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Laser Safety Matters

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Welcome to the tenth issue of Laser Safety *Matters*. This issue looks back at the recent Laser Safety Forum including a number of extended articles from invited presenters as well an article covering the outcome from the laser pointers Call for Evidence. We also look back at the International Laser Safety Conference that took place back in March 2017, as well as insight in to the recently formed Inter-University Laser Safety Meetings.

I would like to say a big thank you to everyone who has contributed articles to this issue and please feel free to contact me if you would like to contribute an article for the next issue, or have suggestions as to the topics you would like covered.

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22nd Laser Safety Forum 2017

September 2017 saw the 22nd annual Laser Safety Forum held in Loughborough, UK. The now customary dinner on the Monday night before the Forum was well attended with around 40 delegates enjoying lively conversation and the usual Burleigh Court dinner. The evening concluded with a 25th anniversary cake provided by Burleigh Court to commemorate 25 years of our laser safety courses at the venue.

85 delegates attended the 22nd Forum, the maximum occupancy possible for the room, which was excellent. Due to the sell-out attendance, a number of previous attendees were too late booking to attend. For the 23rd Laser Safety Forum (September 2018), book now to avoid disappointment. We were pleased to welcome those who were attending for the first time as well as the many who were making return visits to catch up with acquaintances new and old.

The Forum comprised 10 presentations: there could have been more due to the number of requests to speak we received. Therefore, a good proportion of 2018's programme is already in place. As always with the Forum we try to get a blend of subjects that collectively cover the majority of areas. Topics covered include updates to what is going on in the world of standards, real-world examples from alumni where laser safety management is critical as well as considering new approaches for emerging technologies.

The morning session kicked off with **Eric Liggins** (QinetiQ) with his presentation entitled "Setting the standard for Laser Eye Protection: The new ISO 19818". Eric, as the convenor of IEC/ISO Joint Working Group 12 "Eye and face protection against laser radiation", talked about how we need to ensure that PPE performs adequately, that users know what it does, they can rely on it – it will protect their eyes (or skin) – and it is compliant. Eric described the current situation with PPE standards looking at the pros and cons. He then went on to introduce the new standard under development by JWG 12 which brings together expertise from ISO and IEC with the aim to have a new ISO standard, ISO 19818 "Eye and face protection – Protection against laser radiation – Requirements and test methods". Eric kindly agreed to write a more detailed overview of his presentation and this can be found on page 8.

To end the first session, **John Tyrer** (Loughborough University) presented "A Novel Handpiece for Medical Laser Applications". John covered the issues faced in the medical sector, for example exposure to surgical smoke. John discussed how analysis had been undertaken in the past that showed the smoke produced on a daily basis was equivalent to that from 27 – 30 cigarettes. He then went on to speak about practical issues from hand held laser machining including the particles that are being formed and their relative sizes. John spoke about quantifying the problem, hand-piece design and its delivery issues. He then moved on to describe how thorough R&D has led to a refinement of a cyclone modular hand piece. John finished with describing the results of particle size analysis and concentrations at skin and head height from the hand piece following controlled atmospheric chamber experiments at the Health and Safety Laboratories.

Following coffee, the mid-morning session of the forum was kicked off by **Neil Budworth** (Loughborough University) who's talk was entitled "New Sentencing Guidelines – What they mean for you." Neil, the Head of Health and Safety at Loughborough University, gave overview of how the sentencing guidelines have changed. He detailed the 9-step approach from defining culpability to establishing the financial position of the offender based on turnover. With this taken into account, the fine that is imposed can easily run into the millions of pounds whereas before it could easily be 10 times lower. Neil kindly agreed to write a more detailed overview of his presentation and this can be found on page 10.

Matt Flower (MOD) gave the next presentation that focussed on "Laser Directed Energy Weapons Safety Issues ("You want to do what?")". His talk focussed on all aspects of the use of military lasers, from equipment, to the different types of ranges, the role of the Military Laser Safety Team and then moved on to discuss Laser Directed Energy Weapons (DEW). Matt spoke about the large range of laser systems in use today, his team's role and how they go about their work promoting the safe use of lasers by MoD personnel on UK and overseas ranges. Matt went into detail describing lasers on the ranges and the use of backstops and determination of buffer angles and what factors have to be considered. Matt then went on to discuss the UK's Laser DEW programme known as Dragonfire. He spoke about the new issues and hazards faced with the use of such systems, when hazard distances are over 150 km, and how they are looking for ways to solve such issues.

The final two talks of the morning related to laser pointers or laser pens. The first presentation was by **David Rawlings** (Newcastle Hospitals) "Laser pens – the writing is on the wall?". David's talk focussed on the work he and his team had carried out on behalf of Newcastle Trading Standards. Newcastle Trading Standards purchased a range of laser pointers as evidence of products currently available on the market. David explained the range of products tested, from home to office use, before describing the results and the conclusions. As he showed, many of the laser pointers measured exhibited the common issues seen with such products, from incorrect classification to very high output powers.

