Panel Issues Audience Scanning Guidelines

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Note that since the 1998 Conference, ILDA has continued to study the issue of Audience Scanning. For example, in 2009 ILDA produced a paper, “Scanning Audiences at Laser Shows: Theory, Practice and a Proposal”. As of 2010, the updated version of this paper represents ILDA’s current recommendations. Therefore, the information below is presented for historical purposes only.

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The controversial issue of audience scanning came one step closer to being resolved at the 1998 ILDA Conference in Amsterdam. A joint panel of safety officials and laser company representatives put to rest the long-held misconception that safety standards for eye-exposure to lasers vary from country to country.

"Maximum Permissible Exposure (MPE) levels [for laser light] were derived from studies and discussions by international experts," said a statement by the panel. " These standards set forth essentially the same MPE in most industrialized countries. There are not `different standards in different countries.'" Although some countries are not strict in enforcing MPE levels, the panel agreed that MPE levels are here to stay and that it is the responsibility of laser operators to follow them. "It is unprofessional and risky," said the panel, "to produce an unsafe show (or a show where the hazards are not analyzed)." The panel suggested specific methods for measuring MPE levels and recommended a number of steps operators could take to safely perform audience scanning shows.

Industry representatives on the panel included Dirk Baur, MediaLas, Germany; Greg Makhov, Lighting Systems Design, USA (and Chair of ILDA's Safety Committee); Patrick Murphy, Pangolin Laser Systems, USA; and Tony Zmorenski, Walt Disney World, USA. The non-industry members of the panel were Daniel Clark, Loughborough College, UK; Wolfgang Kirchner, WKL, Germany; and John O'Hagan, National Radiological Protection Board, UK.

A complete copy of the statement follows:

Full Text of Amsterdam Safety Panel Statement on Audience Scanning

International Laser Safety Seminar
November 8, 1998 · Amsterdam, The Netherlands
Opening Remarks
Moderator: Tony Zmorenski, Safety Officer, Walt Disney World
Geoff Jones, Entertainment Laser Association, UK
Dr. Daniel Clark, Loughborough College, UK
John O'Hagan, National Radiological Protection Board, UK
Dirk Baur, MediaLas GmbH, Germany
Dr. Wolfgang Kirchner, WKL, Germany
Greg Makhov, ILDA Safety Committee
Patrick Murphy, Pangolin Laser Systems, US

General Principles

Lasers can be eye-safe, up to a certain level.
Beyond a certain level, lasers are definitely eye hazards. There must be safe procedures to prevent damage . But first we must know: At what light level does there begin to be damage?

The Concept of MPE Levels

Since 1972, there has been an internationally agreed-upon hazard concept: the "MPE" or Maximum Permissible Exposure. Actually, the "MPE" includes many different exposure limits, depending on the laser wavelength and time of exposure. The MPE for a given wavelength and exposure duration means: 10 times less than the light level where 50% of subjects' eyes had visible damage. Expressed another way: shining light at the MPE level into a subject's eye has a statistical chance of damaging 3 out of every 100 subjects. In summary, the MPE is a worst-case "safety factor". Exposure at the MPE level is already somewhat hazardous (statistically 3 out of 100 eyes would show signs of visible damage.) So additional factors such as a moving beam are assumed to further reduce the risk.

International Laws and Regulations

The MPE levels were derived from studies and discussions by international experts in laser safety. The MPE is here to stay. It would be difficult or impossible to try to change the MPE. Public safety is expressed by standards which set the maximum legal exposure. These standards set forth essentially the same MPE in most industrialized nations. There are not "different standards in different countries". What differs is enforcement: Some countries are very strict, such as the United States. They demand extensive proof before they allow audience scanning. Some countries were lenient, but now are strict such as the United Kingdom. Owing to the efforts of just two people, audience scanning enforcement was tightened significantly. Some countries are lenient or may not understand or apply the standards. In these countries, it is routinely possible to scan audiences with light significantly exceeding the MPEs.

Responsibilities of Laser Operators

If in a country with strict enforcement, the regulations must be followed. If in a country without strict enforcement, the MPE levels must be followed, for three reasons:
1) Companies must be professional. It is unprofessional and risky to produce an unsafe show (or a show where the hazards are not analyzed).
2) Companies must be proactive. This is to avoid government regulations, or clients worried by press reports (e.g., laser pointers)
3) Companies must be aware of what will happen if only a few well-placed people start to examine shows, and find unsafe ones (e.g., U.K.)
Safety can be a marketing advantage against low-budget, unsafe competitors. Do clients want to risk harm to their audience?

