

Evaluation of ANSI Z136.1-2014 and comparison with Z136.1-2007 and Z136.8-2012

Mike Woods, SLAC National Accelerator Laboratory

on behalf of DOE LSSG Working Group:
Mike Woods (SLAC), Mendy Brown (Sandia),
Matthew Dabney (NREL), Jamie King (LLNL),
Greta Toncheva (LBNL)

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ANSI Z136.1 and Z136.8 Comparison

Z136.1 – *Safe Use of Lasers*

Z136.8 – *Safe Use of Lasers in Research, Development and Testing*

2013 Comparison done for Z136.1-2000, Z136.1-2007, Z136.8-2012

- Presentation on this was given by Jamie King at 2013 DOE LSO Workshop
 - Final report is posted on LSSG documents webpage,
[Report of Findings – ANSI Z136.1 to Z136.8 Comparison](#),
J. King, M. Brown, J. Casson, G. DeWinkle and M. Woods; 12/27/2013
 - Report recommended DOE labs continue to use Z136.1 as a regulatory document, and use Z136.8 for additional guidance. The report noted a number of findings with Z136.8 that would need to be addressed prior to adopting it as a regulatory document in place of Z136.1 requirements.
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- DOE Labs have a regulatory requirement via 10CFR851 to abide by Z136.1-2000, though some labs have approval to use Z136.1-2007.
 - LSSG wants to evaluate and make a recommendation for DOE labs on adopting Z136.1-2014.

Findings in 2013 Report for Z136.8 evaluation

1. **General Considerations**, Section 4.1,
 - Alternate controls. 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.
3. **Interlocks on Removable Protective Housings**, Section 4.2.2
 - Describes using a secured/labeled cover as an acceptable alternative.
 - Similar issue with 4.4.3.2 statement that fiber optics requiring a tool to remove is equivalent to an interlock.
4. **Master Switch**, Section 4.2.4.
 - Changes *shall* to *should* for requirement that energy sources be designed to permit an OSHA LOTO procedure.
5. **Non-Beam Hazards**
 - Section largely moved to Appendix, which is not part of the standard.
6. **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)

ANSI Z136.1-2014 evaluation and comparison with Z136.1-2007 and Z136.8-2012

Project

- Excel spreadsheet developed for comparing sections in 3 documents
- WG members assigned particular sections to compare + identify substantive differences (findings)
- Final report will be published to LSSG documents webpage (~Nov. 1, 2014)



(this presentation focuses on comparing Z136.1-2014 with Z136.1-2007; will not address findings associated Z136.8 differences that are adequately described in the 2013 report)

Findings related to evolution of “Horizontal” and “Vertical” Standards

1. Applicability of a vertical standard

- 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

2. Outdoor Laser Safety Controls

- 2014 revision references Z136.6 and eliminates most of 2007 content
- Z136.8 has same requirements as Z136.1-2007

3. Entertainment, Displays and Exhibitions

- 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

General Findings

1. **Content re-organization and editorial changes in Z136.1-2014**

- New section on acronyms and abbreviations
- Expanded and clearer definitions - e.g., adds definitions for administrative control, engineering control, PPE, LCA, visual interference effects
- Sections distinguish User Control and Manufacturer Control Measures
- Better alignment of controls in appropriate engineering and admin sections e.g., LCA requirements
- Tables 5-7 for MPE values and calculations broken out into more tables in 2014 revision, depending on wavelength range. More user friendly.

2. **Control Measures and Non-Beam Hazards** had significant content and organizational improvements in 2014 revision

