

EVALUATION OF ANSI Z136.1-2014 AND COMPARISON WITH Z136.1-2007 AND Z136.8-2012¹

Paper #

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Overview

Abstract

This paper evaluates the 2014 revision of Z136.1, *Safe Use of Lasers*, and compares it with Z136.1-2007 and with Z136.8-2012, *Safe Use of Lasers in R&D and Testing*. We summarize substantive changes in the 2014 revision with respect to 2007, and we also comment on a few important issues. Department of Energy (DOE) labs have a regulatory requirement via 10CFR851 to abide by Z136.1-2000, though some labs have obtained approval to use Z136.1-2007. The DOE's Laser Safety SubGroup (LSSG) performed reviews in 2013 and 2014 of these different laser safety standards. As a result of the reviews, the LSSG has issued two recommendations for DOE facilities: i) to adopt Z136.1-2014 for regulatory requirements, and ii) to use Z136.8-2012 for additional guidance and information, for example when considering implementation of alternate controls. The LSSG is also planning to benchmark certain policy requirements at the different DOE sites, for both current requirements and for what the modified requirements would be if adopting Z136.1-2014.

Results from the LSSG reviews of the Z136.1 and Z136.8 laser safety standards are described in the reports in References [1] and [2]. The LSSG formed task groups to prepare these reports which were then reviewed by the full LSSG. Recommendations in the 2014 report were subsequently accepted by the LSSG. The primary focus for the reviews was on *shall* and *should* requirements, but also considered other differences such as in the MPE calculations. The reviews also noted important editorial and organizational changes, and commented on significant issues. Below we provide an Executive Summary from the 2014 review report. This is followed by findings of substantive changes and other significant issues, organized by Section numbers used in Z136.1-2007. This paper focuses on evaluating Z136.1-2014. A summary of findings from evaluating Z136.8-2012 is presented in an Appendix.

Executive Summary

The LSSG has recommended that DOE labs:

1. adopt ANSI Z136.1-2014 for regulatory requirements; and
2. use Z136.8-2012 for additional guidance and information to supplement Z136.1, but not use it for regulatory requirements. (For example,

¹ Contributed to the 2015 International Laser Safety Conference, Albuquerque, NM;
<http://www.lia.org/conferences/ilsc>.

Z136.8 may provide useful guidance when considering the implementation of alternate controls.)

Key findings from evaluating Z136.1-2014 include:

- Section 2 *Definitions* was expanded and improved and now includes common acronyms; its Section title is changed to *Definitions and Acronyms*.
- Section 4 *Controls* had significant improvements in content organization and clarity for requirements. In particular, there were good improvements for sub-sections on *Indoor Laser Controlled Areas, Area Warning Devices* at LCA entryways and *Laser Radiation Emission Warnings* inside LCAs.
- Section 7 *Non-Beam Hazards* had significant improvements in content organization and clarity. These included a new section and summary table for irradiance thresholds of some specific NBH, including LGACs, plasma radiation, and ionizing radiation. Two types of non-laser radiation were better defined and described for collateral radiation and laser target interaction radiation.
- Warning signs comply with ANSI Z535.2. Most *DANGER* signal words will change to *WARNING*.
- Eye protection *shall* be required for Class 3B (changed from *should*).
- Alignment eyewear is described and requirements for their use given.
- Significant changes were made to some MPE values and calculations. It's important and necessary to use current MPEs.

