard action spectrum as shown schematically in Figure 7:

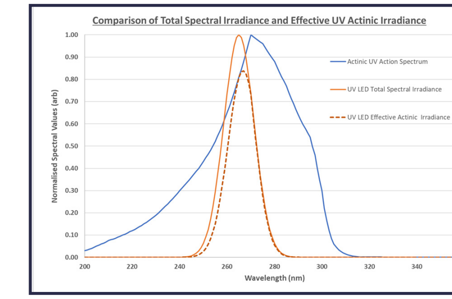

Figure 7: UVC LED Spectrum & 62471 Actinic Hazard Action Spectrum

Figure 7 shows in representative terms how the actinic action spectrum (shark-fin curve) converts the LED source spectrum (solid line) into an 'effective' Actinic spectrum (dotted line). Note in the figure how the effective actinic irradiance spectrum for the LED is reduced in overall magnitude and shifted slightly to the right-hand side, indicating that those wavelengths in the source lying closer to the peak of the action spectrum are weighted more strongly for their hazard potential i.e. in this case, they are more 'effective' in causing an actinic UV hazard around 270 nm. Correspondingly they may be less effective in sterilising a pathogen of concern at another target wavelength of sterilisation. Contrariwise, it is possible to use the action spectrum analysis to identify which UV source spectra are safest to use in terms of a potential accidental exposure to the human eye i.e. where possible operate the lamp system away from the peak of the action spectrum

To quantity the actinic hazard posed by the LED, the total effective irradiance is calculated via a summation process. In the case shown in Figure 7, the LED effective actinic spectrum is determined to represent around 80% of the total input light spectrum hence

Effective Actinic Irradiance E_{s_LED} = 8 $W.m^{-2}$ (6)

The corresponding exposure limit value (ELV) for the actinic hazard is the same as for the laser MPE in this region of the spectrum i.e.

$ELV_{actinic}$ = 30 $J.m^{-2}$ (7)

The corresponding maximum exposure time tmax for the actinic hazard from the LED can be calculated in accordance with equation (2) as follows

$t_{max} = ELV_{actinic}/Es$ = 30/8 = 3.75 seconds. (8)

Figure 8 provides an example of how the actinic UV hazard posed by the LED would be reported using commercially available photobiological safety software [9].

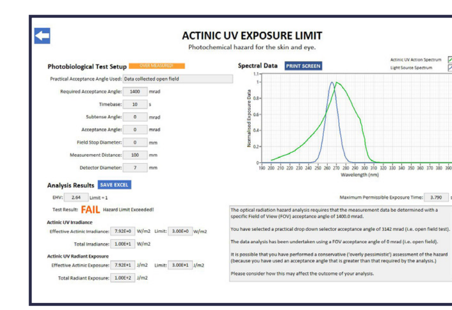

Figure 8: UVC-LED Actinic UV Hazard Report

UV-A Lamp Exposure Example

Optical radiation in the UV-A (or near-UV) region of the spectrum lying from 315 nm to 400 nm is considered much less photobiologically active than deeper UV-B and UV-C radiation. Therefore, it is unlikely to be effective for immediate sterilization of the SARS CoV 2 virus. However, there is a potential application for sterilization via a 'continuous disinfection' process that can be manifested in the UV A and visible violet light region of the spectrum. In these continuous disinfection processes, the 'background' sterilization exposure durations are likely to be of the orders of several hours (rather than a few seconds as ideally occurs within a UV-C sanitization process).

In a similar manner to the actinic region described above, the UV-A photobiological hazard assessment can be undertaken using an appropriate near-UV hazard action spectrum defined in the 62471 lamp safety standard. As a useful example, a comparison can be made with the laser safety approach applied to the Helium-Cadmium laser earlier in this article. In this case, consider several UV-A LEDs emitting at 325 nm each with a with FWHM linewidth of 15 nm, and a combined total spectral irradiance at a target site of E325nm = 10 $W.m^{-2}$.

The output of the UV LEDs and the corresponding 62472 near-UV hazard action spectrum are shown schematically in Figure 9.

