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INTERNATIONAL LASER SAFETY CONFERENCE

March 20–23, 2017

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Conference Program & Proceedings

Addendum

March 31, 2017

Presented by:

Laser Institute of America
Laser Applications and Safety

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Closing Plenary Sessions

Closing Plenary: Looking Forward — Thursday, March 24 — 1:00PM — *Paris*

Session Co-chairs: Karl Schulmeister, John O'Hagan

The closing plenary session is based on the theme of "history and future" where two presentations will review early development phases of national and international product safety standards, while the presentation on laser illuminated light sources is dedicated to the state of the art and upcoming developments. A newly established "Open Forum" will provide a platform to discuss issues that surface during the conference, or perhaps an opportunity to ask a question that has been on your mind for some time.

Closing Plenary Schedule

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THE CDRH/FDA RADIATION SAFETY STANDARD FOR LASER PRODUCTS: A HISTORY

Paper ID# C101

Jerome E. Dennis, Consultant
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Abstract

This invited paper traces the history of the CDRH/FDA Radiation Safety Standard for Laser Products from its inception to the present. This standard was the first such standard. The discussion will cover the changes that have occurred over the past 45 years and give comments on the rationales that have led to the changes that have been introduced

Early days

The CDRH/FDA Radiation Safety Standard for Laser Products, the first standard for the safety of laser products, was published in the Federal register as a Final Rule on Thursday, July 31 1975 as 21 CFR 1040.10 and 1040.11, to become effective one year later on August 2, 1976. Compliance with this standard is a legal requirement applicable to all laser products that are "introduced into commerce," that is manufactured, assembled in or imported into the United States. The standard was to be administered by Bureau of Radiological Health (BRH), a part of the FDA. The author believes that this standard was appropriate because laser radiation, as compared to radiation from other sources of optical or other radiations, was, because of the very high radiance, very well collimated so that the hazard would not be appreciably diminished with distance from the source. This standard contained definitions, the structure for four hazard classes based on emission levels during operation, measurement conditions for classification, performance (sometimes called engineering) requirements, warning labeling and informational requirements. Requirements for medical laser products and emission limits for surveying, leveling and alignment laser products and for demonstration (visual display) laser products.

The final 1975 final rule was preceded by two proposals.

The first of December 10, 1973, contained this basic structure, but has a few aspects that are especially worth noting in consideration of what is understood today as being reasonable:

- No measurement distance was given for the measurement of radiant energy or power,
- Regardless of the level of laser radiation within a protective housing, any beam that could be reflected out through any opening in the housing was within the definition of human access,
- There was no Class IIIa; the classes jumped Class I or Class II to Class III,
- Therefore, a protective housing of a Class III product would only have to prevent human access to any Class IV levels within the product.

The preamble to the proposed standard is considered to be official FDA policy because it has gone through the same regulatory process as the standard itself. However, the requirements of the standard are required to have been cleared by the Office of Manpower and Budget (OMB) in an assessment of the economic impact on the affected industry. In its explanation of the proposed standard, the preamble explains that surveying, leveling and alignment (SLA) laser products are "designed to transmit laser radiation through open space for measuring and positioning purposes." In recent years, the CDRH has used this phrase as its basis for regulating infrared illuminators and designators as well as visual disruptors as SLA laser products. It is here noted that this phrase was dropped in subsequent preambles and proposed and final amendments to the standard.

The second proposal, September 4, 1974, addressed the comments received to the first proposal and modified the content of the proposed standard. One significant change was in the criteria for human access to laser radiation through an opening in the protective housing; human access now included interception by a straight object of 10 cm in addition to interception by any part of the body.

- The final rule, published on July 31, 1975 to become effective August 2, 1976 included: Introduction of Class IIIa for visible wavelengths,
- Change of the unobstructed straight object criterion for human access from being a

straight object of 10 cm to a straight line of 100 cm, and

- An additional criterion of "any line" of 10 cm was added (understood to the regardless be flexible optical fibers) to be applied of level or class of the internal laser radiation.

Manufacturers were invited to individually visit the BHR to discuss problems that they might foresee in meeting the new requirements and to ask any questions they might have. Answers from BRH staff members were considered to be informal and nonbinding. Many manufacturers took advantage of this opportunity and did visit.

As the manufacturers and the BRH began to experience the new standard and its associated reporting requirements, the need for addition guidance and even adjustments to the standard were recognized. Laser Notices were issued to and mailed to all known affected manufacturers. These were intended to address immediate needs that could not wait for the process of amending the standard, or were very specific in their application. These were later assigned numbers to facilitate their referencing. The covered subjects ranging from indicators and interlocks to exemptions. More than 50 numbered notices were issued over the years; as future amendments to the standard were published, some of the notices could be dropped as no longer needed.

A notice of intent to amend the standard was published in the Federal Register on April 1, 1977. The agency again wanted to change the criteria for human access; the 10 cm straight line distance was too short, and the 10 cm line of any shape was unrealistic. This notice also recognized that the use of an 80 mm collecting aperture at no separation distance from the source was an unrealistic approach to assessing the hazard, especially to the eyes. The way the standard was written, a 1 degree rise in temperature of the housing resulting from operation of the laser meant that the emitted radiant power integrated over the infrared spectrum would exceed the allowable limit for collateral radiation.

A new set of amendments was published in the Federal Register on November 28, 1978. Because the FDA considered these amendments to be relaxations reducing the burden on industry, they became effective almost immediately. Some of the more important changes were

- Creation of Class IIa and relaxed requirements for Class II laser products with emissions not intended to be directly viewed and that did not exceed the Class I AEL for emission durations up to 1,000 seconds,
- Deletion of the curved path criterion for human access,
- Established the criterion for the use of collimating optics for the measurement of radiant energy or power effectively establishing a 20 cm measuring distance for diverging emissions.
- Permitted the use of a 7 mm measuring aperture for scanned radiation with a scan velocity of greater than 5 radians seconds^{-1},
- Authorized the agency to approve alternate means of providing or of the wording of required labels.

A new notice of proposed amendments was published in the Federal Register on November 7, 1980 and reproposed on November 30, 1983. The proposals included:

- Increased administrative control of component laser products that are not certified,
- Expansion of the spectrum in the definition of *laser*,
- Adjustment of the criteria for *human access*,
- Clarification of the applicability of the requirement for *protective housing*,
- Relaxation of interlock requirements for Class II and IIIa access,
- A manual reset for Classes IIIb and IV,
- Emission indicators on operation controls,
- Simplification of requirement for scan failure safeguard.

The amended standard was published on August 20, 1985 and has not been amended since then. The changes included:

- Increased administrative control of component laser products that are not certified,
- Expansion of the spectrum in the definition of *laser*,
- Adjustment of the criteria for *human access*,
- Clarification of the applicability of the requirement for *protective housing*,
- Relaxation of interlock requirements for Class II and IIIa access,
- A manual reset for Class IV,
- Emission indicators on operation controls,
- Simplification of requirement for scan failure safeguard,

- Allowance of the term *laser light* for laser radiation in the 400 700 nm range.

In response to suggestions from some manufacturers who were concerned about the necessity for both United States manufacturers and those in other countries to comply with two standards this author became a member of IEC TC76 in 1990, so that the members of this committee in other countries could be made aware of FDA’s positions. Then, in 1992, following an informal meeting with industry, the military and academia, the agency resolved to work toward mutual harmonization of the two standards. A project was begun to amend the FDA standard.