Many DOE facilities will now pursue implementing the use of Z136.1-2014 as a regulatory requirement for laser safety in lieu of Z136.1-2000 or Z136.1-2007. However, facilities that make this change may choose to retain certain controls requirements in their laser safety programs that have been relaxed in recent revisions of Z136.1. To help achieve consistency and assure best practices in the DOE's laser safety programs, the LSSG is initiating a study to benchmark policy requirements at different sites for: i) current requirements and ii) what their modified requirements would be if adopting the 2014 revision of Z136.1. Key controls requirements to benchmark include:

- Baseline eye exam
- Master Key
- Remote interlock connector
- Beam stop/attenuator

- Area warning device and laser radiation emission warning device
- Emergency Stop button for Class 4 LCAs
- Protective eyewear requirements
- SOP requirements for Class 3B and Class 4, and requirement to include written alignment procedures in the SOP.
- Skin PPE requirements and skin exams for UV laser operation

1. General (Section Findings)

i. The description for applicability of a vertical standard is changed:

- Z136.1-2007: vertical standard (e.g., Z136.8) may deviate with Z136.1 and is valid only within scope of that standard
- Z136.1-2014: has same description as 2007 revision + adds sentence stating the vertical standard guidance has precedence over Z136.1 if there is a conflict in requirements
- Z136.8-2012: LSO has responsibility to review and use the applicable horizontal and vertical Z136 standards

Other General Notes (not specifically in this section):

a) *Outdoor Laser Safety Controls.*

- Z136.1-2014 revision references Z136.6 for requirements. The 2014 revision still lists the controls requirements that appear in Z136.1-2007, but properly moves them from the engineering controls section to administrative controls.
- Z136.8-2012 has same requirements as Z136.1-2007.

b) *Entertainment, Displays and Exhibitions*

- Z136.1-2014 revision removed most of the controls requirements in Section 4.5.1 of 2007 revision and also removed Figures 2c-2e. This presumably anticipated release of Z136.10 but it's not released yet.
- Z136.8 has no sections on this.

2. Definitions (Section Findings)

Changes in Z136.1-2014 include:

- i. Title of section changed to *Definitions and Acronyms*
- ii. Section 2.1 added, *Acronyms and Abbreviations used in this Standard*.

- Includes AEL, ANSI, CDRH, LCA, LEP, LGAC and many others
- iii. Expanded and clearer definitions. New definitions include:
 - administrative control
 - control measure
 - engineering control,
 - illuminance
 - LCA,
 - laser product
 - laser target interaction radiation (LTIR)
 - PPE
 - saturable absorption
 - visual interference effects

3. Hazard Evaluation and Classification (Section Findings)

There are very few changes between 2007 and 2014 revisions of Z136.1. Our findings are:

- i. For Outdoor laser operations' hazard evaluation, Z136.1-2014 references Z136.6 and removes the 8-step procedure given in Z136.1-2007. Z136.8-2012 has the same description as Z136.1-2007.
- ii. Z136.8-2012 does not describe laser hazard classification (despite the section title) so Z136.1 must be used for this.
- iii. Z136.8-2012 gives an expanded description of environmental factors affecting hazard evaluation. It removes the description for personnel considerations given in both Z136.1-2007 and Z136.1-2014, and just gives a single sentence stating that the LSO must consider affected personnel in developing control measures

4. Control Measures (Section Findings)

Z136.1-2014 is updated to have sections distinguishing *User* and *Manufacturer* Control Measures. There is a new Section 4.3 *Manufacturer Control Measures*. Then Section 4.4 is *User Control Measures* with sub-sections for *General controls*, *Engineering Controls*, *Administrative (Procedural) Controls*, etc. This is a good organizational improvement. Our findings for the Controls sub-sections are:

4.1. General Considerations

- i. Supervised and Unattended/Unsupervised Laser Operation (4.1.1.2 and 4.1.1.3)
 - 2014 revision removes requirements for Class 3B and Class 4 supervision. Instead, it defines what supervision means and leaves requirements for unsupervised operation to

next section. Change is less restrictive but is a good change.