Following on from David's talk and the final talk before lunch was given by **Martin Drake** (BALPA). Martin gave a presentation entitled "A Pilot's Perspective of being Targeted with a Laser Beam". With Martin being an active pilot on long-haul flights, often to United States of America, hearing his own experiences, and those of colleagues, was fascinating. Martin spoke in detail about the added burden of experiencing laser attacks while flying in a number of scenarios, including when trying to manage aircraft technical difficulties. Adding the complication of a laser strike puts the aircraft in real danger. Martin's accounts gave the audience eye opening accounts of such attacks and really brought home the issues faced for pilots on a daily basis.

After lunch, **Casey Stack** (Laser Compliance Inc, USA) gave a presentation entitled "Laser Product Compliance – A view from across the pond". We were lucky to have Casey present at the Forum this year as he had travelled all the way from the United States of America to be with us. Casey discussed laser product compliance and how a company's activities must meet the laser product laws of the destination country. Casey discussed how this is undertaken in the USA and the importance of getting it right. For example, US Food and Drug Administration law provides fines of $330,000

for problems with laser product compliance; product recalls can run into hundreds of thousands of dollars. Casey discussed the US Federal requirements, US differences with respect to Europe, what is involved in US Certification and the Federal versus State requirements. Casey kindly agreed to write a more detailed overview of his presentation in this increasing area of concern in the UK and the rest of the world. This can be found on page 12.

David Lawton (Lasermet) then talked about "Active Laser Guards". David spoke about how Lasermet have and are still developing solutions for laser guarding that can be used in multiple scenarios, from large facilities to more modest requirements. David first spoke about issues with traditional passive guarding methods and how Lasermet have been searching for better passive guarding materials. This has led to the development of active guarding and the patent pending "Laser Jailer" system, which is felt to be a flexible guarding system with a few limitations. David then showed the latest addition, this being the "glaser jailer", an active laser safety window. To finish, David showed some novel ways of using the same technology in wearable technology, from face protection to a wearable jacket!

Following afternoon coffee and to start the final session of the day **Michael Higlett** (PHE) gave feedback on the International Laser Safety Conference 2017 which took place in Atlanta. He gave an overview of the Conference, pinpointed a number of interesting talks that were given, as well as Forum alumni contributions. A detailed overview can be found on page 13, while on page 15 is a review article covering Michael's presentation about safety issues of low cost laser display systems available on the home and amateur DJ market.

The final presentation before the *Open Forum* was the usual round-up presentation on "Update on Laser Safety legislation, standards and guidance" provided by **John O'Hagan** (PHE). BS EN 207:2017 "Personal eye-protection equipment – Filters and eye-protectors against laser radiation (laser eye-protectors)" had been published in the last 12 months. John discussed the IEC TC 76 "Optical radiation safety and laser equipment" work programme and the two documents currently out for voting: IEC 60825-2 ED4 "Safety of laser products Part 2: Safety of optical fibre communication systems (CFCS)" and IEC TR 60825-5 ED3 "Safety of laser products Part 5: Manufacturer's checklist for IEC 60825-1".

John then went on to discuss the European Mandate on the standardisation of consumer laser products. He spoke about how products should be "safe", while discussions are still ongoing for the limit of Class, should it be Class 2 or Class 3R? Most notably, the plan for IEC to create a standard had been abandoned for now, pending publication of the European standard. John then spoke about the work of CIE and particularly CIE JTC 5 on "Photobiological Safety of Lamps and Lamp systems – Part 1: General requirements and Risk group determination" which is a joint project between CIE Div 6, CIE Div 2, IEC TC76 and IEC TC34. The final item John mentioned was the World Health Organization Non-Ionizing Radiation Basic Safety Standard work on producing the publication "Fundamental Safety Principles for protection against Non-Ionizing Radiation".

The Open Forum closed the day's proceedings with a number of questions posed by the audience, while the majority of the open forum focussed around the "Call for

Evidence: Laser Pointers – A call for evidence on the market, and potential uses, for laser pointers" by the Department for Business, Energy & Industrial strategy (BEIS). Lara Godden from BEIS, who is the lead for the call and who had been present for the majority of the Forum, came forward to explain the call, what is required, field any questions from the audience and to state the end date of 6th October. Following on from this, Lara agreed to write an article regarding the Call for Evidence and the outcome; this can be found on page 6.

In conclusion, this was an interesting day covering a wide range of laser safety issues with attendees catching up with fellow professionals providing valuable feedback and sharing solutions to their own experiences in dealing with laser safety issues.

23rd Laser Safety Forum event details, 2018

The 23rd annual Laser Safety Forum will be held on Tuesday 11th September 2018 at the Burleigh Court Conference Centre, Loughborough, UK. A pre-Forum dinner will be available at 7:00 pm on Monday 10th September 2018, the fee being £27.

If you would like to present at the upcoming forum, please contact us at **laser@phe.gov.uk**. Presenting at the Forum guarantees you a free place at the Forum.

Topics provisionally confirmed for 2018 include:

Implementing Laser Safety Management at UCL

PIV System at Sheffield Hallam University

My life in medical physics

Unmanned Aerial Systems and lasers

30 years of rock and roll - the pointy end!

Safety of laser projectors

The presentations will be followed by the Open Forum session, providing an opportunity to raise any laser safety issues that attendees would like to discuss.