In 1993, a Notice of Intent to amend the standard was published in the Federal register. The intent was to achieve closer requirements to those of IEC 60825-1, Edition 1.2. Proposed amendments were published for comments on March 24, 1999. The most important changes included adoption of the IEC classes and Accessible Emission Limits (AELs). Due to the amount of time between the Notice of Intent and the proposed amendments, Edition 2 of IEC 60825-1 was well on its way to being amended with a Committee Draft for Vote (CDV) having been circulated in October 1999. That same month, the CDRH presented its proposed amendments to the Technical Electronic Product Radiation Safety Standards Committee (TEPRSSC), a legislatively established committee with which the FDA is required to consult as part of the process in promulgating standards. The CDRH requested and obtained the agreement of TEPRSSC that the agency should wait to study the IEC draft before deciding whether to repropose to harmonize with the new Edition 1.2 of the IEC standard that was likely to be approved of to go ahead with its own 1999 proposal. Edition 1.2 of IEC 60825-1 having won approval was published in August, 2001.

The New Century

Because of its commitment toward harmonization and realizing the amount of time that the last set of proposed amendments took before publication, the CDRH decided to take an interim step by issuing policy guidance. In July, 2001, Laser Notice 50 was issued saying that the agency would not object to conformance with many of the requirements of the IEC standard in lieu of conformance with its comparable requirements. Then, in 2007, with the publication of Edition 2 of IEC 60825-1, the agency updated this notice saying that IEC Editions 1.2, 2, or its own standard were all acceptable except as specifically noted in the guidance.

Then, in 2013, the CDRH again published proposed amendments in the Federal Register. Again, the timing was not good because at that time Edition 3 of IEC 60825-1 was well on its way toward publication in 2014. This led to the CDRH having to decide whether to again formally repropose, or to again update Laser Notice 50. The agency is prohibited from prematurely divulging its specific plans until they are made public to all. In the meanwhile, the agency has published additional guidance documents and in October, 2016, convened a meeting of TEPRSSC. These subjects are discussed in other papers given during the technical sessions of this conference.

THE EARLY STAGES IN THE DEVELOPMENT OF THE IEC LASER PERFORMANCE STANDARD

Paper C102

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Abstract

The International Electrotechnical Commission (IEC) held its first meeting in Baden-Baden, Germany in 1974, hosted then by the VDE, because VDE had served as secretariat of another technical committee which had issued an early electrical safety standard for laser products, but it dealt only with electrical safety issues. —The USNC-IEC informed the IEC Central Office that the American National Standards Institute (ANSI) had just issued a first edition of ANSI Z136.1-1973, Safe Use of Lasers and the US could take on the Chair and Secretariat of a new TC on "Laser Equipment." Mr. George M. Wilkening, the Chair of the ANSI Z136 Committee, agreed to chair the new IEC TC76 and the —US Bureau of Radiological Health (BRH) offered to serve as the Secretariat. In the second meeting, held in Amsterdam in 1976, Henry Rechen of the BRH, began serving as the first secretariat of TC76. A major decision of the Amsterdam meeting was to base a first draft of a new IEC standard (IEC 825) on the just-published US Federal Regulation (21CFR1040) on basic system safety requirements for manufacturers. A second major decision of the was to include a section on user guidelines, since most countries - other than the US and UK had no user safety standards, and to base them on the US ANSI Z136 guidelines for the "Safe Use of Lasers." In the third meeting, held in Washington, DC in 1977, the definitions of each class (I, II, III and IV) and the details of each manufacturing requirement were discussed in detail. Since the US Federal regulation contained very detailed legal wording, there was criticism of many of the elaborate phrases in English. These discussions and a great deal of language editing continued in minute detail during the next meetings held in Moscow, USSR in 1979 and den Haag, NL in 1980. By 1982, the meeting in Stockholm, Sweden, there was a greater sense of agreement on many points along with updated concepts based upon changes and corrections introduced by BRH and ANSI in the US standards and guidelines as greater experience was gleaned from the US experience. Some stalemates remained until the final draft for voting was issued after a 1983 meeting in Zurich, Switzerland. The torch of the TC Chair was passed to Dr. Bengt Klemen (Sweden) after the Zurich meeting and the first edition of IEC 825 was issued in 1985. Dr. Jerry Glen (US) then replaced Robert Landry of CDRH as Secretariat.

Introduction

The early stages in the development of the IEC laser product performance standard, now known as IEC 60825-1 required nearly a decade to reach an international consensus. Many of the questions, concerns and debates that have surfaced within IEC TC76 in the past decade were also the subject of considerable debate in the early decades. The strong search for international consensus began with the first meeting held in Baden-Baden, Germany (then "West Germany") in June 1974. That first meeting was quite memorable for me, since Baden-Baden was a beautiful spa town and the fantastic formal dinner hosted by the Deutsche Kommission Elektronik (DKE) in the Verband der Elektrotechnik (VDE) was extremely elaborate, with ice sculptures and a formal, simultaneous presentation of dinners at each setting. Many early international friendships were made.

Figure 1. Photograph of the participants in the first meeting of IEC TC76.

Early Meetings

Table 1 lists the early meetings. For some time the meetings of TC76 were biennial; however, the TC76 meetings later became annual and generally held in the fall of the year.

Table 1. Early Meetings of IEC TC76 (1st .

Year	Location
1974	Baden-Baden, Germany
1976	Amsterdam, the Netherlands
1977	Washington, DC USA
1979	Moscow, USSR
1980	den Haag, the Netherlands
1982	Stockholm, Sweden
1983	Zurich, Switzerland
1986*	Paris, France
1987	Prague, Czechoslovakia
1988	Berlin, Germany
1990	Boulder, Colorado, USA
1991	Kobe, Japan
1992	Rotterdam, the Netherlands
1993	Milan, Italy
1994	Stockholm, Sweden
1995	Sydney, Australia
1996	London, UK
1997	Frankfurt, Germany
1998	Houston, Texas USA
1999	Milan, Italy
2000	Mishima, Japan
2001	Kista, Sweden
2002	Didcot, UK

*Annual meetings held thereafter.

Initial Establishment of IEC TC76

In the early 1970s, an IEC technical committee on electrical safety of products such as lasers had prepared an electrical safety standard for laser products [which for a short time became IEC 825-2, but later abandoned], but it dealt only with electrical safety issues. Germany and some other IEC members suggested that an IEC laser safety standard be established, although there was some concern that a standard limited to optical safety was really the purview of the International Standards Organization (ISO) and not the IEC. Nevertheless an organizational meeting was held in Baden-Baden, Germany, hosted by DKE/VDE in June 1974. The US National Committee (USNC) for the IEC informed the IEC Central Office that the US had just issued a first edition of its national standard, ANSI Z136.1-1973, *Safe Use of Lasers*, and the US could take on the Chair and Secretariat of a new TC on “Laser Equipment.” Mr. George M. Wilkening, the Chair of the ANSI Z136 Committee, agreed to chair the new IEC TC76 and the US Bureau of Radiological Health (BRH, later to become the Center for Devices and Radiological Health of the US Food and Drug Administration) offered to serve as the Secretariat.

Biological Effects and Setting MPEs

Since one of the most important issues related to maximum permissible exposure limits (MPEs) [1-5], several of the early delegates had been involved in early vision and biological research on laser effects on the eye – to include Dr. John Marshall (UK), Frank Borland (UK) Prof. Franz Hillenkamp (Germany), Dr. Bengt Kleman (Sweden), Dr. JJ Vos (the Netherlands), David Sliney with ML Wolbarsht (US) and Dr. Wanda Czerska (Poland) to name a few.