- 2014 revision changed title from Unattended to Unsupervised. Signage requirements changed from DANGER to WARNING. 2014 revision is more concise and is improved.
- Z136.8 has same descriptions as Z136.1-2007 for *Supervised Laser Operation* but has some differences for *Unattended Laser Operation*. It more appropriately requires: i) the laser user to implement the appropriate control measures rather than the LSO and ii) requires the LSO to approve the operation. It also requires documenting training given to those who may enter the LCA during unattended operation. Like Z136.1-2007 however, it requires use of the DANGER signal word rather than WARNING.

ii. Controls requirements for Class 2 and Class 3R lasers (Table 1 in Section 1.2)

- Both Z136.1-2007 and Z136.1-2014 state these are exempt from any control measures except for conditions of intentional intrabeam exposures. But this conflicts with requirements given elsewhere in standard, for example:
 - Unsupervised/unattended operation has *shall* control requirements (4.1.1.3 in 2007 and 4.4.1.2.1 in 2014). Unattended/Unsupervised operation of these lasers *shall* have a clearly visible label.
 - Equipment labels are required (4.3.14 in 2007 and 4.6.6 in 2014)
 - Education and training (Section 5.1). Training *should* be provided to users working with or potentially exposed to these lasers.

○ Z136.8:

- Does not have Table 1 summary that appears in Z136.1.
- Has a requirement for an area warning sign in 4.1.1.3 for unattended operation (comment: area warning sign is more appropriate than equipment label but *should* have both)
- Has same requirement as Z136.1 for education/training (Section 5.1)

iii. Laser Pointers:

- Z136.1-2014 describes laser pointers in Section 4.5, *Special Considerations*. It removes most of description, guidance and warnings given in Z136.1-2007. Given the

widespread use of laser pointers and common problems of laser pointers exceeding 5mW levels, it is unfortunate to abbreviate the description for laser pointer hazards and appropriate controls.

- Z136.8 does not describe laser pointer hazards and controls.

iv. Visual Interference Effects

- Z136.1-2014 adds a definition for this in Section 2, "Those effects associated with viewing of bright visible lights. These may include glare, flashblindness, and after-images." Definition isn't present in Z136.1-2007 or Z136.8-2012.
- Z136.1-2014 Section 4.1 adds following requirement (not present in Z136.1-2007 or Z136.8-2012), "control measures commensurate with the hazards *shall* be devised to reduce the possibility of exposure of the eyes or skin to hazardous levels of laser radiation and to mitigate indirect hazards due to visual interference effects." However, no controls requirements for this purpose are explicitly described.
- Z136.1-2007, Z136.1-2014 and Z136.8-2012 all comment that temporary flashblindness, glare, and startle have become an increasing concern but are not covered in the standard. This is described in both Z136.1 revisions in Section 7.5.1 *Ergonomics* and in all 3 standards in Section 8, *Criteria for Exposures of Eye and Skin*.
- None of these 3 Z136 standards properly address the issue of temporary impaired vision from exposures below the MPE, in particular for potential exposures to Class 2 or Class 3R alignment lasers or laser pointers. This is an issue that should be explicitly addressed in Z136.1, in contrast to the statements given in Section 7.5.1 and Section 8.

v. Reported incident conditions

- A list of 15 conditions most often contributing to reported incidents are given in Section 4.1 of Z136.1-2007. These are also given in Appendix C of Z136.8-2012, but they are not given in Z136.1-2014. This information is important and should have been included in Z136.1-2014. Having it in an Appendix is probably best, but there should be an appropriate reference to it in Section 4.1.

4.3. Engineering Controls

i. Implementation of engineering controls

- In the 2014 revision, the requirement changed from *LSO shall effect* these controls to *LSO shall review and approve*. Revision wording is better.

- Z136.8 has similar statement as 2007 Z136.1 except mistakenly uses word "affect" rather than "effect."

ii. *Protective Housings* (4.3.1)

- 2014 revision is reorganized to include equipment labeling requirements in this section which appears in 4.3.14 in 2007 version.
- Z136.8 has no requirements for equipment labels on protective housings which isn't good.

iii. *Operating a laser without a protective housing* (4.3.1.1)

- 2014 revision states only engineering controls requirements, focusing on items such as barriers and beam stops; removes broad description of using administrative controls and PPE since this section is for engineering controls.