If you would like to attend the Forum, please visit our **website** to complete the online booking form including all additional extras. Bookings need to be completed by 10th August 2018 and delegate numbers are limited to 85.

Attendance fees:

Standard rate:	£200
Discount rate:	£150 (former course participants)
Presenters:	No fee

Laser pointers: Call for Evidence Outcome

Lara Godden, Department for Business, Energy & Industrial Strategy

On 8 January 2018, the Government announced new measures to tackle the sale of unsafe laser pointers, including strengthening safeguards to stop high-powered lasers entering the country.

These actions are being taken in response to the Call for Evidence on laser pointers conducted last year, which was presented to attendees at the September 2017 Laser Safety Forum in Loughborough.

The Call for Evidence was launched due to increasing incidents in recent years involving laser pointers, including eye injuries from laser pointers and laser beams being shone at planes in flight. There were 1,258 laser attacks reported on aircraft in the UK in 2016, according to the Civil Aviation Authority. British Transport Police said there were 466 laser incidents recorded between 1 April 2011 and 31 October 2016 involving ground transport. Furthermore, over 150 incidents of eye injuries involving laser pointers have been reported since 2013, with the vast majority of these involving children.

Regulations already limit the general sale of laser pointers, and Government is taking additional steps to ensure that high powered laser pointers are not widely available in the UK for general use. More powerful laser pointers can be sold for specialist use, but our focus is on ensuring the safety and appropriate use of those devices available to the general public. We will work with manufacturers and retailers to improve laser pointer labelling, indicating that they must not be pointed at eyes or at vehicles and must state the power level of the product. The policing of online laser pointer sales will also be improved through working with online retailers. Government will also work to raise awareness of the risks associated with laser pointers and provide additional support to local authority teams to carry out increased checks at the border, including testing products to ensure they are safe.

Margot James, Consumer Minister at the time, said:

“The Government has listened to concerns from pilots, health professionals and safety experts, which is why we are going further than ever before to crack down on the sale of unsafe devices. Public safety is of the utmost importance and we are working to increase the public’s knowledge of the potential dangers associated with these devices and strengthening the penalties for when they are misused.”

Professor John O’Hagan, of PHE’s Laser and Optical Radiation Dosimetry Group, said:

“Over time we have become increasingly concerned about the dangers of growing numbers of unlabelled and incorrectly labelled high power laser pointers being bought by the public. It is tragic that we continue to see eye injuries, especially in children. Laser safety experts at Public Health England have worked closely with local authorities in stopping large numbers of these lasers reaching UK consumers. The extra protections proposed should help even further - if you have a laser and you don’t need it, remove the batteries and get rid of it.”

These measures build on tough new penalties in the Laser Misuse (Vehicles) Bill, which was introduced by the Department for Transport last year. The Bill expands the list of vehicles it is an offence to target with lasers. It also makes it easier to prosecute offenders by removing the need to prove an intention to endanger a vehicle. People who shine laser devices at transport operators could be jailed for up to five years. At the time of writing the Bill is going through Parliament.

The full outcome of the call of evidence can be downloaded **here**.

Inter-University Laser Safety Meeting

Lewis Jones, Loughborough University

A new inter-university laser safety group has been formed to address some of the specific requirements of researchers who use laser equipment. This group was created following repeated discussions with users of Class 4 laser measurement equipment who were having difficulties in implementing safety controls to create Class 1 or 2 experiments. It was found that some of this equipment (old and new) could not be externally controlled, ultimately preventing it from being adequately interlocked. This is a major hurdle in creating a safe working environment and we are looking to form a strategy to work with equipment manufacturers and suppliers to ensure that machinery provided is capable of being safely controlled in a way that is suitable to the research community.

The group, of now over 35 universities, met twice in 2017 at events held at Loughborough University. The purpose of these meetings was to discuss with a wide range of research laser users the common issues encountered, form a coherent strategy for laser safety across universities, listen to experts in the field of laser safety and from specialist inspectors, and to develop an action plan to coordinate solutions to the machinery being supplied to universities.

The main point of action for the group is now to establish how group university procurement processes can support the drive to improve the guarding and interlocking of laser machinery. The reason for this is that current health and safety requirements in the purchasing frameworks are very general and do not address the specific needs of laser users. The wish is to establish a set of minimum standards and requirements for laser safety to be included in all purchasing decisions. This would allow clear communication of needs to key suppliers and give unknowing purchasers a set of guidelines for safety that must be met.

The tender process to renew the existing laser-purchasing framework (APUC – LAB1007AP) is not expected to take place until 2020. This gives the group time to develop a team, capture user requirements and propose the new framework. While

this is being driven by the university purchasing framework it is expected that this will have benefit to other laser users as well.

If anyone is interested in learning about or participating in the Inter-University Laser Safety Forum please contact Dr Lewis Jones **L.Jones@lboro.ac.uk**, the next event will be held at Loughborough University on Monday the 21st May 2018.