The first occupational laser safety guidelines, limits and safety guides, such as an Army-Navy medical technical bulletin, were issued in 1968 and an Air Force publication issued around that time. The Threshold Limit Values Committee on Physical Agents of the American Conference of Governmental Industrial Hygienists (ACGIH) prepared the first national recommendations for exposure limits in the United States. These were issued in 1968 [6]. I was quite involved in all of these early efforts. During the 1960's, there were also efforts to derive exposure limits and occupational safety guides in the United Kingdom. A. Mendoza of the Ministry of Aviation in London drafted, to my knowledge, the first British recommendations for safe exposure of the eye (British Ministry of Aviation, 1965). There were international exchanges of information, and I have fond recollections of providing a great deal of consultation to Mr. Bernard Weston of the Safety Services Organization, Ministry of Technology, Orpington, Kent, in the late 1960's. His work formed the basis of the Ministry of Technology Code of Practice and the first edition of BS4803 (Ministry of Technology, 1968; later BSI, 1974). We also met with and corresponded with research scientists in Germany (e.g., the GSF research team of F. Hillenkamp et al. in Neuherberg), in the Netherlands (Vos et al.), in Sweden (Tengroth, Kleman, et al.) and in Britain John Marshall and John Mellerio at the Institute of Ophthalmology and Richard Borland at the RAF Institute of Aviation Medicine, who all were investigating retinal injury thresholds for the derivation of exposure limits.

Thus, during the meetings of TC76 between 1976 and 1982 (Amsterdam to Stockholm) the biophysicists and ophthalmic and vision scientists had already been in wide correspondence with one another, and they reviewed and deliberated the exposure limits in the ANSI Z136 standard [2], which was updated in 1980. These limits obviously influence the derived AELs – the accessible emission limits – in the US Federal Performance standard [3]. Eventually there was a general acceptance of most of those AEL values in IEC TC76.

Extended Sources

During the earliest period of meetings (1976 –1986) one of the major points of debate related to the potential hazards of reviewing diffuse reflections and extended source laser radiation. The ACGIH/ANSI exposure limits as well as those in the US federal laser performance standard were divided into small sources and extended sources by a dividing line known then as “alpha-min” that varied with pulse duration and could have values up to 22 mrad [2-8]. In those days “min” referred to the minimum value to apply the extended-source limits – then expressed in terms of radiance and radiance dose. Since the dividing line for Class 3 and Class 4 lasers was defined as a diffuse reflection hazard there was concern by Dr. Sutter of the Physikalisch Technische Bundesanstalt in Germany that Class 3 lasers could theoretically pose a hazardous diffuse reflection within a viewing distance of 13 cm from a white diffuse reflector. Although this was not considered a realistic concern by some delegates, there was a note added in the early editions of the IEC standards to caution against viewing Class 3 diffuse reflections at a distance less than 13 cm from the reflecting surface. Setting emission limits for extended sources – such as diffuse reflections – was to occupy the concerns of TC76, WG-1 for decades. The reason was that the retinal spot-size dependence of laser-induced retinal injury was controversial. Theoretical mathematical models of thermally induced retinal injury predicted a spot-size dependence for milliseconds-to-seconds of exposure, but not for q-switched or sub-microsecond exposures. US and French biological studies showed an apparent spot-size dependence of retinal injury from short-pulse exposures, which later led to a correction factor C_6 for extended-source AELs. As it turned out, this dependence was much later shown to be an experimental error [9], and further revisions in the extended-source limits were made [10]. It is interesting to note that the intrabeam viewing, “point”-source MPEs for exposure durations between 1 ns and 0.25 s remained unchanged from 1973 [1, 11] to 2014! Only in 2014 were MPEs (and corresponding Class 1 AELs) revised, but only for exposure durations less than 18 μs.

Measurement Apertures

In the very beginning, both the ANSI Z136 and BRH standards specified an 80-mm measurement aperture for laser classification without mentioning a measurement distance, but was presumably at the aperture (zero)! The rationale for this large Aperture what’s related to the largest reasonably foreseeable telescope or military optical site that might be use for intra-beam viewing at a distance. However this large diameter aperture was reduced to 50 mm – first by IEC and later by ANSI and BRH after it was recognized that a reasonable measurement distance for a laboratory simulation was limited to only 2 m (based upon the shortest laboratory bench used by any of the delegates – i.e., from Australia). Certainly any laser beam would sufficiently diverge at a distance where a 7 x 50 binocular might be used and certainly more to more than 80 mm at a viewing distance of several hundred meters where an 80-mm aperture would be used. There was also the consideration that any optical system had transmission loss and that further added to the level of safety. BRH also recognized during this period that IR-C background thermal radiation would exceed the limit for collateral radiation if captured by an 80-mm aperture at the aperture. WG-1, convened by David Sliney (US) agreed on 50-mm aperture at 2 m from the aperture to simulate use by telescopic optical aids.

The next big debate centered on measurement conditions to simulate proximal viewing and the geometrical capture of highly diverging beams viewed by eye loupes, etc. For simplicity, it was finally agreed at the Moscow meeting that positioning the 50-mm aperture at 10 cm covered the worst-Case viewing condition near the aperture. This decision was to haunt WG-1 for decades. After publication of the 1st Edition of IEC 825 in 1984 [12], BRH, then having become the Center for Devices and Radiological Health of the US Food and Drug Administration (CDRH/FDA), had already changed the measurement aperture to 50 mm at a distance of 20 cm and defined a measurement geometry that was not accepted by several delegates in WG-1. Some German delegates insisted that the scientific literature showed historically that there was an individual who was so myopic that his near point was only 70 mm, and they argued for a 70-mm measurement distance. Fortunately, Prof. Franz Hillenkamp, a renowned biophysicist and the then leader of the German delegation, successfully convinced his delegation to compromise at 100 mm (as it has remained until today), since any individual with such extreme myopia would have very poor retinal images of a laser "point" source. The vision scientists all agreed that 20 cm was sufficiently short, but these were out-voted by other delegates who wished to remain on the very conservative side of the question.

A 7-mm aperture was used for MPEs to protect against hazardous retinal exposures, and after some questioning on why this was used for all scanning beams in the US standards, the delegates to TC76 agreed to that rationale.

Classification Time Base

Another contentious issue related to setting a worst-case viewing/exposure duration for continuous-wave (CW) laser products. This was termed the "time base" for classification. Although 0.25 s was widely agreed as acceptable for the "aversion response" applicable to the AEL for Class 2 laser products, there were very spirited debates during the Moscow and den Haag meetings on a maximum state time. Some were suggesting that 10 s was a very lengthy duration for intra-beam viewing, with others favoring values of 100 s because of the difficulty of remaining in the beam (along with discomfort glare). There were some who argued for at least 1,000 s and even 30,000 s (~8 h). Many participants were particularly concerned about a child not knowing better, staring into the beam for 8 h. The lone woman participating in the meeting, Dr. Wanda Czerska from Poland, then stood up and stated: "You men are clearly totally ignorant about children! No child would have the attention span for such lengthy durations!" This led to a 100-s time base for normal, unintentional viewing, except "…where intentional long-term viewing is inherent in the design or function of the laser product for intentional viewing." There were similar criticisms of the UV time base that never was reduced below 30,000 s, which remains a problem!