- Z136.8 has same description as Z136.1-2007

Interlocks on Removable Protective Housings (4.3.2) and *Service Access Panels* (4.3.3)

- 2014 revision does not allow defeatable interlocks for covers that can be removed in operation and maintenance modes; this is allowed in 2007 version. 2014 revision allows defeatable interlocks for service access panels, same as in 2007.

- Z136.8 has same description as Z136.1-2007

Remote interlock connector (4.3.7) and *Beam stop/attenuator* (4.3.8)

- 2014 revision removes requirements for these but includes information in Appendix D on manufacturer-required controls via CDRH and IEC.

- Z136.8 also removes these requirements

Laser Area Warning Signs and Activation

Warnings (4.3.9)

- 2014 revision has significant re-organization of requirements and changes title for section; much improved description and clarity. Clearly distinguishes an entryway *Area Warning Device* (4.2.8) from *Laser Radiation Emission Warning* (4.2.9) inside the LCA. Area entryway warning device requirement is new.

- Z136.8 has similar description as Z136.1-2007 but relaxes *shall* requirement for activation warning to *should* for Class 4.

Indoor LCA Requirements (4.3.10.1 and 4.3.10.2)

- Z136.1-2007 describes many admin controls in this engineering controls section. The 2014

revision is organized better to put engineering and admin controls in the appropriate sections, so admin requirements are moved to 4.4.3.5.

- Z136.8 has almost identical description to Z136.1-2007

vii. *Outdoor control measures* (4.3.11)

- 2014 revision has a single sentence to refer to Z136.6 and administrative procedures in 4.4.3.6. This is a good change.
- Z136.8 has same description as Z136.1-2007

4.4. Administrative Controls

i. *Alignment Procedures* (4.4.5)

- Class 2 and Class 3R requirements:
 - 2014 revision removes requirement to perform Class 2 and Class 3R alignment in a manner to avoid exposures above MPE (has no discussion on alignment procedures for Class 2 or Class 3R)
 - Z136.8 has same requirement as 2007 revision
- Written alignment procedures in SOP
 - Z136.8: *shall* be approved by LSO for Class 3B and Class 4
 - Z136.1 (2007 and 2014): *should* be approved by LSO for Class 3B and *shall* be approved by LSO for Class 4.

ii. *Outdoor Control Measures* (4.4.3.6 in Z136.1-2014)

- First sentence in 2014 section gives reference to Z136.6 for requirements, and then gives list of 12 items for admin controls used outdoors. In 2007 version, these same 12 admin controls appear in the engineering controls Section 4.3.11
- Z136.8 is organized the same as Z136.1-2007 and has these admin requirements in the engineering controls section.

4.5. Special Considerations

i. *Laser demonstrations involving the general public* (4.5.1)

- This section material was largely removed in the 2014 revision. It will be described in Z136.10 when released. This is also removed in Z136.8.

4.6. Protective Equipment

i. *Eye Protection* (4.6.2)

- Z136.1-2014: *shall* be required for Class 3B and Class 4 when engineering or other administrative controls are not practical
- Z136.1-2007: *shall* be required for Class 4 and *should* be required for Class 3B, when engineering or other administrative controls are inadequate to eliminate exposure hazard
- Z136.8: same as Z136.1-2007

Comments: change to *shall* requirement for Class 3B is good in 2014 revision, but qualifier description is better in 2007 version. Would be better to say that whenever there are open/accessible Class 3B or Class 4 beams eye protection *shall* be required.

ii. *Factors in Selecting Alignment Eyewear* (4.4.4.2.5 in Z136.1-2014)

- Z136.1-2007 does not explicitly address this, but it's implicitly allowed
- Z136.8-2012: has similar section as Z136.1-2014 but has confusing requirements on OD requirements
- Z136.1-2014. Has additional requirements than given in Z136.8 and has clear OD requirements:
 - For routine laser operations and most alignment procedures full protection eyewear *shall* be used. Alignment eyewear *shall* only be permitted for specific authorized alignment procedures with visible laser beams (not in Z136.8)
 - Alignment eyewear *shall* have OD to provide full protection for ideal source diffuse viewing at a distance of 20cm (not in Z136.8)
- Both Z136.8 and Z136.1-2014 have statement, "Ultimately the LSO *shall* approve the selection, use and appropriate OD for all alignment tasks"

iii. *Limitations of Laser Eyewear Protection* (4.4.4.2.9 in Z136.1-2014)