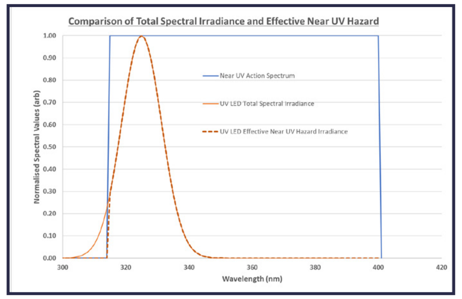

Figure 9: UVA LED Spectrum & 62471 Near-UV Hazard Action Spectrum

The analysis of the near UV photobiological hazard is similar to that described above for the actinic hazard with the main difference being that the near-UV hazard action spectrum is represented by a 'top-hat' function spanning from 315 nm to 400 nm. It can be seen in Figure 9 that the LED source spectrum under assessment is truncated only at the lower end of the window, i.e. below 315 nm, with approximately 95% of the LED emission lying within the near-UV hazard band. This equates to an effective near-UV source irradiance for the LED of the order of EUVA = 9.5 W/m 2. This may be compared to the total spectral irradiance of the source given as E325nm = 10 $W.m^{-2}$. Because of the top-hat nature of the near-UV hazard action spectrum, many workers will simply treat the total emission of any LED source in this region as being 'effective' for the near-UV hazard.

The corresponding exposure limit value in the near UV region is ELVUVA = 10000 J.m-2, this is equivalent to the corresponding laser safety MPE. It can be determined that the corresponding maximum exposure time is:

$$t_{max} = ELV_{UVA}/EUVA = 10000/9.5 = 1052 \text{ seconds} \quad (9)$$

Given that the LED irradiance is a factor or 10x less than that produced by the low divergence He-Cd laser beam in the earlier example, it turns out the maximum permissible exposure time for the near-UV hazard will be around 10 x longer i.e. approximately 1000 s for the LED, versus 100 s for the laser exposure.

Long Term Near-UV Photobiological Hazard Limit

The analysis for the UV-A hazard above used the same exposure limit value of ELV_{UVA} = 10000 $J.m^{-2}$ that can be found in both the laser (60825) and lamp (62471) standards. However, it can sometimes be overlooked that depending upon which standard is consulted, a discrepancy can exist in the near-UV photobiological hazard region. Specifically, certain safety standards report a 'long-term' near-UV exposure limit in spectral irradiance terms rather than a 'dose' related radiant exposure limit. In this case the spectral irradiance limit commonly applied is ELV_{UVA} = 10 $W.m^{-2}$ and this is typically applied for exposure durations longer than 1000 s.

Thus if a limit value of ELV_{UVA} = 10 $W.m^{-2}$ is applied to the analysis of the UVA LED above, then it could be determined that a UV-A source whose effective irradiance is EUVA = 9.5 W/m-2 would not be deemed hazardous per se. This finding can also be inferred from the analysis where tmax was determined to be longer than the t = 1000 s that is actually used as a boundary between an effective radiant exposure limit of 10000 J.m 2 and an effective spectral irradiance limit of 10 $W.m^{-2}$ for t > 1000s. This discrepancy should be borne in mind when analysing optical radiation hazards in the near-UV region, pending harmonisation of all the relevant safety standards in the near future..

Next Steps

The increased prominence and widespread use of UV LED sources will likely bring with it a need to refine and review the various limits and approaches adopted in the safety standards, especially for the UV lamp safety Risk Group designations in the 62471 standard. Interestingly, there is also growing interest in the far UV-C region of the spectrum, around a wavelength of 222 nm [10], where the UV light sterilisation process might be achieved alongside a drastically reduced hazard potential to the human eye and skin. Developments in the far-UV area will be interesting to follow. It is also likely that light tissue interactions associated with skin therapy research in the near UV region of the spectrum will lead to a better understanding of a host of potential injury mechanisms occurring in this region with further action spectra developed related to e.g. light induced vitamin D synthesis and erythema (skin reddening).

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3 How Hazardous is the Sky? – Dr Neil R Haigh (Blueside Photonics Ltd) & Simon Hall (Optical Analytics Ltd) – ILSC 2019, March 2019, Florida, USA

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Meet the Author

Neil Haigh has a PhD in Applied Optics (Imperial College, London), allied with a string technical background gained in industry in fibre optics, optical communications, and laser safety. He is presently involved in the development of both LED light sources, analytical software, and associated technical training.