Technical Factors in Audience Scanning

Non-scanning effects (audience illumination): Diffraction gratings, lumia light washes. High-inertia scanners (takes >1 second to stop): Mirror balls, cone scanner, polygon scanner.
Both [of the above effects] are relatively safe -- easy to detect failure, time to close shutters. These have been approved in the U.S. for audience scanning.
Low-inertia scanners (takes less than 1 second to stop), Galvanometer scanners, AO deflectors.These [three effects] are riskier -- harder to detect failure, shorter time to stop light output. Needs a very fast shutter such as a PCAOM. Unapproved (or very rare) in the U.S. for audience scanning
(Note: The rest of the discussion focuses on low-inertia scanners; specifically, galvo scanners)

Measurements of the MPE Levels

There are MPEs for three types of exposure: average, single pulse, reduced single pulse. Because we are talking about scanning, in most situations only "reduced single pulse" needs to be examined. This is more than one pulse (scan) in 1/4 second. Even a fan scan (scanning a line and moving it down the audience) would cause multiple pulses in less than 1/4 second, into a single eye. Thus, "reduced single pulse" applies. The pulse duration (how long the beam scans across a 7mm aperture) is the most important measurement.

Measuring with an oscilloscope and detector.
Measuring with a LOBO LMS-2 meter
Measuring with a POE MPE Meter.

Audience Scanning Safety Practices

Caution: No system or test can absolutely guarantee eye safety when deliberately scanning the audience. You should use accepted instruments and practices to check the questionable parts of your show. The following tips are general ways to make your show safer through good design practices, and if accepted instruments are not available at your show site.

Do Not Scan with Pulsed Lasers

Pulsed lasers (e.g., metal vapor, pulsed YAG, pulsed solid-state) are inherently hazardous due to the power of each pulse. It requires exacting calculations to even consider scanning an audience with pulsed lasers. Because of the great potential danger, use continuous wave lasers (e.g., he-ne, argon, krypton, diodes, cw YAG, cw solid-state) only.

Increase Divergence

For ranges of less than 30 meters, using a lens to increase divergence can allow for visually effective power levels while maintaining controllable irradiance levels. A bright, fuzzy beam is far safer (and more visually effective) than a dim, tight beam with the same irradiance.

Don't Use a Single Beam

You should never aim a single beam into the audience. In general, if a single beam is safe, then any scanned effects such as cones and fans will spread the light out, and be too dim to be effective.

Move the Projected Effects

When projecting a fan or tunnel, move the effect through the audience. This reduces the multiple pulse accumulation.

Don't Rely on Faster Scanning

In general, you will not increase safety by scanning faster. Although the beam spends less time in the eye, there are more crossings of the eye, and thus the total light energy delivered remains about the same.

Attenuate Power with Size

The smaller the projected effect, the greater the concentration of energy. Any effect that grows from a point, or shrinks to a point should have a proportional fade in/ fade out.

Limit Anchor (Dwell) Points

Anchor points reduce beam velocity and increase exposure. Where possible, use blanking to emphasize beams, rather than anchor points.

Scan Fail Interlock

Use a scan fail interlock of some sort. Chances of a still beam from a laser entering someone's eye are small, but consider the consequences!

Program "No-Exposure" Conditions in the Show

Allow time for the eyes to recover by parking effects outside of the audience area. A good "no-exposure" time is 10 seconds or longer.

Measure the Irradiance

Typical shows should not exceed 10 milliwatts per centimeter squared, or 100 watts per meter squared. You need to know what you are delivering to the audience.

Quick Test for Aversion Response

Note: The following tip is only for use when you believe your show is safe by using the above tips AND you are aware you could damage your eyes if your show is not safe. Use your computer or PCAOM controls to set the laser output to all green or all white. Run the show while standing at the closest audience access point. As the laser crosses your eyes, evaluate the brightness. If you have a desire to avert your eyes, you are probably approaching or exceeding the internationally agreed safety levels (MPE).

Respect the Audience

Not everyone enjoys bright lights in their eyes. Remember that they trust you to ensure their safety.