- Both Z136.1-2014 and Z136.8 have new sections on these that are similar. They include good information on limitations related to high power lasers, saturable absorption and reflective technology

iv. *Skin Protection* (4.6.6)

- Z136.1-2014 adds new sections on UV laser skin protection and skin protection limitations.

4.7. Area Warning Signs and Labels

i. WARNING signal word is added in Z136.1-2014 and Z136.8

- Z136.1-2014: (compliant with Z535.2)

- WARNING replaces DANGER for Class 3R, Class 3B and most Class 4 lasers; also used for area warning sign for unattended Class 3B or Class 4 operation
- DANGER restricted to Class 4 lasers with high power (multi-kW) or pulse energy
- Z136.8-2012: (not compliant with Z535.2)
 - DANGER used for Class 3R, Class 3B and Class 4 lasers. (same as Z136.1-2007)
 - WARNING *shall* be used for open beam unattended operation in non-interlocked area
- ii. Sign Format
 - Z136.1-2014: adopts Z535.2 3-panel format; does not show Z136.1-2007 compliant signs but permits their continued use
 - Z136.8: shows compliant signs for both Z535.2 and Z136.1-2007

5. Education and Training (Section Findings)

- i. Embedded lasers.
 - Z136.1-2007 and Z136.8: education and training *should* be provided for maintenance and service personnel for systems with embedded Class 3B or Class 4 lasers
 - Z136.1-2014: education and training *shall* be required for maintenance and service personnel for systems with embedded Class 3B or Class 4 lasers where beam access is required during maintenance or service

6. Medical Examinations (Section Findings)

- i. Following a suspected or actual laser-induced injury.
 - All 3 standards state this *shall* be done as soon as practical (usually <48 hours) and that this *shall* be done by ophthalmologist
- ii. Medical surveillance (baseline, prior to beginning laser work, consisting of Amsler grid, visual acuity, color vision, ocular history)
 - Z136.1-2007: *should be required* for laser personnel using Class 3B and Class 4; and incidental personnel *should* have a visual acuity exam
 - Z136.1-2014: *should be considered* for personnel exposed to Class 3B and Class 4
- iii. Z136.8-2012: has conflicting requirements in 6.1 (*should be performed*) and 6.3 (*is at discretion of* the institution) for Class 3B and Class 4 laser users
 - Skin Exams
 - Z136.8-2012: laser users exposed to UV lasers *should* obtain an annual skin exam
 - Z136.1: 2007 *suggests* this and 2014 *recommends* this for users exposed to UV lasers

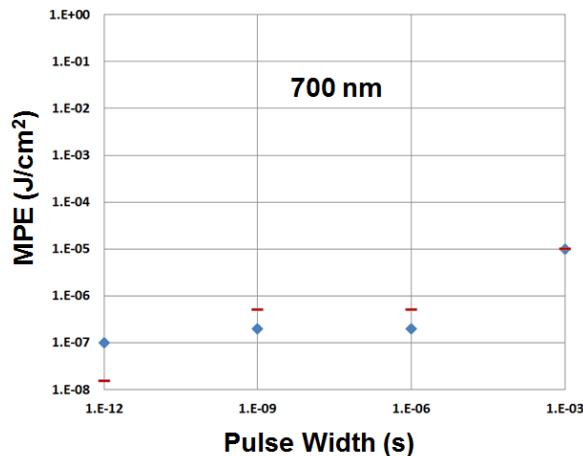
7. Non-Beam Hazards (Section Findings)