Setting the Standard for Laser Eye Protection: The new ISO 19818

Eric Liggins, Qnetiq

Introduction

Users of personal laser eye protection need to be confident that it is going to protect them from injury, be tough enough to survive life in a modern industrial or lab environment, and enable them to see what they are doing. Whilst it is not possible to guarantee perfect eyewear, a well-written performance standard can ensure that eye protection is specified and tested to an extent where it won't let you down.

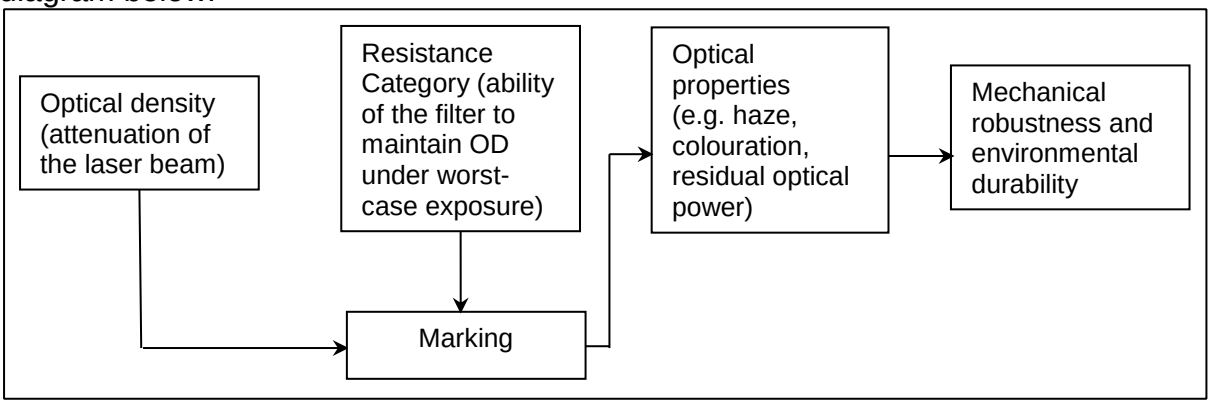
Existing standards for eye protection

There are two big players on the block in terms of laser protection standards. Laser users in Europe (including the UK!) currently buy eyewear that is certified to meet EN 207, whereas those in North America and some other countries use ANSI Z 136.7. Both standards have strengths, but also have areas where there is scope for improvement. The European standard EN207 has the advantage that it is harmonized with the E.U. PPE Directive, but contains a number of historical aspects that can be unhelpful to users. For example, OD of a filter is rigidly linked to the resistance of that filter to laser damage, so these properties cannot be specified independently – even if that would be better for a laser user. There are other problems with EN207, such as citation of outdated MPEs, a number of mathematical imponderables, and the fact that its content is resistant to stakeholder requests for change.

The ANSI standard, on the other hand, adopts a rather different philosophy, where a great deal more responsibility is placed in the hands of the eyewear user – with the assumption that the user or distributor of the eyewear has enough knowledge to specify it correctly. The ANSI approach would not be acceptable in Europe under the PPE Directive. However, Z 136.7 does contain much that is exemplary, such as the treatment of saturable absorption (a.k.a. transient photobleaching), and the willingness of the ANSI committee to take on board stakeholder input.

The new ISO standard

A new standard for laser eye protection, under development within ISO and IEC, aims to bring together the best aspects of these two previous standards, but miss out some of the more frustrating elements. The standard – to be published as ISO 19818 – will set out minimum requirements for personal laser eye protection, along with test methods that can be used by manufacturers, or test houses, to certify eyewear as meeting the standard. The principal building blocks of ISO 19818 are set out in the diagram below.



Main performance requirement elements of ISO 19818. Additional clauses will cover aspects such as "Information to be supplied to the user", "Test methods" etc.

As well as familiar quantities such as OD and haze, the standard introduces a measure of resistance to laser damage, known (in the current draft) as Resistance Category (RC). The precise values for each RC are still to be published, but a higher RC will mean that a laser protector can survive a higher beam irradiance or radiant exposure without losing its protective properties. Of course, this may come at the expense of visible light transmission, weight or some other property that is important to the user – hence the need to specify both OD and RC correctly for the intended use of the eye protection. There is one final proviso in the standard: impractical or potentially hazardous combinations of OD and RC have to be marked so that users are not put at risk of injury (for example, a filter with an OD of 2.0, but a very high resistance to laser damage, must be marked with lower RC consistent with a safe laser exposure behind the filter). I am very grateful to everyone who took time to complete the marking survey that was advertised last October. The results have been very useful in defining clear, unambiguous markings for future laser protective eyewear.

The new standard will be aimed primarily at manufacturers and test houses, telling them what needs to be done to manufacture and sell good, safe eye protection that is fit for purpose. There will be guidance for users of such eye protection, and that guidance is planned for inclusion in the laser user's guide, IEC TR 60825-14 and the ISO guide to eye and face protection ISO 19734 (not yet published). Look out for updates on the publication timeline for ISO 19818 at the annual Laser Safety Forum, and in "Laser Safety Matters".

The Silent Revolution in Health and Safety and What it Means to You

Neil Budworth, Health, Safety and Risk Manager Loughborough University

There has been a silent revolution in the world of health and safety over the last couple of years. You probably won't even have noticed it, unless you are involved, but it is a revolution none the less.