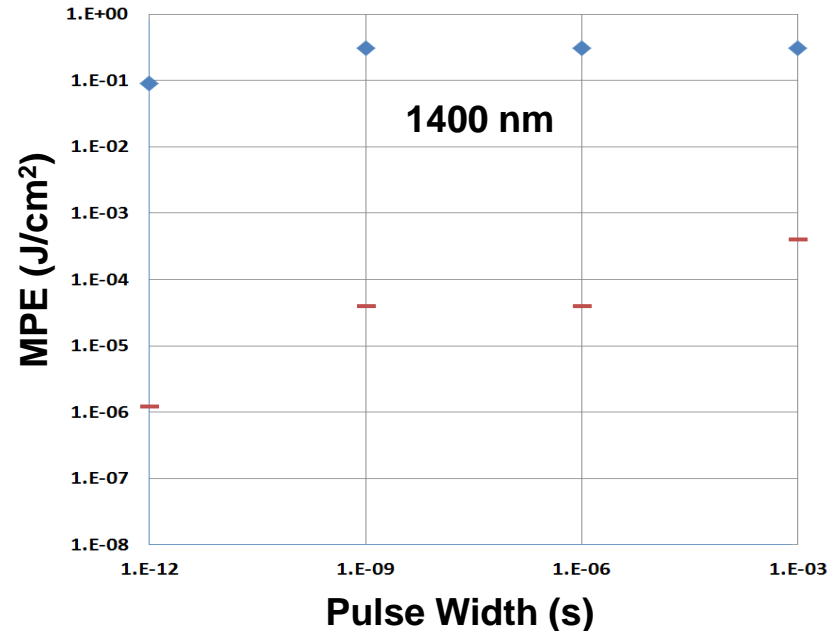
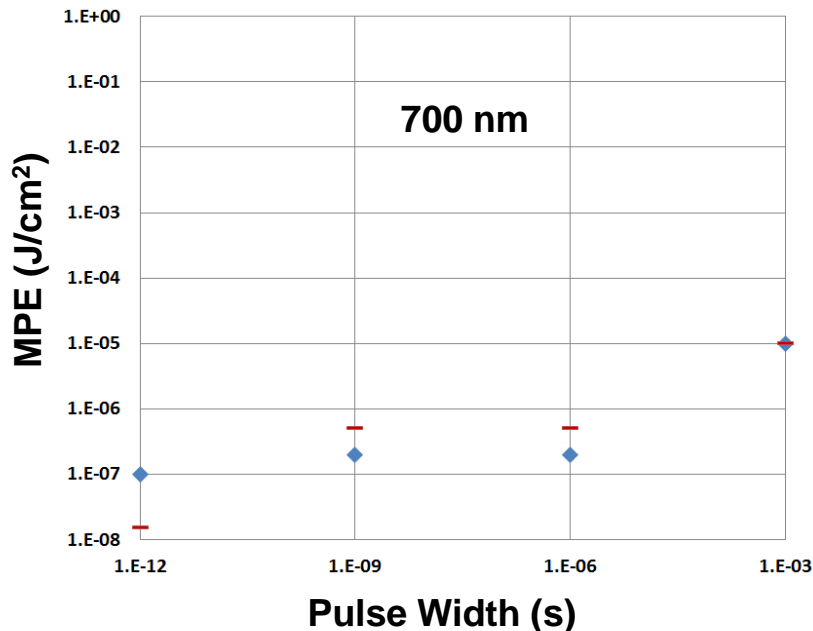
- e.g., *4.4.2.8 Area Warning Device* requirements at entry to LCA
4.4.2.9 Laser Radiation Emission Warning device requirements within LCA

MPE Updates and Calculations

1. MPE updates in 2014 revision have significant changes
2. Rule 3 for multiple-pulse lasers eliminated except for extended sources with angular subtense between 5-100mrad and with wavelength of 400-1400nm

➤ Two examples of changes for single pulse point source MPEs

- ◆ 2014 MPE
- 2007 MPE



Engineering Controls - Findings

- 1. Adequacy of engineering controls** (4.4.2 in 2014 revision)
 - Requirement changed from *LSO shall effect* to *LSO shall review and approve*
 - Z136.8 has same description as Z136.1-2007
- 2. Operating a laser without a protective housing** (4.4.2.1.1 in 2014 revision)
 - 2014 revision states only engineering controls requirements, focusing on items such as barriers and beam stops; removes broad description of using admin and PPE
 - Z136.8 has same description as Z136.1-2007
- 3. Defeatable interlocks on removable protective housings** (4.4.2.1.3 in 2014 revision)
 - 2014 revision removes discussion on this which stated that if interlocks are defeated then have to satisfy requirements in 4.4.2.1.1
 - Z136.8 has same description as Z136.1-2007
- 4. Remote interlock connector and beam stop/attenuator** (4.3.7, 4.3.8 in 2007 revision)
 - 2014 revision removes requirements for these
 - Z136.8 also removes these requirements

Administrative Controls - Findings

1. Alignment Procedures (4.4.3.8 in 2014 revision)

- Class 2 and Class 3R alignment procedures:*
 - 2014 revision removes requirement to perform alignment in a manner to avoid exposures above MPE (has no discussion on alignment procedures for Class 2/3R)
 - 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.