- i. Irradiance dependence of specific NBH.
 - Z136.1-2014 adds Section 7.1.1 and Table 7-1 for this. These provide a very useful summary of the approximate irradiance thresholds for when LGACs, plasmas or ionizing radiation may be produced.
- ii. Non-laser radiation: collateral radiation and “laser target interaction radiation” (LTIR)
 - Section 7.2.2 was significantly re-organized to better distinguish and describe these 2 types of non-laser radiation
- iii. Electrical hazards
 - Z136.1-2014 adds new information including *should* requirements for grounding metallic parts of laser systems and for correcting 8 potential hazards that are often observed (e.g., uncovered electrical terminals and non-adherence to LOTO requirements), and new sections on arc flash and electrical hazard regulations.
- iv. Fiber optic fragment hazards and nanoparticles
 - Z136.1-2014 adds new sections on these physical hazards.
- v. Laser Disposal
 - Z136.1-2014 changes *should* to *shall* for ensuring that donated equipment complies with applicable safety standards such as FLPSS (Z136.8 has this as *should* in a standalone section 4.7).
- vi. Z136.8-2012 does not have any NBH requirements in the normative part of the standard. All the NBH description is in the Appendix, which is informative only.

8. Criteria for Exposures of Eye and Skin (Section Findings)

- i. MPE updates in 2014 revision have significant changes for some wavelengths and pulse parameters.
- ii. Rule 3 is eliminated in Z136.1-2014, except for extended sources with angular subtense between 5-100mrad and with wavelength of 400-1400nm.
- iii. There are large changes in the 2014 revision to the C_C correction factor for 1200-1400nm wavelengths, which result in large increases

- ◆ 2014 MPE
- 2007 MPE



- iv. Two examples of changes for single pulse point source MPEs are shown in Figure 1.
- v. An example of how OD requirements change using 2014 MPEs rather than 2007 MPEs is shown in Figure 2.

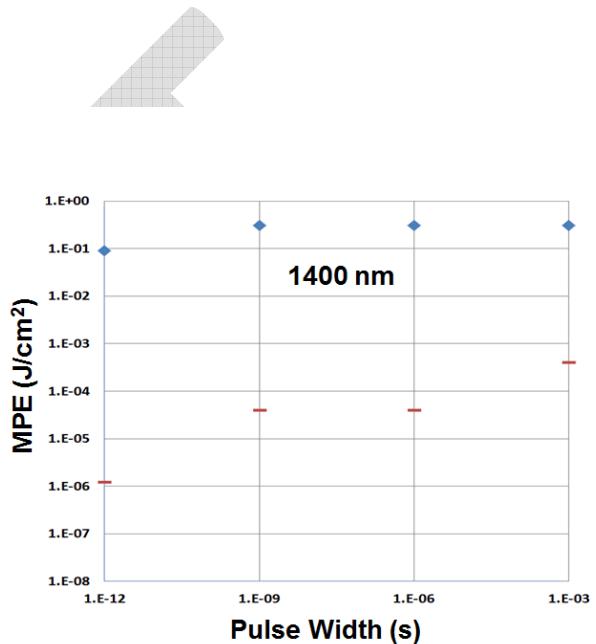


Figure 1: Single pulse point source MPEs at two wavelengths, calculated using Z136.1-2007 and Z136.1-2014