Without too much fanfare, on 1 February 2016, the Sentencing Council's Definitive Guideline for Health and Safety Offences, Corporate Manslaughter and Food Safety and Hygiene Offences (more commonly referred to as the 'Sentencing Guidelines') came into force in England and Wales and the impact has been profound.

Guidelines have, for the first time given clear guidance on how health and safety (and food hygiene) offences should be treated by the courts. The guidelines clearly signalled to courts that Health and Safety offences should be treated with the same severity as data or financial mismanagement.

The result: fines have increased by at least an order of magnitude. A serious offence will no longer attract a fine of a few thousand pounds, they are now more likely to result in fines of hundreds of thousands, or millions of pounds.

The sentencing guidelines define a series of steps which direct the court to the level of fine that should be imposed. If you have any safety responsibility it is important to understand these steps.

The first step in determining the appropriate fine level is to define the level of culpability. There are four potential culpability categories from low to very high. The factors which are considered include whether industry guidance was implemented, whether concerns raised by employees were ignored or whether there was evidence that the organisation expended significant effort on health and safety, and the incident happened with no warning. The category of culpability should reflect the level of seriousness with which the organisation manages safety. An assessment resulting in a very high culpability can have a huge impact on the level of the eventual fine.

The second step is to determine the harm category. This has two elements – the seriousness, or potential seriousness of the harm and the likelihood of the injury occurring. A matrix is then used to determine the harm category on a scale of 1-4

Armed with these two pieces of information and the turnover of the organisation the courts then turn to a series of tables which are based on the organisation's turnover; below £2m; £2-10 million, £10-50 million and above £50 million.

The court simply refers to the relevant table and cross references the level of culpability and the harm category. These tables give a starting point and an illustrative range for the fine. The court then takes into account any aggravating circumstances (i.e. putting profit before safety) and also any mitigating circumstances.

The result is broadly consistent fines which are much much higher than before. In 2016, 19 companies received fines of a million pounds or more with the highest being £5 million. In 2017 we see the trend continuing with million pounds plus fines appearing almost every other week. The impact is perhaps best illustrated by looking at one organisation which was fined twice, once before the new guidelines were implemented and once after. The company concerned was Wilko. Wilko were fined for a fatality in January 2016 and the fine was £200,000. A year later they were fines for an injury where a young employee was paralysed from the waist down with a resultant fine of £2.2 million.

How does this apply to laser safety? The same sentencing guidelines apply. Consider the impact of a beam strike or an electrocution due to poorly guarded equipment – a serious injury with long lasting consequences. Consider how closely your organisation follows the guidance on the guarding of equipment and the robustness of your management arrangements. The wrong answer could land you with a fine in the order of £1-2 million. The difference in the starting point for a serious (but not fatal) incident is £100,000 for low culpability compared with £2 million for very high culpability.

The impact of not taking safety seriously and following available guidance now is clear and has a significant price tag!

One year on how have things changed? The sentencing guidelines appear to be being applied fairly consistently and fines have increased massively. There is also an increasing willingness to fine or jail senior managers. In 2015/16, 46 company directors and senior managers were prosecuted under health and safety laws, compared to an average of 24 in each of the previous few years. One other development is that we have also seen more companies being heavily fined when there was no injury or ill health, but where there was a breach of legislation and the potential for serious injury was clear.

Another point that has been made very clear in the last year is that it is up to the judge to determine the outcome of the case. Even if both parties agree on the culpability and harm categories the judge can, and in some cases has, chosen to ignore their suggestion and referred to a more severe harm or culpability category and hence imposed a high fine.

The guidelines are still relatively new and the one area where the courts are still finding their feet is where the turnover of the organisation greatly exceeds £50 million. The guidelines suggest that where a company has a very high turnover fines greater than those recommended in the existing tables can be levied, but the guidelines give no suggestion on how to do this consistently.

So health and safety fines are now of a level that warrants serious consideration. The kind of injury that could be sustained through inadequate guarding or misuse of lasers could easily lead to an organisation facing a very significant fine and individuals facing personal legal action. The degree to which published guidance and industry best practice is implemented and the level of attention applied to health and safety issues makes a huge difference to the potential outcome of any case. The future, whatever it brings, will be interesting.
For those wanting more detail, the guidelines can be found **here**.

Laser Product Compliance a View from Across the Pond

Casey Stack – President, Laser Compliance

The rapid growth of laser use has made laser safety a critical part of today's business and consumer landscape. Whether due to government regulation (such as the EU), fear of expensive legal judgement (U.S.) or simple human decency and good business practices, manufacturers strive to limit the potential for injury to their customers. A great deal of training, procedure and safety equipment goes into creating safe laser user environments today.

However, as any safety engineer will extol, wherever possible, safety should be engineered into the product, rather than being dependent upon knowledge and behaviour of individuals. In fact, a great deal of the laser safety afforded the user, is baked into laser products during the design and manufacture process. This area of safety is called 'product compliance'. Indeed, many Class 1 laser products with embedded higher power lasers owe their safety entirely to the product compliance, as the user need not observe any special operating procedures. Generally speaking, laser product 'safety' is an action performed by the user, while laser product 'compliance' is a function of the manufacturer.