*Control requirements for Class 2 and Class 3R lasers:

- Z136.1-2007 and 2014:
 - Both revisions state these are exempt from any control measures: Table 1 in Section 1.2 (except for intentional viewing in medical applications); 2014 revision also states this in 4.1 (but notes Class 3R requirement for unattended operation)
 - Statement in above bullet contradicts controls requirements given in other parts of standard for unsupervised/unattended operation (*shall*), equipment labels (*shall*), education and training (*should*)
- Z136.8-2012: no general statement on controls requirements, but has requirements for unattended operation (area warning sign rather than equipment label) + education/training

Warning Signs - Findings

- 1. 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
- 2. Sign Format**
 - Z136.1-2014: adopts Z535.2 3-panel format; does not show .1-2007 compliant signs but permits their continued use
 - Z136.8: shows both Z535.2 compliant signs and Z136.1-2007 compliant signs



Example sign in
Z136.1-2014

PPE Controls - Findings

1. Eye protection

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

2. Alignment eyewear

- Z136.1-2007: not explicitly discussed but implicitly allowed
- Z136.8-2012: Adds section on alignment eyewear and factors in selecting it
- Z136.1-2014: Adds similar section as Z136.8, but also has additional 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
 - Alignment eyewear *shall* have OD to provide full protection for ideal source diffuse viewing at a distance of 20cm

3. Limitations on eyewear, use with high power lasers, saturable absorption, and reflective technology

- Both Z136.1-2014 and Z136.8 have new sections on these that are similar

4. Skin protection

- 2014 revision adds new sections on UV laser skin protection and skin protection limitations

Education and Training- Findings

1. Embedded lasers

- Z136.1-2007 and Z136.8: education + 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

2. Medical Exams

- Following a suspected or actual laser-induced injury.
 - All 3 standards require this be done as soon as practical (usually <48 hours) and that this be done by ophthalmologist
- 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
 - 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

3. 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

Non-Beam Hazards - Findings

1. General comments

- Z136.1-2014. Significant rework of this section with many improvements and new info.
 - New and clearer definitions for non-laser radiation, collateral radiation and laser-target interaction radiation
 - New section on fiber optic fragment hazards. Personnel working with fiber optics need to be warned of this hazard.
 - New section on nanoparticles. Processes that produce laser-generated nanoparticles *shall* be engineered to avoid entry of such particles into the body.
- Z136.8-2012. Moves most information/requirements to non-normative Appendix, which is informative only and not part of the standard. Normative text comments that LSO may need to seek assistance from other safety/IH personnel.

2. Irradiance dependence of NBH

- Table 7.1 added in Z136.1-2014 for this for ignition, LGAC production, plasma production and for ionizing radiation.

3. Electrical Hazards

- Z136.1-2014 adds *should* requirements on grounding metallic parts of laser systems. Adds *should* requirement on correcting 8 potential hazards that are often observed (e.g., uncovered electrical terminals, non-adherence to LOTO requirements).

4. Laser disposal

- Z136.1-2014 changes *should* to *shall* for ensuring that donated equipment complies with applicable safety standards such as FLPPS (Z136.8 has this as *should*)

Laser Pointers, Visual Interference Effects - Findings

1. Laser Pointers

- 2014 Revision removes most requirements and information, including:
 - Recommendation that pointer *should* not exceed 1mW
 - FDA warning on possibility for eye damage to children
 - *Should* not be given to children
 - Comment that key approach to laser pointer safety is to recommend education and training to all involved with these products
- Z136.8 does not discuss laser pointers

2. Visual Interference Effects

- 2014 Revision adds a definition for this for effects associated with viewing of bright visible lights, which may include glare and flashblindness
- 2014 Revision adds requirement that control measures commensurate with the hazards *shall* be devised to mitigate indirect hazards due to visual interference effects
- Both 2007 and 2014 Revisions comment that temporary flashblindness, glare, and startle have become an increasing concern but are not covered in the standard. They both reference FAA and Z136.6 for this issue in outdoor laser operations.
- Neither 2007 nor 2014 Revisions address this issue for potential exposure to laser pointers or Class 2, Class 3R alignment lasers
- Z136.8 does not address this

Preliminary Recommendations:

- Working Group recommends to LSSG that DOE labs adopt the 2014 Revision for regulatory requirements. Key findings include:
 - significant improvements in content organization and clarity
 - need to use updated MPEs
 - eye protection *shall* be required for Class 3B (changed from *should*)
 - alignment eyewear requirements given
 - Warning signs comply with ANSI Z535.2
- Working Group recommends continuing to use Z136.8 for additional guidance; for example, when considering need for alternate controls

Next Steps:

- Discuss Working Group's preliminary findings and recommendations with LSSG members at annual meeting on 8/21
- Complete spreadsheets of comparison and identification of findings
- Complete report by ~ November 1 and post to LSSG website