U.S. Department of Labor Issues Enforcement Guidance For Recording Cases of COVID-19

WASHINGTON, DC – The U.S. Department of Labor's Occupational Safety and Health Administration (OSHA) has issued interim guidance for enforcing OSHA's recordkeeping requirements (29 CFR Part 1904) as it relates to recording cases of COVID-19.

Under OSHA's recordkeeping requirements, COVID-19 is a recordable illness, and employers are responsible for recording cases of COVID-19, if the case:

Is confirmed as a COVID-19 illness;
Is work-related as defined by 29 CFR 1904.5; and
Involves one or more of the general recording criteria in 29 CFR 1904.7, such as medical treatment beyond first aid or days away from work.
In areas where there is ongoing community transmission, employers other than those in the healthcare industry, emergency response organizations (e.g., emergency medical, firefighting and law enforcement services), and correctional institutions may have difficulty making determinations about whether workers who contracted COVID-19 did so due to exposures at work. Accordingly, until further notice, OSHA will not enforce its recordkeeping requirements to require these employers to make work-relatedness determinations for COVID-19 cases, except where: (1) There is objective evidence that a COVID-19 case may be work-related; and (2) The evidence was reasonably available to the employer. Employers of workers in the healthcare industry, emergency response organizations and correctional institutions must continue to make work-relatedness determinations pursuant to 29 CFR Part 1904.

OSHA's enforcement policy will provide certainty to the regulated community and help employers focus their response efforts on implementing good hygiene practices in their workplaces and otherwise mitigating COVID-19's effects.

For further information and resources about the coronavirus disease, please visit OSHA's COVID-19 webpage.

Under the Occupational Safety and Health Act of 1970, employers are responsible for providing safe and healthful workplaces for their employees. OSHA's role is to help ensure these conditions for America's working men and women by setting and enforcing standards, and providing training, education and assistance. For more information, visit www.osha.gov.

The mission of the Department of Labor is to foster, promote and develop the welfare of the wage earners, job seekers and retirees of the United States; improve working conditions; advance opportunities for profitable employment; and assure work-related benefits and rights.

Original Release: February 14, 2020

Source: https://content.govdelivery.com/accounts/USDOL/bulletins/27bcd57

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A dog receiving photobiomodulation (laser therapy).

Laser Use in Veterinary Medicine: *Beyond the Introduction*

By: David S Bradley, DVM, FASLMS
Veterinary Medical Director, Summus Medical Laser

As mentioned in the introductory article in the January/February issue of LIA Today the biggest use of lasers in the veterinary field is for photobiomodulation or laser therapy. However, that is a more recent development growing rapidly just in the last 6-8 years. Over 20 years ago, CO2 surgical lasers were first introduced to veterinarians and became very popular for a wide variety of conditions. In many practices, the surgical laser completely replaced the scalpel for surgery. Surgery and PBM are the two biggest areas of laser use by veterinarians. However, there are other areas where lasers have become an integral part of the veterinary armamentarium.

Veterinarians, as a rule, tend to be resourceful practitioners. They readily adapt and are willing (and sometimes compelled!) to explore alternative methods to improve the health of their patients. In addition, with many owners considering their pets more and more a part of the family, the level of care demanded has driven the incorporation of many technologically advanced modalities for routine diagnostic and therapeutic procedures. These include ultrasound, endoscopy, MRI, CT, chemotherapy, radiation therapy, orthotics, organ transplants, open-heart surgery, and, of course, lasers.

Lasers are used by many general practitioners but also by veterinary specialists. Diode lasers are used for many dental procedures. They are routinely used in ophthalmology to treat glaucoma and intra-ocular tumors as well as retinal disease. They are also used for endoscopic procedures especially in the equine world for many common upper respiratory conditions. The holmium laser is used for laser lithotripsy and arthroscopically for joint-related issues. As mentioned above, the CO2 laser can completely replace a scalpel for all general soft tissue surgery. It is particularly useful for oral and perianal surgery. It has nearly revolutionized pharyngeal surgery, particularly for the brachycephalic breeds.