Derivation of MPEs and AELs

The subject of MPEs and the derivation of AELs based upon worst-case exposure conditions was a major topic of discussion leading up to the first edition of IEC 825-1 in 1984. At that time there were several biophysicists and vision scientists involved, but they argued against a technical committee like IEC trying to set MPEs, since that was the purview of health and medical expert committees. Clearly, it was IEC's task to set product emission limits based upon the MPEs. At the meeting in den Haag in 1980, Prof. Franz Hillenkamp (Germany) and Prof. John Marshall (UK) pushed for a TC76 resolution to state that it was not responsible for deriving MPEs, but this was the realm of expert committees of the World Health Organization and similar international health-based committees; this resolution passed with unanimous support. This was later interpreted to mean the International Non-Ionizing Radiation Committee (INIRC) of the International Radiation Protection Association (IRPA) and then the successor, the International Commission on Non-Ionizing Radiation Protection (ICNIRP).

LEDs Introduced in Kobe

During the 1991 meeting held in Kobe, Japan (before its serious earthquake in January 1995), the US proposed that LEDs be included in the scope of IEC 60825-2 for optical fiber communication systems (OFCS). The US ANSI Z136.2 standard for OFCS had included LEDs in that standard because laser manufacturers had complained that LED suppliers had unfairly argued to users that LED OFCS systems were safer and did not have to comply with all the rules surrounding laser sales and use. There was general agreement, but at the closing plenary session, the German Delegation proposed expanding the proposed addition to all of the laser standards and all possible applications. They argued that if LEDs could ever be hazardous, then the requirement to assess LEDs should be universal! Despite warnings from Jerry Dennis that this move would "…require assessing even LEDs in Grandma's alarm clock," the motion passed as the last action item before adjournment. Few could anticipate all the problems that ensued from this last-minute action, and Edition 2 was published in 1992, which included LEDs in its scope. It would take more than a decade to remove this needless requirement and endless discussions attempting to determine how to evaluate complex chip emitters as a laser [14-17]! Common sense finally prevailed with the acceptance of the fact that LED surface emitters were limited in radiance (as argued by Dr. Joseph Tajnai from the US in the 1994 meeting in Stockholm, after the LED industry finally had felt the impact of new tests and certifications).

Viewing Diverging Beams – "Condition 2"

After the publication of the 2nd Edition of IEC 825-1: 1993 (subsequently renumbered as Edition 1 of IEC 60825-1 after the addition of amendments), the major WG-1 debate related to what was to be referred to later as measurement condition 2 and several approaches were aired during the meetings in Rotterdam, Milan and Stockholm. The earlier measure of energy captured by a 50-mm aperture at 100 mm was considered inappropriate for many fiber optic emissions. To resolve the problem for the next amendment, WG-1 held a special interim meeting of measurement experts in Washington, DC in 1995. Dr. Sutter (Germany) argued for retaining the same collection angle (50/100) of the earlier measurement condition. After much discussion, all finally agreed to a compromise position of a 7-mm aperture at shorter distance than 100 mm to simulate eye loupes but not so short as 14 mm. The following draft amendment, however, unexpectedly failed from NO votes sent in by Austria, German and Switzerland. The next amendment was delayed for several years before another Condition 2 formulation could be completed that was more in tune to Dr. Sutter's position, and this resulted in Edition 1.2 in 2001.

It was to take a decade before sufficient experimental and theoretical evidence was presented on the lack of optical collection by high-power eye loupes to arrive back to the 1995 Washington proposal.

IEC Chairmanship

The IEC TC76 has been very fortunate to have excellent chairs. As noted earlier, George Wilkening (US) served as Chair, TC76 from 1974-1983, followed by Bengt Klemen (Sweden), 1984-1996. H. David Edmunds (US) then served as Chair in 1997 and 1998, followed by Jerome Dennis 1999 (Milan) to 2014.

Conclusion

In its 44 years of existence, IEC TC76 has been highly productive in preparing a range of standards for laser products and is now pursuing sound standards for the photobiological safety of lamp products as well.

The make-up of the TC 76 committee varied during its history. During the first 6-7 years of its existence, there was a large percentage of research scientists – particularly those who were working in the vision sciences and in laser biophysics. After the publication of the first edition in 1984 the delegates most often were industrial hygienists, safety engineers or health physicists, with an ever-increasing contingent of laser safety specialists. Over the last decade there has been a growing contingent of representatives from test houses. Needless to say the emphasis for needed amendments has evolved along the lines of the participants. Even the more recent discussions in TC76 relating to consumer-use lasers and laser pointers are echoes of long past debates [14-18].

Acknowledgements

I greatly acknowledge thee assistance in historical recall provided by Robert Landry and Jerome Dennis, both retirees of the US FDA, Center for Radiological Health.

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Meet the Author

Dr. David Sliney is a medical physicist/biophysicist who worked for 42 years for the US Army Medical Department, Aberdeen Proving Ground, MD, where he led the Laser/Optical Radiation Program. He received his Ph.D. from the University of London, Institute of Ophthalmology. He has been actively involved in setting MPEs and AELs for lasers since 1965. He is most recognized as the co-author of two books, *Safety with Lasers and Other Optical Sources – A Comprehensive Handbook* (1980) and Medical Lasers and their Safe Use (1993). He is convener of IEC Technical Committee TC76, Working Group WG-1, which develops AELs for laser products and has been a US delegate to IEC TC76 since its formation in 1974.

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Speaker Biographies

Abramowicz, Jacques

Jacques Abramowicz, MD, is an expert in the use of ultrasound for prenatal diagnosis of fetal anomalies and screening for early detection of ovarian cancer.

Dr. Abramowicz's research focuses on the prenatal diagnosis of fetal anomalies, screening and early diagnosis of ovarian cancer, and the bioeffects and safety of ultrasound. He is on the Executive Bureau of the World Federation of Ultrasound in Medicine and Biology, is a member of the WHO Guidelines Task Force on Non-Ionizing Radiation and was elected a member of the Scientific Expert Group of the International Commission on Non-Ionizing Radiation Protection in May 2016.

Dr. Abramowicz received the William J. Fry Memorial Lecture Award from the American Institute of Ultrasound Medicine for his significant contributions to the scientific progress of medical diagnostic ultrasound. He also was the recipient of the 2011 March of Dimes Jonas Salk Leadership award.

He has published 175 scientific articles in international peer-reviewed journals, as well as more than 20 book chapters. He is co-editor of several books and the editor of "First Trimester Ultrasound: A Comprehensive Guide," published in 2015. In addition, he has delivered 220 lectures to national and international audiences

Ball, Kay

Dr. Kay Ball is an Associate Professor of Nursing at Otterbein University in Westerville, Ohio, where she teaches Bachelors, Masters, and Doctoral nursing students. She also is a perioperative nurse educator and consultant. Kay has served as the Laser Program Director for two different healthcare systems and has many years of experience in managing an operating room suite and a PACU.

Kay received a PhD in Health Related Services from Virginia Commonwealth University (2009) where she researched the key indicators of compliance with surgical smoke evacuation recommendations as her doctoral thesis. Professional organizations include FAAN, AORN, and ANA's NOLF. She has authored 3 editions of Lasers: The Perioperative Challenge (1st, 2nd, and 3rd editions), Endoscopic Surgery, and many chapters and articles on healthcare topics. Kay lectures globally on surgical smoke hazards, lasers, and nursing issues.