The 'EN/IEC 60825-1' is the laser product standard which defines compliance requirements for most of the world. However, the United States has another set of laser product standards in place since 1976. These are 'US 21 CFR, Part 1, Subchapter J, sections 1002 – 1040.11'. The US regulations are sometimes called simply "1040". These regulations are enforced in the US by a government regulatory agency: the Food and Drug Administration's Center for Devices and Radiological Health (FDA CDRH). Unlike many countries, in the US these requirements are law, having been voted in by the US Congress. Manufacturing or distributing non-compliant laser products in both the US and the EU can lead to expensive product recalls, and in the US, very large fines (approx. £250,000) and even prison, although enforcement rarely is required to this level.

Although US 21 CFR 1040 is still on the books today, and has advantages for about 5% of laser product manufacturers, the IEC 60825-1 edition 2 2007 can legally be used for most portions of compliance in the US via the terms of FDA 'Laser Notice No. 50', dated June 24, 2007.

Although in most countries laser products are required to be compliant to laser product standards, in the US there is another layer of regulatory requirement for manufacturers and importers. Manufacturers and/or distributors of laser products to the US must 'Certify' their laser products under the terms of 21 CFR 1010 and 1040. This process of 'self-certification' is performed by the manufacturer or importer, not by a third party or test lab. This self-certification is performed on every unit manufactured through end-of-line testing, reporting, and the application of a 'certification label' to each unit. The certification process includes filing of a large 'initial laser product report' as well as 'annual reports' to the US FDA CDRH. Self-certification is still required when IEC 60825-1 is adopted for Classification and compliance.

US regulations prohibit the manufacture of two categories of laser products which would exceed 'Class IIIa' (essentially 3R) levels. These categories are: 'surveying, levelling and alignment' (SLAs) and 'demonstration laser products'. This regulation is 21 CFR 1040.11. Laser pointers, for example, fall into the SLA category and are therefore limited to 5 mW. Demonstration laser products include laser display devices, light show projectors as well as the actual 'light show', video and film projectors, and more. Where Class 3R levels would be inadequate to perform a required task, such as providing the required brightness for a Laser Illuminated Projector (LIP) for cinema use, a special permitting process is available where safe use can be assured. This government permit, called a 'variance', allows the manufacturer or user to 'vary' from the regulations in certain cases.

The US FDA CDRH is a federal level organization, and these federal laser requirements including variances apply in all states uniformly. However, individual states may, and some states have, implement additional user safety requirements. For example, New York State requires a state license for operators of what are essentially Class 3B and 4 lasers used on a mobile basis for any purpose. Texas requires prior state visibility and approval of LSOs, as well as certain operators, and most service personnel for Class 3B and 4 laser products. Several states also require fee registration for all Class 3B / 4 devices. To date, no US states have applied additional product compliance requirements above those of 21 CFR or IEC 60825-1.

Although the international IEC 60825-1 laser product standard can be used for laser product compliance in the US, additional federal and some state requirements must be observed prior to importation. Some non-compliant laser products may be impounded and destroyed upon importation if not US certified upon arrival. Awareness of the additional requirements for US importation will save time, money and hassle.

Meet the author
Casey Stack serves as President of Laser Compliance a consultancy. He also acts as Commissioner of the Board of Laser Safety, is a contributing author to IEC 608258-1 and is Vice-Chair of ANSI Z136.10

International Laser Safety Conference 2017

Michael Higlett, Public Health England

March 2017 saw the International Laser Safety Conference (ILSC®) taking place at the Sheraton® Atlanta Airport, Atlanta, GA, USA.

Representatives attended the 2017 ILSC from 14 countries, totalling close to 180 delegates, 13 of which were alumni, and with John O'Hagan as the Conference General Chair. The conference brought together attendees ranging from those just starting out in the world of laser safety, to world-renowned experts. ILSC took place over four days separated into three sessions, excluding the opening and closing

plenary sessions. The sessions included the main Scientific one, which covered all 4 days, with two other sessions running sequentially in parallel with it: the Technical Practical Applications (2 days) and Medical Practical Applications (2 days) sessions. In total, there were over 85 speakers.

The papers provided a mixture of fundamental laser safety science and practical laser safety issues. Copies of the Proceedings are available from the organisers, the Laser Institute of America.

The conference was well balanced over the 4 days, including the three main sessions, as well as a number of networking events including the Welcome Reception and the Sponsors Reception. Fitted around these were some additional laser standards committee meetings.

Over the 4 days of scientific sessions there was in total 13 sub sessions covering areas such as Bioeffects, Broadband Radiation, Standards and Regulations, Non-beam Hazards, Product Safety, User Control Measures, Hazard Assessments and Outdoor Lasers & Laser Displays with many excellent presentations. Over the course of the scientific sessions, there were 8 presentations from alumni with 3 talks previously (with slight modification) being presented at the Laser Safety Forum. These talks being "Laser eye dazzle safety framework" by Dr Craig A. Williamson and Dr Leon N. McLin, "Laser bird repellents - A pain in the eye?" by Dr Ronald Mallant and "Darwinian Laser Safety & laser safety evolution" by Prof. John Tyrer. All of these were presented at 21st Laser Safety Forum in 2016. Prof. John Tyrer also presented "Inherently Safe (Class 1C) Medical Hand-piece Design; the development of a skin system which contains Optical Radiation and Plume" at the Medical Practical Applications seminar. John's talk was updated and presented at the 22nd Laser Safety Forum in 2017.