The benefits of laser to the doctor and patient are the same for both human and veterinary. For the doctor, the laser adds versatility and precision. There is often less bleeding so visualization is improved. A laser can allow for less invasive procedures and, therefore, often shorten procedure time. It can expand the types of procedures that can be performed. For the patient, this all means less tissue trauma, shorter hospitalization, and quicker recovery. It will reduce pain and swelling and can reduce the risk of infection. This will lead to fewer rechecks and fewer bandage changes. These advantages save both time and money for all parties involved.

Again, the most widespread use of lasers in the veterinary field is for laser therapy; to reduce pain and inflammation and to enhance tissue healing. And it is the healing effect that is most beneficial. Laser therapy directly stimulates tissue repair, regeneration, and remodeling. It allows practitioners to resolve conditions that were traditionally less responsive. In addition, it helps many common conditions heal much faster and much better.

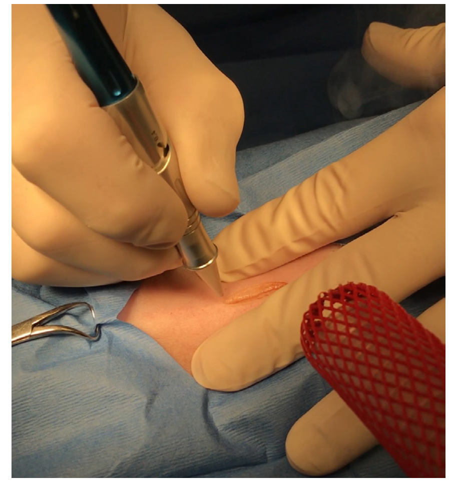
Laser light in the red and near-infrared range is absorbed by specific chromophores in the body (cytochrome C oxidase/hemoglobin/water) and this has a positive effect on specific biological reactions. This photochemical reaction increases blood flow to the tissue, stimulates the release of O2 from the hemoglobin delivered, and enhances the conversion of O2 to useful energy by cytochrome C oxidase in the production of ATP. This leads to improved cellular function and/or an increase in cell growth, replication, repair, or production of beneficial biochemical compounds – enzymes, proteins, cytokines, immunoglobulins, DNA/RNA. There is a cascade of secondary and tertiary effects that enhance/accelerate/improve the following physiologic reactions.

- Vasodilation
- Angiogenesis
- Lymphatic drainage
- Accelerate tissue repair and growth
- Faster wound healing
- Decreased fibrosis
- Improved osteogenesis
- Analgesia
- Decreased inflammation
- Improved nerve function, axonal regeneration, neurologic repair
- Immunoregulation/Immunomodulation
- Acupuncture stimulation
- Trigger Point modulation

Therefore, laser therapy has been advocated for a broad range of clinical applications for pain management, wound healing, reducing inflammation/swelling/edema, and rehab in both large and small animals. Measurable positive results can be seen consistently in the following conditions:

- Arthritis/DJD (Hip dysplasia)
- Muscle, ligament, and tendon injuries (Sprains, strains, and tears)
- Ulcerations and open wounds (Lick granulomas, Hot Spots, Abscesses)
- Acute and Chronic Ear Problems
- Post-Surgical pain/healing/rehab
- Trauma/Fractures
- Neck and Back Pain (Acute and chronic)
- Neuromuscular disease/damage/degeneration
- Even some respiratory, urinary, and GI conditions

The two most important features that determine the optimum response of a laser are wavelength and power. Laser light in the red and near-infrared range has biostimulatory properties. Roughly, this corresponds to wavelengths between 600nm and 1100nm. The shorter wavelengths are absorbed more superficially and therefore do not have the ability to penetrate as readily as the longer wavelengths. Wavelengths in the visible red range (650nm-660 nm) are highly absorbed by melanin and other superficial receptors. These can enhance wound healing. They may also stimulate trigger points, acupuncture points, and/or cause a release of secondary messengers that may improve other deep-seated conditions. From absorption spectra data we know that the wavelengths near the 970nm range have moderately increased absorption by water. With the higher-powered lasers, this can create some thermal gradients and increase circulation in these areas. It is also near the peak of the Hb absorption curve. However, the 905 nm wavelength is even closer to the peak of the hemoglobin absorption curve. Recent studies have indicated that this wavelength creates as much as a 30-50% increase in O2 release to the tissue over the 970-980 nm wavelengths. The most important discovery was related to wavelengths nearer the 800nm range (750-830). These are at the peak of absorption for the cytochrome-C oxidase enzyme. This is the rate-limiting step in the conversion of O2 to ATP within the electron transport cycle. These wavelengths will accelerate the production of ATP within the mitochondria. Utilizing all 4 wavelengths can give you a synergistic effect and/or a wider range of treatment options across a broader spectrum of clinical conditions and patients which will result in better clinical outcomes.