Barat, Ken

Ken is the former Laser Safety Officer at Lawrence Berkeley National Laboratory and the National Ignition Facility. He is presently working as a laser safety consultant. He is a LIA Fellow and winner of the Rockwell Award. He has authored 5 text books on laser safety and related topics. Authored numerous laser safety articles. Was the chair of the first 7 LSO Workshops and chair of the DOE LSO Working Group. He is presently chair of the ANSI Z136.8 Committee.

Bartges, Joseph

Dr. Joe Bartges received his bachelor's degree from Marshall University and DVM from the University of Georgia. After completing a one year internship at the University of Minnesota, he completed a dual residency in small animal internal medicine and nutrition, a Ph.D., and a post-doctoral position at Minnesota. He was Professor of Medicine and Nutrition, held the Maurice Acree Endowed Chair of Small Animal Research, and was head of the department of Small Animal Clinical Sciences at The University of Tennessee before joining the Cornell University Veterinary Specialists and Cornell University in February 2015. Currently, he is past President of the American Society of Veterinary Nephrology and Urology and serves on the editorial board of 5 journals including serving as an Associate Editor for the Journal of Veterinary Internal Medicine.

Ciprazo, Eddie

Mr. Eddie Ciprazo is the LSO at the University of California at Berkeley and a Certified Laser Safety Officer (CLSO). Prior to moving into the laser safety field, he spent 10 years as an EH&S Radiation Specialist. Eddie has provided laser safety training for LIA and Kentek and has been the laser safety consultant for the SPIE Photonics West Exhibition for over 10 years. He is also member of SSC-10 (Safe Use of Lasers in Entertainment, Displays and Exhibitions) and was the Co-Chair of the 2007 Practical Application Seminar and a past member of the Board of Laser Safety.

Curley, June

June Curley RN, BSN, CNOR, CMLSO was first exposed to lasers in1983 while working in Saudi Arabia. In 1987, she gained expertise as Chair of the Laser Safety Committee in the Operating Room at Hershey Medical Center in Hershey, PA. From 2005 to present, she has been on staff at Tampa General Hospital in Tampa, FL which is a Level I Trauma Center as well as a Regional Burn Center. She earned her CMLSO in 2007 and as Clinician of Laser Safety she enjoys teaching and supporting laser safety.

Daem, Jan

Jan Daem is an Optical radiation safety expert and product safety engineer at BARCO and Chairman of the European Regulatory Sub-Committee & Finance Committee, Laser Illuminated Projector Association (LIPA). Jan Daem is currently focused solely on the worldwide introduction of laser illuminated projector systems. In this position as well as Chairman of the European Regulatory Sub-Committee, he is ensuring safety standards and regulations are created without unnecessarily-strict restrictions upon manufacturers and without undue safety hazards for consumers and AV professionals. The activities include managing a worldwide team of professionals evaluating the light emitted from projectors, as well as interacting with regulatory officials at region, state and EU Commission levels. Jan is also very active on the IEC TC-76 Committees.

Dennis, Jerome E.

Jerome E. (Jerry) Dennis is vice chairman of IEC TC 76 having completed 15 years as chairman of that committee. He retired in 2008 after 32 years with the CDRH as the agency's international expert in laser product safety standards. Since his retirement he has been consulting to manufacturers and government. Prior to joining the FDA in 1975, he spent 15 years in industry involved in laser research and product development and applications.

Dennis, Vangie

Vangie Dennis is the Director of Patient Care Practice: Ambulatory Surgery Emory Healthcare located in the metropolitan area of Atlanta. Vangie has been a nurse for thirty-eight years. Professional organizations include the Association of Operating Room Nurses (AORN), Laser Institute of America, AORN Advanced Technology Specialty Assembly, American Association of Gynecological Laparoscopist, and the American Society for Lasers in Medicine and Surgery.

Early, Edward

Dr. Edward Early received his B.S. from Texas A&M University and a M.S. and Ph.D. from the University of California San Diego, all in physics. Following a post-doctoral position, he joined the staff at the National Institute of Standards and Technology, where he worked on optical radiation standards. He joined TASC in 2004 and currently supports the Air Force Research Laboratory in the area of high-energy laser safety analyses. He is a member of DEPS and LIA.

Ertle, William

Bill has been associated with Rockwell Laser Industries (RLI) since 1989 and has served as President since 2003. He has provided in-depth lectures and training presentations for numerous RLI Training Institute courses, industry conferences, as well as presentations for events at Sandia National Laboratories, Los Alamos National Laboratories, The Fabricators and Manufacturers Association, IEEE/LEOS, OPTCON, ALAC, Bay Area Laser Safety Officers (BALSO) and the International Laser Safety Conference (ILSC). Bill has also authored and co-authored several laser safety articles. Bill has served as the Chairman of the ANSI Z136 Technical Subcommittee on Control Measures and Training (TSC-4) since 2003 and is a voting member of the Accredited Standards Committee, the main Z136 committee. In 2008, Bill was appointed Secretary of the IEC TC 76 Committee - Optical radiation safety and laser equipment, that prepares international standards for equipment (including systems) incorporating lasers. He is an active member of the Laser Institute of America (LIA) and a former member of their Board of Directors as well as a member and fellow of the American Society for Lasers in Medicine and Surgery (ASLMS). He is a member of the Canadian Standards Association (CSA) Technical Committee on Laser Safety and is a Certified Laser Safety Officer and Medical Laser Safety Officer by the Board of Laser Safety. Bill is a graduate of Xavier University, Cincinnati, OH.

Flemming, Brian K

Brian K. Flemming, MA, BA(Hons), MSc, EngD, C.Eng MIET, C.Math FIMA, MBPsS, is a Principal Systems Engineer at Leonardo MW Ltd., based in Edinburgh, UK, and is an industry member of the Military Laser Safety Review Panel within the UK Ministry of Defence. He is the UK technical lead in the development of the joint US-UK Military Advanced Technology Integrated Laser hazarD Assessment (MATILDA) Range safety tool, based on Probabilistic Risk Assessment (PRA) methods.

Grimblatov, Valentin

Valentin Grimblatov is a specialist in medical lasers, laser-tissue interaction and light dosimetry. His research interests include dosimetry of medical laser diagnostics and therapy. He was a Director of Laboratory of Quantum Electronics at I.I. Mechnikov University (USSR), and invited professor-consultant at Electromedicale Inc, (Italy). He holds 25 patents issued in USA, Europe, Russia and author (co-author) of more than 100 papers in pier reviewed journals and a book " Medical Applications of Low Level Laser Therapy" (USSR, High Education (in Russian). He has been on review board of International conference "Bios2007-2008".

Hadler, Joshua

Joshua Hadler is the NIST Chief Laser Safety Officer, and has been with NIST since July 2002. Mr. Hadler is a Physicist and Calibration Leader in the Laser Radiometry project of the Quantum Electronics and Photonics division in Boulder, CO. Prior to joining NIST, he was an Engineering Physicist at the Stanford Linear Accelerator Center, in Menlo Park, CA. Following his work at SLAC, Mr. Hadler worked at the University of Colorado at the Laboratory for Atmospheric and Space Physics, and ILX Lightwave inc. in Boulder.