One aspect of the ILSC talks that I find particularly useful is that you get to hear about the rationale and processes behind the decisions that lead to what is found in laser safety standards. This helps you get a better understanding. This year there were a number of talks which looked back at history, explaining how certain aspects of the standards evolved and why, and if they are still needed. Lots of this information cannot be found online, or in books, but only from such talks and discussions with those experts present at the time.

The first Laser Safety Practical Applications Seminar (now known as the Technical Practical Applications Seminar) was held in in 2007 in parallel with the main conference, leading to clashes when deciding what to attend. Since the introduction of a Medical Practical Application Seminar in 2011 (run in parallel with the first 2-days of the scientific sessions) the popularity of these sessions has gathered pace. As in previous years, it is noticeable that after the first 2 days (when the Medical Practical Applications Seminar has finished), the number of attendees drops, showing the large number of medical practitioners coming solely for these seminars.

Topics covered in the Medical Practical Applications Seminar were: Cleaner air in the operating room: The impact of surgical plume on healthcare providers and patients, Plume hazards associated with aesthetic laser systems, Better outcomes for burn victims utilizing medical lasers, Animals are people too! Lasers in veterinary medicine, So you are the LSO: now what?, Setting up a laser laboratory: Avoid the pitfalls,

Power/energy measurements, why should I or do I care?, Optical fibre lasers and their hazards, plus a number of other topics.

In the closing plenary session, an open forum was hosted by John O'Hagan with an expert panel including the final speakers: Jerry Dennis, Jan Daem, David Sliney. They were also joined by Karl Schulmeister. Together they answered a number of questions that had been provided in advance by conference attendees. Question topics included: "Lasers and their use on LED screens", "Best approach to paper based inspection of lasers without losing integrity", "Questions on C_5, including simplification being possible?", "Restrictive nature of using C_5 and larger spot sizes", "α-dependency being made understandable", "How to classify / calculate hazard distances for super-continuum laser systems" "How do you see visual acuity being incorporated into eyewear selection criteria?" Another question asked related to the term MPE, discussing the use of the term and should we be refraining from using it? Should it be changed to "Zero Risk Exposure" and MPE being the level at which we say that the risk of injury is deemed unacceptable.

As at each ILSC, the awards luncheon takes place. The R. James Rockwell Jr. Educational Achievement Award, which went to Professor John O'Hagan for recognition of his outstanding contribution in laser safety education. The second award was the George M. Wilkening Award in Laser Safety. This year this went to Wesley J. Marshall in recognition of his outstanding contribution to bioeffects relating to the establishment of human exposure limits and in safety standards development and education. As I am sure you will agree both John and Wesley were highly deserving of their awards due to their many years of contribution in laser safety.

The main strength of the conference over the years is the wealth of practical information available for both laser safety professionals and for those who "do" laser safety as a part of their job. For those new to the discipline it is a relatively unique opportunity to meet and learn from many of the key players in laser safety throughout the world. However, that world is limited; there are a number of countries not represented. Of nearly 180 delegates, 75% were from the US – the remainder were from 13 countries. Out of those 13, only the UK and Canada got into double figures.

The 2019 ILSC will be held at the Embassy Suites® Lake Buena Vista South, Kissimmee, Florida, USA, from 18 to 21 March 2019. ILSC is organised by the Laser Institute of America and further information is available from the Conference web site (**https://www.lia.org/conferences/ilsc**)

Laser Display Systems: Do We See Everything?

Michael Higlett, Public Health England

Today, laser display systems can be bought very cheaply. Whereas not so long ago, the only "affordable" laser displays (> £200) would typically be purchased by an amateur DJ for parties, today £20 - £40 systems are readily available to the general public. These systems can be purchased from a range of local shops or over the internet, especially around holiday times such as Halloween, Christmas and New Year.

For at least the last 2 years the market has seen the arrival of many new low-priced devices aimed at the home-use market for either illuminating the inside or outside of the home, and with multi-coloured static or strobing spots and images (Figure 1). It is also not uncommon to see laser displays operating in a static position or in motion in a shop or out of a shop window illuminating the public and potentially vehicles passing by.

Figure 1. Laser products for home use

Furthermore, the reduction in cost of lasers over the last 3 – 5 years has resulted in wider availability of laser displays for local / amateur DJs to enhance the entire experience of the event (Figure 2).

Figure 2. Laser displays aimed at the DJ market.

The laser displays that are being used are commonly Class 3R or Class 3B laser products, which raises the question as to whether the DJs are following safe protocols in setting the lasers up for use? Do they understand the risks? Do they comply with the appropriate standards and guidance?