This image depicts an example of surgery using a laser.

Laser power is the rate at which the laser energy is delivered. Although seemingly straightforward, the power question seems to raise the most discussion regarding appropriate parameters. The physics associated with laser penetration within non-pigmented tissue is well established and quantified by the rate of decay of an incident beam as it moves through tissue.

Classification of all lasers is dictated by the FDA, based on the maximum power the laser can deliver. It is used for guidance when discussing safety and the potential to cause harm/damage, especially to the eye. Most therapeutic lasers are class IIIa, IIIb, or IV. Class IIIb lasers produce < 500 mW of power (1/2 watt). Class IV Lasers are anything over 500mW of power. Class IV therapy lasers are extremely safe. The main benefit of higher power is the ability to deliver enough photons at the surface (a larger total dose) to compensate for the power loss (decreased number of photons) reaching deeper tissues. This allows for a more direct photochemical response on these tissues. Lower dosages are used when treating superficial wounds/lesions and for acupuncture point or trigger point stimulation. Adjustable power output can make a Class IV laser effective for superficial dermatologic lesions, deep musculoskeletal conditions, and anywhere in between!

Notwithstanding years of research on the bio-stimulatory effects of laser light, we are just starting to realize all the clinical applications for veterinary patients (and humans!). Exciting new possibilities include help with OCD (osteochondritis dessicans), chronic rhinitis/bronchitis, insect/ snake bites, allergic reactions, chronic intestinal or urinary tract inflammation, bacterial/viral infections, and adjunct therapy to improve stem cell results. Laser therapy is becoming a standard of care for the control/palliation of many secondary effects related to chemo and radiation therapy in cancer patients. There is optimism for neurologic trauma including concussions, brain ischemia and stroke, peripheral nerve damage, IVDD, and stenosis. It's worth emphasizing again that laser therapy does not just accelerate healing; it actually improves repair, regeneration, and remodeling of tissue. Post-op complications are reduced. Muscle atrophy can be reversed. Type 1 collagen production yields better tendon and ligament strength and elasticity. There is a positive effect on neurologic function and axonal sprouting. The joint capsule, synovial lining/fluid, and cartilage all benefit. Therefore ROM, function, flexibility, and mobility are all enhanced. The potential for re-injury is greatly reduced. Performance animals not only recover quicker but they can regain their competitive edge. Pets can get back to their daily routines and become an active member of the family again.

> "It's worth emphasizing again that laser therapy does not just accelerate healing; it actually improves repair, regeneration, and remodeling of tissue."

These are exciting times. Like all technology, lasers have become smaller, safer, more efficient, and easier to use. Their broad range of applications makes them not just affordable but profitable. It's no wonder that lasers are rapidly becoming an indispensable tool in thousands of veterinary hospitals.

About the Author - *David S Bradley has practiced for over 30 years in Mixed, SA, Equine, and Exotics with a special interest in surgery. He began using lasers in private practice in 1999, but shortly thereafter began training and education in laser physics and tissue interaction. He has authored numerous articles and a chapter in two recently published texts related to Laser Therapy and Laser Surgery and has lectured nationally and internationaly on veterinary laser use.*

NEWSLETTER

Volume 1 • Issue 2

Recently Certified

Tyler O'Neill - CLSO
Adapt Laser System

Certification Maintenance Tip!

You can earn BLS CM points by reading laser-related peer-reviewed academic journal articles. Points for journal article reading are claimed in Category 9, Other Activities. Record your reading using the Journal Article Verification Worksheet and have it signed by your supervisor. Attach it to your Certification Maintenance Worksheet as evidence of completion. You can earn 0.25 CM points per hour of reading for a maximum of 2.0 CM in Category 9. Visit our website for details.