Haigh, Neil

Dr. Neil Haigh, Technical Director, LUX-TSI, Pencoed, Wales, UK. Neil has a 1st Class Academic background with a Ph.D. in Applied Optics (Imperial College, London), and a 1st Class Honours in Physics (Bedford College, London) allied with a strong technical background in optical fibers communications and optical radiation safety, including the safety assessment of laser and LED device technology. He has over 25 years industrial experience in science-based manufacturing disciplines, particularly in research, development, as well as the development and delivery of specialist photonics related technical training courses, including advanced courses in laser, lamp and LED safety.

Hall, Simon
Professor Simon Hall CPhys, has 32 years of experience in optics and metrology. He was the chief Laser safety advisor at the National Physical Laboratory in the UK while also leading the Adaptive Optics research group. He now works as an independent consultant in optical metrology and to develop Augmented Reality optical elements using holography. He is the Chairman of the British Standards "Optics and Photonics" Committee, member and the national expert for CIE, IEC and ISO committees. He is currently visiting Professor in the School of Computing and Engineering at the University of Huddersfield.

Hewett, Daniel
CAPT Dan Hewett is a laser product specialist in the MR and Electronic Products Branch, Center for Devices and Radiological Health, Office of In Vitro Diagnostic Devices and Radiological Health, Division of Radiological Health, U.S. Food and Drug Administration.

Higlett, Michael
Michael Higlett completed Mphys in Physics with Lasers and Photonics from the University of Hull in 2004 and Ph.D. at the University of East Anglia in 2009. His research involved ultrafast spectroscopy investigating the optical properties of ultrathin gold films, with part of the project at the RIKEN institute in Japan. Michael joined the HPA (now Public Health England on 1 April 2013) in December, 2008, where he is a member of the Laser and Optical Radiation Dosimetry Group working for Dr John O'Hagan as Senior Radiation Protection Scientist. Current research includes optical radiation safety of laser displays and LEDs, together with the development of assessment protocols and instrumentation methods.

Hoang, Anh
Anh Hoang BS MS MBA Anh Hoang has 30 years of experience as executive management position in product development of medical laser, medical devices, and scientific instrumentation. 1980s, Anh managed surgical laser research at LaserSonic, designed Solid State and Gas laser. Designed first compact high power Nd:Yag laser for Laparoscopic surgery and Superpulse CO2 laser for GYN, ENT, and general surgery. Early 1990s, Anh served as Vice President of R&D at Xintec, now Convergent Laser Technologies, developed Nd:YAG and Holmium Laser. Currently serves as CEO and CTO, Convergent Laser Technologies Designed a new high peak pulse Holmium laser.

Holcomb, R. Dewayne
R. DeWayne Holcomb started his career in the US Navy Nuclear Program, and has been working in the field of Health Physics since his discharge in 1987. He has worked in radiation and laser programs across the country, including three major research Universities, NASA and DOE facilities, and commercial industry. He maintains his CLSO, CHP, and NRRPT certifications.

Holmér, Anna-Karin
Anna-Karin Holmér is a consultant in optical design and laser safety at Combitech AB, which is a Saab group company. She did her PhD at Chalmers University of Technology in Sweden at Applied Physics and has since been working with optical design in diverse optical fields eg light scattering measurement systems for the eye, diffractive optical elements, ferro electric liquid crystal components, micro lithographic systems, military training systems and head up displays for avionics. Anna-Karin has been a member of the laser safety standardisation committee TC76 since 2003.

King, Jamie
Jamie King is a Certified Laser Safety Officer with over 25 years of experience in laser safety. He has served as the LSO for NASA-Ames Research Center, Sandia National Labs (California), and is currently the laser safety subject matter expert for Lawrence Livermore National Laboratory. Jamie serves on the ASC Z136, SSC-1 and SSC-8 subcommittees and is chair of DOE's EFCOG Laser Safety Task Group. He authors, publishes, and distributes the LLNL Laser Lessons Newsletter for which he received an EFCOG Appreciation Award in 2014. This newsletter has a readership of over two thousand individuals worldwide.

Krivonosov, Liz
Liz Krivonosov, BASc (Chem Eng), DIH, PEng, CIH, ROH Liz is a licensed Professional Engineer, Certified Industrial Hygienist and Registered Occupational Hygienist. Liz is President of KRMC Inc, a hazardous materials consulting company offering consulting services to academic, health care institutions, government and industry. She is a frequent laser safety trainer and lectures on laser safety at the Graduate school for Occupational Hygiene at the University of Toronto. Liz also worked at Ryerson University where she developed programs including laser safety. Liz also worked at the University of Toronto for 20 years as the Manager for Environmental Protection.

Kumru, Semih
Semih Kumru is presently laser bioeffects research physicist with Optical Radiation Branch, Air Force Research Lab, (711 HPW/RHDO). He studies optically-directed-energy human effects including non-lethal technologies and safety standards and is the lead for High Energy Laser Applied Bioeffects research team. After receiving his Ph.D. in physics, Semih joined US Air Force in 1996. He worked as a staff health physicists and as an assistant professor of physics at US Air Force Academy before joining AFRL in 2002.

Lau, Erwin

Dr. Lau's experience covers a wide range of areas, including optics, optical devices, semiconductor devices, analog communications, micro- and nano-fabrication. He has over 10 years of experience in the design, characterization, modeling and simulation of high-speed electronic, optoelectronic devices, and optical systems. Dr. Lau has performed design, risk analysis, and failure analysis of solid-state lighting, liquid-crystal displays (LCDs), light-emitting diodes (LEDs), and lasers. He has extensive experience in optical metrology, colorimetry, luminance, reflectance, and cosmetic appearance of surfaces of all types. Dr. Lau has performed laser and LED radiation safety analysis for numerous consumer electronics and medical products.

Leon, Nathaniel

Niel Leon is currently the Laser Safety Advocate for the Johns Hopkins University, Homewood Campus. He has been instrumental in upgrading the laser safety program to facilitates the research objectives of JHU principal investigators by maximizing experimental controls and understanding while implement a culture of safety within the university's education pedagogy. He has 38 years of experience in mechanical systems design includes product development, commercialization and field support in both commercial and governmental sectors. Niel Leon's teaching experience ranges from development of corporate training programs to lecturing on Small Business Innovation and Research Grant applications to developing needle-free injections systems.

Lieb, Thomas

Thomas J. Lieb has more than 25 years' experience in laser safety and laser safety training, and is President of L*A*I International, an independent company providing consulting, and safety containment systems for material processing lasers. Tom is also a member of ASC Z136 Safe Use of Lasers, Chairman of the subcommittee for ANSI Z136.9 Safe Use of Lasers in a Manufacturing Environment. He is a past (2010-2012) member of the Board of Directors of the Laser Institute of America (LIA); and involved in the past and current offering of the PAS (Practical Application Seminars), concurrent to the International Laser Safety Conference. He is Chair of IEC/TC 76 on the Laser Safety Standard IEC [EN] 60825 and Convener of the subcommittee for ISO/IEC [EN] 11553 Safety of Machines, Laser Processing Machines (General and Hand-held). Tom has authored a number of technical papers and articles for publication, and contributed to the CLSO's Best Practices in Laser Safety manual, and the text book Laser Materials Processing, Migliore, et al, Marcel Dekker, NY.

Lindgren, Martin

Martin has been working at the Swedish Radiation Safety Authority since 2006. His current work includes developing laser safety regulations, processing laser license registrations, supervision of laser applications for art and Entertainment, and market surveillance of consumer laser products. He is a member of the TC76 committee.

Lund, David

David Lund has 50 years of experience in laser bioeffects research and laser safety while working for the US Army Medical Research and Development Command. He is an active member of the ANSI main committee and subcommittees.