When buying home-use or local / amateur DJs' laser display products, users expect them to comply with the laser safety product standards of IEC 60825-1:2014 [1] or ANZI Z136.1:2014 [2] (if you live in the USA). However, as shown with laser pointers, this might not always be the case. So, can we assume that low cost laser displays always meet the standards? Or do we get more than we expect - not only for power and emitted wavelengths but also strobing of the laser patterns displayed.

This leads to a number of questions. Are these products safe? Is the power output higher than expected, and is it from the wavelengths stated? Moreover, does the product comply with all of the appropriate standards such as IEC 60825-1:2014 [1]? Another consideration, which is not included in IEC 60825-1:2014 [1], is whether the laser product can flash / strobe, and if so, is this at a frequency likely to affect someone who suffers from epilepsy?

Public Health England have been carrying out assessments on a number of home use laser displays as well as devices commonly bought by amateur DJs. Twenty domestic (16) and Semi-/Professional (4) laser displays have been assessed. Eleven of these are designed for indoor use, seven for outdoors and two are stated for use either indoors or outdoors.

Initially, a visual inspection of each laser product was undertaken. The visual inspection included the packaging, instructions and labelling on the laser product. Following the visual inspection, the emission spectrum for each laser was assessed and the laser output power was measured. If the device was found to have a strobe option, additional measurements of temporal pattern were made. All devices measured were mains (240 V) powered. Undertaking the inspections determined compliance with the requirements of IEC 60825-1:2014 [1], ANZI Z136.1 2014 [2] and CFR 1040.10 [3].

Out of the products that have been on sale on the UK market, the assessments showed that all twenty laser products should not be available for purchase. The tested products failed due to either a single issue or a combination of issues that included power, emitted wavelength(s), classification of the product and insufficient or incorrect user information.

What has become noticeable over the past 18 months and observed in many of the newer products (less than 12 months old) was the use of one or a number of diffractive optic elements to produce the range of visual effects. The diffractive optics were made from a range of materials with varying levels of robustness and quality. While the mounting was the same, e.g. glued, the amount of glue used varied, with some just held with two small spots. While in normal use some of the devices would probably remain attached, the diffractive optic element could become easily detached from others. In many cases, if the diffractive optic was missing, it could result in accessible laser beams up to 40 – 100 mW, capable of causing eye injuries, even for momentary exposures.

A number of the laser products on the market do not meet the requirements of IEC 60825:1 2014 [1], with many classified incorrectly or labelled wrongly. Many of the products were supplied with the American label layout as in CFR 1040.10 [3]. In some cases the CFR 1040.10 labels have been modified by replacing the Roman numerals prefix with the IEC 60825:1 2014 [1] /ANSI Z136.1:2014 [2] prefixes, as shown in Figure 3.

Figure 3. Examples of laser product labelling.

It would appear that manufacturers are aware of the differences between the prefixes; however, the fact the label layout and wording are incorrect questions whether the appropriate standard is being considered or whether CFR 1040.10 [3] is being used because it is freely available.

An increasing number of laser displays use strobe effects. Flashing or patterned effects can make people feel disorientated, uncomfortable or unwell. All of the laser products, which strobed, strobed in the range 4 – 25 Hz, the region of photosensitive epilepsy. In the UK, the flash rate of strobe lights is restricted to a maximum of four flashes per second (4 Hz) by the Health and Safety Executive for music and similar events [4]. However, some people can be sensitive to rates as low as 3 Hz and as high as 60 Hz.

Another concerning finding is the emission of infrared radiation from a few of the laser products, a common occurrence with laser pointers, but not for professional laser display products – none of which were assessed here. In one particular case, an infrared laser operated independently of the position (ON or OFF) of the interlock key when the laser was powered.

Stricter controls, or more effective application of existing controls, may be needed to ensure laser products available to the general public from the internet and high street stores in the UK are safe. Many of the laser products are classified incorrectly, while many are labelled incorrectly for the UK market too. A combination of CFR 1040.10 [3] and replacing the classification prefix with that used in IEC 60825:1 2014 [1] is used in the majority of products. These products therefore no longer meet the American standards and so are also not fit for sale in the United States of America.

Finally, in most cases the safety of these laser displays depends critically on the diffractive element remaining in the beam path. If this plastic element falls off or the motor shaft breaks, the beam from the laser display may be capable of causing serious eye injuries.

References

1. IEC 60825-1. “Safety of laser products – Part 1: Equipment classification, and requirements”. International Electrotechnical Commission, Geneva, 2007.
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3. Centre for Devices and Radiological Health (CDRH, 1995), Laser Product Performance Standard, Title 21, Code of Federal Regulations, Part 1040.10, Washington DC, Government Printing Office.
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PHE Training Courses:

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At Burleigh Court, Loughborough

Laser Safety Management Course

5 day course, Monday – Friday (arrive Sunday evening for dinner)

15 – 19 October 2018

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2 day course, Tuesday – Wednesday (arrive Monday evening for dinner)

22 – 23 May 2018 - *Full*

27 – 28 November 2018

Laser Safety Forum

Tuesday 11 September 2018

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Laser Safety Forum

The Laser Safety Forum is open to anyone with an interest in laser safety. Membership is currently free. You can join by sending your details to **laser@phe.gov.uk**