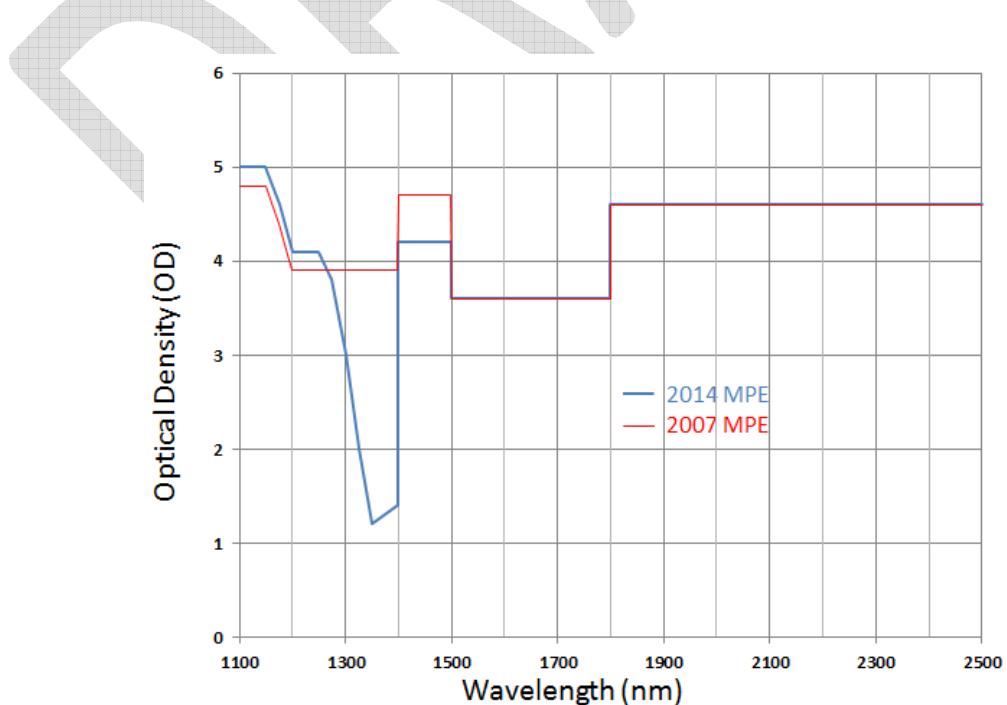


Figure 2: Optical Density required for an OPA with pulse parameters: 2mJ, 50 fs, 120 Hz

9. Measurements (Section Findings)

- i. No substantive differences between the 2007 and 2014 revisions of Z136.1.
- ii. Z136.8-2012 does not have this section, so Z136.1 must be used. For example, when a user builds a laser or modifies a commercial laser, measurements will be needed to determine output beam parameters, to classify the laser, and to calculate OD requirements

10. Tables (Findings)

- i. The 2014 revision of Z136.1 adds Table 1 for the minimum pulse repetition frequency for which Rule 2 (average power MPE) can be used. This is given for different wavelength regions.
- ii. The recommended intra-beam exposure duration for UV wavelengths is changed from 30,000 seconds to 100 seconds. See Table 2.
- iii. MPE wavelength dependence. Table 5a in Z136.1-2007 for point source MPEs has been expanded into Tables 5a-5d in the 2014 revision for UV, Visible, near-IR and mid-to-far IR wavelength regions. Table 5b in Z136 for extended source MPEs was similarly expanded in the 2014 revision into Tables 5e-f for visible and near-IR wavelength regions. These changes provide better clarity and ease of use. Table 6 for wavelength-dependent correction factors and Table 7 for skin exposure MPEs were also similarly expanded into multiple tables depending on wavelength.
- iv. Table 5c in the Z136.1-2014 revision gives separate retina and cornea MPEs for wavelengths between 1200-1400nm.
- v. Z136.8 has no Tables, so Z136.1 must be used for MPEs and OD calculations.

11. Figures (Findings)

- i. Area warning sign examples in Figure 1:
 - o These have been revised in Z136.1-2014 to use the 3-panel format which is compliant with Z535.2.
 - o Z136.8 primarily shows the Z136.1-2007 sign formats but also shows a 3-panel Z535.2 compliant sign.
- ii. Demonstration laser examples shown in Figure 2 in Z136.1-2007 have been removed in the 2014 revision, since this should be addressed in the forthcoming Z136.10.

Z136.8 also does not show these examples.

Z136.8 also shows additional examples of LCA configurations.

- iii. Z136.1-2014 adds Figure 14, time dependence of α_{max} , and adds Figure 15 for the wavelength dependence of the correction factor used to determine the corneal MPEs for 1200-1400nm wavelengths.
- iv. Z136.8 does not have any of the MPE-related figures that are in Z136.1.