Luttrull, Jeffrey

Dr. Luttrull strives to provide the most technologically most up-to-date, safest and most effective treatments available for patients with retinal and macular disorders. Dr. Luttrull is internationally recognized as an innovator in the treatment of retinal diseases. His contributions, including "high-density / low-intensity subthreshold diode micropulse laser" (SDM) and Retinal Protective Therapy™, are advancing the treatment and understanding of retinal disease. Through his research, Dr. Luttrull has been a pioneer in advocating early and preventive treatment of diabetic retinopathy and age-related macular degeneration to reduce the risks of visual loss.

Dr. Luttrull is an "Honor Award" recipient of the American Society of Retinal Specialists and founder and Executive Director of LIGHT: The International Retinal Laser Society.

Mallant, Ronald

Education: Utrecht University, Geophysics, 1972-1977 University of Amsterdam: 2013-2014, Physics Teacher Education Professional activities before 2012: R&D manager at Renewable Energy Research lab. Since 2014: Laser safety expert active for the Dutch Defence organisation as well as external parties. Verification of laser parameters and laser classification. Education of Laser Safety Officers. Consultant on laser safety issues. Active in NATO and IEC expert panels.

Marshall, Wesley

Marshall has consulted on numerous projects involving laser equipment and systems. He has developed laser hazard analysis software, as well as educational courses involving laser safety and hazard awareness. Marshall serves on the Accredited Standards Committee for Safe Use of Lasers Z136, as a chair for Technical Subcommittee 7, which provides example calculations for the Z136 standards. He also serves as the chair for the SAE G10T Laser Safety Hazards Committee, providing guidance on outdoor laser operations.

Previously, Marshall served as the chair of Standard Subcommittee 6, which is responsible for the ANSI Z136.6 Safe Use of Lasers Outdoors. He has numerous publications in laser applications credited to his name. Marshall also served as a Manager of the Laser/Optical Radiation Program in the US Army.

McLin, Leon
Dr. McLin is employed by the Air Force Research Laboratory, 711 Human Performance Wing, Optical Radiation Branch, Fort Sam Houston, TX. He has worked for the Air Force as a researcher on laser visual and laser bioeffects since 1987. He has served as a member of the committee for the American National Standards Z136.1, the Safe use of Lasers and Z136.6, Safe Use of Lasers Outdoors. Dr. McLin has a B.A. in biology, (Temple University), an O.D. (Doctor of Optometry, Pennsylvania College of Optometry, and an M.S. in physiological optics, (University of California, Berkeley).

Mitsuhashi, Shoji
Shoji Mitsuhashi was born in Kanagawa Prefecture, Japan in 1958. He received the B.D. from Tokyo University, Japan in 1981. After the graduation, Shoji Mitsuhashi started working for Sony corporation for consumer video recorder, R&D strategy, and from 2010 as the chief safety product assurance, mainly for laser equipment. Additionally, he is working for IEC TC76 laser safety committee as the expert and had driven the publication of the new safety standard for image projectors as the project leader. He has been given The IEC 1906 Award in 2016 from IEC international.

Murphy, Patrick
Patrick Murphy is executive director of the International Laser Display Association, and author of the websites LaserPointerSafety.com and LaserSafetyFacts.com. Since the early 1990s, he has worked on laser/aviation safety issues through the SAE G10T Laser Safety Hazards and G10OL Operational Laser committees. Murphy is a member of ANSI Z136.1, Z136.6 and Z136.10. He is a member of FDA's Technical Electronic Product Radiation Safety Standards Committee (TEPRSSC), which advises FDA on changes in laser and other radiation safety proposals. He presented papers at ILSC in 1997, 2009, 2011 and 2015.

O'Hagan, John
Dr. John O'Hagan heads the Laser and Optical Radiaton Dosimetry Group at the UK Health Protection Agency. He is Director of Division 6 "Photobiology and Photochemistry" of the CIE (International Commission on Illumination) and Convenor of Working Group 8 "Basic Safety Standard" of the International Electrotechnical Commission TC76 "Optical Radiation Safety and Laser Equipment". He Chairs the British Standards shadow EPL/76 Committee and is a Visiting Fellow at Loughborough University.

Oian, Chad
Chad A. Oian received a B. S. degree in Engineering Science from Trinity University in San Antonio, Texas in 2010. He is a computational analyst focused in modeling laser-tissue interactions at the Tri-Service Research Laboratory in San Antonio, Texas. He is an employee of Engility working with The Air Force Research Laboratory (711 HPW/RHDO). His research has included modeling the thermal response in skin, cornea, and retina to laser exposures in the visible and IR bands.

Owens, Patricia
Patti Owens, business owner of AsetheticMed Consulting International, provides consultation services in the areas of aesthetic and medical safety compliance. Patti is the active secretary on the ANSI Z136.3 committee along with serving on the International Electrotechnical Commission (IEC) TC 76 WG4 and WG12. Patti Owens is also presently working part time with Dr. Mark Sofonio, Board Certified Plastic Surgeon, in Rancho Mirage, CA. Patti's past employment includes 2 years as OR educator and 13 years as the Laser Manager and LSO at Providence St. Peter Hospital in Olympia, WA. She has practiced over 15 years in the aesthetic field.

Parkinson, Jay
Jay Parkinson is a laser safety specialist with over 23 years of practical experience working in laser safety. Jay has served as VP of Operations and Laser Safety Officer for a laser display and special effects company that was considered the world leader in their field. After leaving the special effects and display industry he has worked for Rockwell Laser Industries (RLI) as their primary standards consultant and now also works independently through Phoenix Laser Safety, LLC. Jay has a wealth of practical knowledge concerning the application of laser safety to manufacturers and users in the areas of entertainment, consumer and commercial goods, industry, medicine, instrumentation, education, and telecommunications. He has extensive experience performing facility audits in industrial and research settings, designing custom laser safety programs, and teaching in laser safety training courses. His specialty is assisting manufacturers comply with FDA/CDRH, IEC, and other national and international laser product safety performance requirements by performing classification analyses and preparing: Laser product reports, Importation documentation, OEM registrations, Corrective action plans, Technical information to document support European declarations of conformity. Jay is a Certified Laser Safety Officer (CLSO) with a B.S. in Physics from the University of Washington. He serves as an expert on the IEC technical committee (TC 76) that is responsible for the international IEC 60825 series of standards, and is the secretary of a working group within that committee. Jay also actively participates on a variety of ANSI Z136 committees and has been a member of the Laser Safety Hazards subcommittee of the G-10 Aerospace Behavioral Engineering Technology Committee.

Paura, Randolph
Randy Paura is a Professional Engineer with his own consulting business for laser materials processing and safety. A lifelong career with special purpose machine design and build for industrial manufacturing has provided Randy with experience in serving automotive, aerospace and heavy equipment production facilities. Recent publications include the section titles "Laser Weld Quality Monitoring" and "Laser Beam Weld Design, Codes and Quality Assessment" of the ASM Volume 6A "Welding Fundamentals and Processes", 2011. He is active with ANSI Z136 ASC and as Vice-Chair for ANSI Z136.9 "Safe Use of Lasers in Manufacturing Environments".

Piper, Jessica

Dr. Piper is an electrical engineer with expertise in optics and electronics. In the realm of optics, her focus areas include nanophotonic design, simulation, and analysis, including the design of gratings, optical coatings, and metasurfaces; consumer product laser eye safety compliance; and metal optics and plasmonics. In the realm of circuits, Dr. Piper has particular expertise in analog circuit design and troubleshooting, including precision circuits, audio generating and processing circuits, high voltage/high power circuits, and vacuum devices.