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Email: bls@lasersafety.org
Website: www.lasersafety.org

Changes Coming Soon!

We are excited to announce that BLS is working toward ANSI (ANAB) accreditation, which means that we will be making changes to our procedures to ensure we are in compliance with the ISO IEC 17024. This may result in changes to our certification management system, in particular record keeping. We will keep CLSOs and CMLSOs informed of the changes to come that may affect documentation requirements for recertification in the coming year.

Paper-and-Pencil Exam Administration

The next pencil-and-paper exam will be offered prior to the 2020 DOE LSO Workshop on **August 17, 2020 in Austin Texas.** Computer-based testing will resume once our third party test administrator's testing facilities open up. After that, Computer–based testing will be available year-round. For exam information, visit www.lasersafety.org, or contact us at bls@lasersafety.org.

CLSO Exam Reference Guide Now Available

Thanks to the considerable efforts of the CLSO Technical Review Board, an updated CLSO Exam Reference Guide is now available and includes sample questions. This guide is available to download for free on the BLS website.

Download Here

DOE LSO Workshop

The DOE LSO Workshop is a great opportunity for CLSOs to earn CM credit toward renewal! The Workshop was **rescheduled** due to the COVID-19 pandemic. The new date of the workshop is **August 18-20, 2020.** You can find a link to the Workshop on the BLS home page www.lasersafety.org

ASC Z136 Annual Meeting

The ASC Z136 Annual Meeting was **postponed** due to the COVID-19 virus. It will be rescheduled to a later date. Check the Z136.org website for updates or for more information please email z136@lia.org

Write for BLS!

Looking for a way to earn BLS CM points for free? BLS has restarted it's newsletter and is inviting CLSOs and CMLSOs to share laser safety knowledge with the laser community! Published article submissions are worth 0.5 BLS Certification Maintenance (CM) points in Category 3. For more information on guidelines and regulations, email us at bls@lasersafety.org. Check out one of our submissions on the next page!

Laser Safety for the Layman

by Christopher Mordica, CLSO

About the Author - Certified Laser Safety Officer

Christopher Mordica was born and raised in Columbia MO and he started studying Photonics at the age of 16 in high school. He enrolled at Indian Hills Community College and achieved a diploma in Electronics/Computer Occupations, followed by an A.A.S Degree in Laser Electro Optics technology. He has been working in the medical manufacturing field for the last decade holding titles of Manufacturing Laser Technician I / II, Sr. Laser Manufacturing Support Technician / ILSO/ CLSO and is currently the Equipment Maintenance Supervisor / CLSO for Integer in Chaska MN, overseeing all 5 buildings on their campus. Recently Christopher has also joined both the ANSI Z136.9 and TSC-7 Subcommittees. He continually looks to improve the laser safety program at his site in the hopes that it can be used as an example for all other sites within the corporation. His goal now is to develop a training program for his alumni so that the future generation of techs can have a better understanding of what is expected and needed out in the field.

Becoming an LSO

Being chosen to become a new LSO for your organization can be an exciting time, as it indicates a level of confidence held by your employer that you are capable of taking on this new responsibility that grants you the authority and final say on all things related to laser safety, which let's not forget brings greater earning potential in terms of raises/promotions and also opens up new career paths where the only limit to your potential is set by how far you wish to take it. But as the old saying goes "with great power comes great responsibility" which is why it cannot be stressed enough that each LSO has both the duty and responsibility to ensure the safety of all personnel that works on or around high-powered lasers. And one of the most effective but challenging ways of doing this is creating and maintaining your own *Laser Safety Program.*

Within this article I aim at providing some of the very methods taken to establishing the program that I have today, and while not a complete list of everything that encompasses a laser safety program, having these basics will allow you to build a foundation to which the rest can be developed.