12. Appendix A. Laser Safety Programs (Section Findings)

No changes were made in the 2014 revision for Z136.1.

Acknowledgements

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References

- [1] DOE Laser Safety SubGroup Report, [Evaluation of ANSI Z136.1-2014 and comparison with Z136.1-2007 and Z136.8-2012](#), M. Woods et al., 2014.
- [2] DOE EFCOG Laser Safety SubGroup Report, [Report of Findings – ANSI Z136.1 to Z136.8 Comparison](#), J. King et al., 2013.
- [3] American National Standard for Safe Use of Lasers, ANSI Z136.1, published by Laser Institute of America, <http://www.lia.org/>.
- [4] American National Standard for Safe Use of Lasers in Research, Development or Testing, ANSI Z136.8, published by Laser Institute of America, <http://www.lia.org/>.

Meet the Authors

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Appendix: Summary of Findings on Z136.8 evaluation in Reference [2]

1. General Considerations, Section 4.1,
 - Alternate controls. Z136.8 removes requirement that these provide equivalent protection.
2. Engineering Controls, Section 4.2
 - Products being developed which are sent offsite out of control of developer. Description is new. States that such products *should* (rather than *shall*) meet as many FLPPS requirements as possible. This conflicts with FDA requirements.
3. Interlocks on Removable Protective Housings, Section 4.2.2
 - Describes using a secured/labeled cover as an acceptable alternative. But a secured/labeled cover is a less robust engineering control than an interlocked cover.
 - Similar issue with 4.4.3.2 statement that fiber optics requiring a tool to remove is equivalent to an interlock. Again, a cover/connector requiring a tool to remove is a less robust engineering control than an interlocked cover/connector.
4. Master Switch, Section 4.2.4.
 - Changes *shall* to *should* for requirement that energy sources be designed to permit an OSHA LOTO procedure. This conflicts with OSHA requirements.
5. Emergency Conditions, Section 4.2.8.2.1.
 - Changes *shall* requirement for Class 4 LCAs to have an Emergency Stop device to having the LSO evaluate if it's needed.
6. Non-Beam Hazards
 - Section largely moved to Appendix, which is not part of the standard.
7. Following sections in Z136.1 were removed and not addressed:
 - Protective Housing (4.3.1), Walk-in Protective Housing (4.3.1.2)
 - Equipment Labels (4.3.14, 4.7.5)
 - Labeling of Laser Protective Windows, Barriers, Viewports (4.6.5.2, 4.6.5.4, 4.6.5.5)
8. Tables
 - Z136.8 does not have any of the tables present in Z136.1. Most of the Z136.1 Tables are related to MPE calculations and so are not needed in Z136.8. But Z136.1 also includes Tables 10-11 which are very useful summary tables for controls requirements and it is unfortunate that similar tables do not exist in the Z136.8.
9. Laser User Facilities
 - Section 4.4.2 on this is new and contains the following requirements:
 - i. The LSO *shall* be notified of any new or modified beam paths that may impact safety.
 - ii. If the supervisor of the facility is unsure of potential hazards associated with a user's experiment, then the LSO *should* be consulted and an SOP for the user experiment *shall* be generated.
- Comments:
 - *Laser User Facility* is not explicitly defined.
 - The above requirements may not be practical and/or may need to be addressed differently.
10. Alignment Eyewear
 - Section 4.5.2.10 is new. It provides useful information but also adds new and somewhat conflicting OD requirements.
11. Limitation of Laser Eyewear Protection
 - Section 4.5.2.11 is new. It contains useful information in high power or high pulse energy applications.
 - This section contains new requirements:
 - Users of LEP *shall* be trained to understand potential early signs of eyewear damage.
 - the LSO *shall* ensure that the potential saturable absorption is evaluated.
12. On-the-Job Training (OJT)
 - Section 5.3 is new. It calls out OJT as essential but contains no *shall* or *should* statements.
 - It does not require OJT be documented.