Pollard, Leslie

Leslie Pollard is a professional medical / surgical laser education specialist. A BLS Certified Medical Laser Safety Officer (CMLSO), Leslie holds a B.S in Medical Technology and Associates, and Associates in Laser Electro Optics Technology. She has over 18 year experience in the surgical operating room, over 20 years in medical/surgical laser education, with concentrations in minimally invasive surgical technologies and surgical approaches. She currently owns and operates Southwest Innovative Solutions, Inc. a successful private consulting group dedicated to providing on line and on site educational programs to perioperative staff and physicians in surgical facilities, physician offices, and professionally owned medical spas. She is a member of the Laser Institute of America, American Society for Lasers and Medicine, and participated as an invited speaker and content development advisor for the 2011 International Laser Safety Conference.

Rodriguez, Carmen

Carmen E. Rodriguez has worked for the University of Pennsylvania's Perelman School of Medicine in the Radiation Oncology Department for 15 years.

Sakaris, John

John Sakaris has forty-eight years of health care experience starting in the United State Navy 1967. Operating room experience 1971 to present, CNOR since 1991. Member of AORN since 1976. Laser experiences late 1970s or early 1980s to present, just recertified as CMLSO for the third time. Currently he is Deputy Laser Safety Officer at MD Anderson Cancer Center in Houston, TX.

Schulmeister, Karl

Dr. Karl Schulmeister is a consultant on laser and lamp product safety at the Seibersdorf Laboratories in Austria. He is technical secretary of the IEC working group that is responsible for the international laser safety standard IEC 60825-1. Over the laser ten years, his group developed a computer injury model in order to quantitatively predict injury thresholds for the retina, cornea and skin. Karl is a fellow of the LIA and received the Rockwell Award in 2015.

Scroggins, Robert

Robert is a registered nurse with 33 years of nursing experience. During my time in the OR I worked as a staff nurse, team leader for various specialties, assistant nurse manager, facility Laser Safety Officer/Resource nurse for Clinical Technology. In that capacity, I instituted a successful smoke evacuation program for the health system and taught a variety of courses related to patient and staff safety. Currently I am the Clinical Programs Manager for Buffalo Filter, manufacturer of surgical smoke evacuation equipment and travel extensively speaking on the hazards of surgical smoke and ways to mitigate the hazard.

Sliney, David

Dr. Sliney holds a PhD in biophysics and medical physics research from the University of London (Institute of Ophthalmology), an MS in physics and radiological health from Emory University, and a BS in physics from Virginia Polytechnic Institute. He retired from the US Army Medical Department after 42 years of service in 2007. He currently holds associate faculty positions in the Johns Hopkins School of Public Health and in Drexel Institute of Technology. He serves on many standards committees. He is a Wilkening awardee and was co-author of the 1,000-page book, Safety with Lasers and Other Optical Sources.

Smalley, Penny J.

Penny is an international speaker who has helped many facilities create comprehensive laser programs. She has been instrumental in developing laser safety guidelines and recommendations for national and international agencies. She has authored guidelines on safety and has served on leadership roles within prestigious organizations, such as ANSI. She also helped create the International Council on Surgical Plume and serves on its Board. Recently Penny assisted with state legislation to mandate plume evacuation.

Stack, Casey

Casey Stack has been involved in commercial laser technology for more than 30 years, founding his first laser company as a teenager. He has founded and led a number of US based laser and non-laser product companies, addressing more than 600 laser products from military to scientific to entertainment. He previously held posts as Chair of the International Laser Display Association's Technical Standards Committee and as a Director of the ILDA, authoring several of its International Standards. He serves as a member of the ANSI Z136.1 & IEC 60825 Committees and is Vice-Chair of the forthcoming ANSI Z136.10 Laser Safety Standard. He is currently involved in founding "ILIPA" a new industry trade association for the domestic and international manufacturers of laser illuminated cinema projection systems. Today, he is President of Laser Compliance, an independent Laser Product Compliance Consultancy based in Utah, USA.

Stewart, James
James Stewart is a UK based safety practitioner possessing occupational safety and health skills as well as specialist technical knowledge and understanding of display applications employing laser technology. He currently works as an independent consultant to many of the UK's major entertainment venues. His expertise is used by venue operators to ensure the risks associated with laser display installations are sufficiently controlled and managed to ensure the safety of workers, performers and members of the public. James is the project lead for the IEC 60825-3 safety guidance for laser display applications.

Stuck, Bruce
Bruce E. Stuck is retired after over 40 years working radiation protection for the US Army Medical Research Programs in Philadelphia, San Francisco, and San Antonio. He serves on the ANSI ASC Z136 and ACGIH committees and recently completed his term on the ICNIRP Commission. His primary interest is in laser bioeffects and development of laser exposure limits that are both protective and facilitate their safe use. He currently does som limited consulting in this area.

Thomas, Robert
Robert J. Thomas, Ph.D., received his B.S. degree in physics from Pittsburg State University, Pittsburg, KS in 1989. He later received his Ph.D. in physics from the University of Missouri, Columbia, MO in 1994. There, he contributed to the fields of spectroscopy and numerical simulations for strained-layer semiconductor heterostructures as a graduate student. In 1994, Dr. Thomas joined the Air Force Research Laboratory in San Antonio, TX. For many years he has been a national leader in the areas of experimental and theoretical biomedical optics—particularly those areas which apply to the establishment of safety standards and exposure limits. He has authored and co-authored more than 40 peer-reviewed papers and more than 50 other contributed papers in the areas of laser-tissue interactions, tissue optics, computer simulation, and laser safety exposure limit definitions. Dr. Thomas is a member of SPIE, APS, DEPS, the IEEE, and in 2007 was named a Fellow of the Laser Institute of America (LIA).

Dr. Thomas's contributions to the Laser Institute of America have primarily involved basic research for the scientific foundations of laser safety and the development of the ANSI Z136 series of standards. These contributions have led to his role as the Secretary of the ASC Z136 from 2005-2010, and in 2010, appointment as the Chairman for the ASC Z136. He has served in multiple LIA-related leadership roles, and regularly serves as an organizer, contributor, and session chair at the International Laser Safety Conference.

Tyrer, John
John is the Professor of Optical Instrumentation at the School of Mechanical and Manufacturing Engineering, Loughborough University where he heads up research groups in Optical Metrology, High Power Laser Processing, Computer Generated Holography and of course Laser Safety. John has actively works in the field of industrial and medical laser safety, advises Govt. Agencies, Industry, Public Bodies and Universities on all aspects of laser safety – especially practical solutions.

Wheatley, Trevor
Trevor Wheatley is an Electrical Engineer with tenure as a lecturer within the School of Engineering and Information Technology UNSW Canberra, where he researches in experimental quantum parameter estimation. Trevor chairs the Standards Australia SF-019 Committee on laser safety and is the head of the Australian delegation on IEC TC 76. He is the Presiding member of UNSW Canberra laser safety committee. Trevor researches, teaches and consults in laser safety in both Australia and New Zealand.

Williamson, Craig
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Jie Zhang, PhD candidate, studying at Laser Advanced Manufacturing, Beijing University of Technology, PR China, is engaging in laser processing and manufacturing technology research for a long term and has completed a number of cooperation projects with some large enterprises.

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