Developing an Inventory (Lasers Information)

Creating a simple yet robust inventory system will provide any new LSO with a proper foundation upon which their laser safety program can be built on. Based upon my personal experience as a laser technician over the past decade I understood the importance of why an inventory was not only critical but in my opinion serves as the very foundation of which any program should be developed based upon one simple rule ***"How can any LSO ensure the safety of their campus, if they do not understand the hazards present with each laser and where to find them"***

The Table below shows only a small portion of what would later make up my site's *laser inventory template*. Understanding your laser's capabilities is incredibly important as it allows you the LSO to determine what hazards may be present at based upon things such as Wavelength, Class, Power, etc.

Specific Laser Information	
Manufacturer:	Address:
Model #:	Serial #:
Wavelength (nm):	Laser Type (Nd:TAG, CO2, etc.):
Laser Class for system:	Laser Class for embedded laser:
Beam Divergence (milliradians):	Bean Diameter (mm):
Operating Mode (continuous, pulse, etc):	
Power (Watts):	
Energy (joules):	
Pulse width (s): Frequency (Hz):	

Performing Audits both Internal and External

Performing Audits for each laser system at your site whether *Internal* or *External* can help establish if there are any findings that violate *ANSI Z136.1* Standards or OSHA safety regulations. And while understanding all standards and regulations can be a difficult task at times, it ultimately should be looked at as an opportunity to develop your own ability in spotting compliance issues. Such as warn out or incorrect labels and most importantly safety violations that present a direct risk of allowing both *exposure* and *access* to the hazard in question. As I stated before having a full understanding of all ANSI and OSHA regulations can take decades of training and practice to correctly implement, which is exactly why I personally reached out to Thomas Lieb, President and Founder of L*A*I – International, an independent company offering both engineering and consulting services to companies dealing with laser technology. After performing your audit if any findings come forth such as compliance or safety hazards it will be important to follow up with your site EH&S and create a risk assessment of which findings to tackle first, with safety of course taking priority above all else.

Example of an OSHA Violation found during an Audit

OSHA Violation

While taking a closer look at the station it was found that there was a safety issue present that was previously unknown, the station has a very large opening along the direct beam path in which the beam can escape. The wavelength used by this laser is one that can be transmitted directly to the retina causing permeant blindness. ***It was later revealed that a cover for this section of the station did exist at one point but was scrapped due to an increased need to perform maintenance in a timely manner to get production running again.***

NOTE: The final point to make for this section of why performing audits are critical, is because they can also uncover the history of the machine in question. As such can be seen with the example provided, where lack of knowledge and respect for laser safety resulted in the removal of physical guarding that was designed and intended to protect against both exposure and access of the known hazard present.

Affected vs. Authorized and Knowing the Difference

The last topic I will touch on is one related to training your Affected vs. Authorized users and ultimately knowing the difference between the two. ***(Note: The definitions provided are unique to the author's site and are not defined in ANSI Z136.1)***

Affected

Laser associates whom are trained on how to operate and run production in a ***Class 1 environment*** but who are ***NOT*** trained in performing maintenance on the system and ***Shall*** never operate the laser with guards or interlocks bypassed. ***No PPE required***

Authorized

Laser associates whom are trained to perform routine preventive maintenance and or troubleshooting that may result in taking the laser from a class 1 environment to a ***class 3B or higher***. Authorized associates ***Shall*** be trained in proper PPE use/handling prior to any work performed on said system. *PPE REQUIRED*

CONCLUSION

The industry of laser technology will continue to grow exponentially for years to come and will require more individuals that understand and can apply the standards correctly. And if my own journey of becoming an LSO/CLSO has taught me anything it would be that 1. Misinterpretation of standards is more common than not, and 2. That associate compliance with any program developed depends solely on the culture that is established by your organization through leading by example.

And finally, I will leave you with a quote that has always stuck with me through the years and at its core represents the very essence of why we all have become LSOs.

"an ounce of prevention is worth a pound of cure"

About BLS

The mission of the Board of Laser Safety (BLS) is to provide a means for the recognition of laser safety professionals through certification and to promote competency in the field of laser safety. BLS certification will enhance the credibility of a designated Laser Safety Officer, and demonstrate that individuals serving in the field have agreed to adhere to high standards of safety and professional practice. For the employer, having a CLSO or CMLSO on staff demonstrates due-diligence and helps to ensure legitimacy and adequacy of the laser safety program, validating the company's dedication to a safe working environment for all employees.