



Laser Safety Subgroup

To: LSSG
From: Jamie King, ANSI Z136.1 to Z136.8 Comparison Subgroup Lead
Mendy Brown
Joanna Casson
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Mike Woods
Date: 12/27/2013
Re: Report of Findings – ANSI Z136.1 to Z136.8 Comparison

A subgroup was commissioned at the 12/10/2012 quarterly meeting to review the recently released ANSI Z136.8 *for the Safe Use of Lasers in Research, Development, or Testing*. The purpose of the review was to determine whether the new standard should be used as a guidance or best practice document, or should be adopted in place of the ANSI Z136.1 *for the Safe Use of Lasers*. Because of the use of both the Z136.1 (2000) and (2007) revisions across the DOE complex, the comparison was made between all three standards. The subgroup consisted of:

- Jamie King – Team Lead, LLNL
- Mendy Brown, SNL
- Joanna Casson, LANL
- Gary DeWinkle, PNNL
- Mike Woods, SLAC National Accelerator Laboratory

The ANSI Z136.1 (2000) was subdivided into five sections with each subgroup member taking an assigned segment and making a determination whether it was covered in the other standards at an equal, more restrictive, or less restrictive way. The results were disseminated and collected onto an Excel spreadsheet (Attachment 1).

Below is a summary of findings of differences between the “.8” and the 2007 version of the “.1”. For the most part, the standards are written in a way that utilized the same layouts and numbering which made cross-reference fairly simple. Detailed findings can be found in Attachment 1.

1. Some sections were moved to the Appendix in the “.8”. This is significant because the appendix section is considered as “Information Only”, and thus does not state any requirements.
2. Maximum Permissible Exposure Limits (MPEs) are not present in the “.8”. This requires the “.1” to be used for this information. The omission is to ensure that conflicting MPEs don’t arise because updates to the “.1” and the “.8” get made at different times.
3. The “.8” does not have any of the tables present in the “.1”. Most of the “.1” tables are related to MPE calculations and so are not needed in the “.8”. But the “.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 “.8”.
4. The “.1” and “.8” documents contain much useful information and guidance, and also include requirements in the form of “shall” and “should” statements. The “.8” provides a lot of additional information and guidance for the R&D environment that is not present in the “.1”. It would be useful for clarity for all of the “.1” and “.8” documents to be organized to more clearly distinguish between guidance and requirements.
5. The following are sections are newly appearing in the “.8”. They provide informational guidance, but in some cases they also include additional controls requirements that are not present in the “.1”:
 - Sections 3.2-3.4 (*Laser Beam Path*, *Laser Process Interactions* and *Laser Use Location*) in the “.8” replace Section 3.4 (*Environment in Which the Laser is Used*) in the “.1”. The new section on *Laser Use Location* introduces different types of laser use areas that can affect the determination of controls requirements; the



- types of areas considered are Unrestricted, Restricted, Controlled, Exclusion, and Inaccessible.
- Section 4.4.2, *Laser User Facilities*. This contains the following requirements:
 - The LSO shall be notified of any new or modified beam paths that may impact safety.
 - 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.
(Note: Laser User Facility is not explicitly defined. The above requirements may not be practical and/or may need to be addressed differently.)
 - Section 4.4.3.3, *Fiber Optic Safety Guidelines*.
 - Section 4.4.4.1, *Laser Robotics with Inaccessible Beam Paths*.
 - Section 4.4.5, *Export Controls*
 - Section 4.5.2.10, *Alignment Eyewear*. Alignment eyewear may only be used for visible beams and is defined by having an OD that is less than what is needed for full protection from a primary or direct laser beam. It is implicitly allowed in the ".1" but is not explicitly discussed. This new section provides useful information but also adds new and somewhat conflicting requirements. Specifically, it states:
 - *for continuous wave alignment lasers, the alignment eyewear OD shall reduce irradiance to a Class 2 to Class 3R level.* (Note: full protection eyewear would reduce the irradiance to a Class 2 level, so this requirement would permit only a 0.7 reduction in the OD.)
 - *for pulsed lasers, the alignment eyewear OD shall be no more than 1.4 less than the full OD protection.*
 - *The LSO shall not recommend alignment eyewear OD with a value less than the point source diffuse OD requirement* (Note: this is a much less restrictive requirement than the above requirements that only permit up to an OD1.4 reduction. The OD required for point source viewing of diffuse reflections at 0.5-meter distance can be OD4-5 less than for full protection.)
 - 4.5.2.11, *Limitations of Laser Eyewear Protection*. This new section contains useful information in high power or high pulse energy applications. It 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.*
 - 4.6.3.4, *Warning Signal Word*. Allows the use of a Warning Sign for all Class 3B and some Class 4 laser use areas. It allows the use of these signs for unattended operations and beams crossing aisles. (Note: Warning signal word will be described in the 2014 revision of the ".1".)
 - 4.6.3.5, *Signal-Words Laser Warning Signs*. This describes area posting signs that make use of IEC symbols. (Note: updated sign format which is consistent with IEC and compliant with Z535 will be described in the 2014 revision of the ".1".)
 - 4.6.4.3.1, *Sign for Multiple Lasers in the Same Area*.
 - 5.3, *Hands-on Training aka On-the-Job Training (OJT)*. Calls out OJT Training as "essential".
 - Section 6.5, *Skin Evaluation*. Recommends (**should**) chronically exposed individuals to UV radiation receive annual skin cancer screening.
 - Section 7.2, *Miscellaneous Non-beam Hazards*. Adds requirements and guidance for laser-related waste, degradation/malfunction of laser cooling systems, and compliance with building codes.
6. The following sections of the ".8" contain significant changes to requirements or to informational guidance found in corresponding sections in the ".1".
- 4.1, *General Considerations*. In description for substituting alternate control measures (appears in separate section 4.2 in ".1") removes requirement that these controls provide equivalent protection.
 - 4.2, *Engineering Controls*. Adds description of developing products which are then sent offsite and may not meet FLPPS or IEC requirements for laser products – this description may not meet FDA requirements.
 - 4.2.2, *Interlocks on Removable Protective Housings*. Describes an alternative to fail-safe interlocks if a tool is required and there is an appropriate warning label.
 - 4.2.4, *Master Switch*. Changes *shall* to *should* for requiring energy sources to be designed to permit an OSHA LOTO procedure (this may not comply with OSHA requirements).
 - 4.2.6.2, *Enclosed Beam Path*. Refers to protective housing requirements but these have been removed.



- 4.2.7.2, *Activation Warning Systems*. Changes *shall* to *should* for requiring this for Class 4 systems.
 - 4.2.8.1, *Indoor LCA (Class 3B)*. Allows an exception to posting the LCA if exclusions apply, but doesn't describe the exclusions.
 - 4.3.1, *Standard Operating Procedures (4.4.1 in ".1")*. Adds the requirement (**shall**) for the approval of Standard Operating Procedures for Class 3B lasers (this is a **should** in the ".1"), but exempts visible wavelength lasers $\leq 15\text{mW}$.
 - 4.3.4, *Alignment Procedures (4.4.5 in ".1")*. Adds the requirement "shall" to have written alignment procedures in the SOP for Class 3B (this is a "should" in the ".1").
 - 4.3.5, *Alignment Procedures for Class 3B and Class 4 Lasers (4.4.5.1 in ".1")*. This includes the following additional requirements:
 - i. Changes description for wearing protective eyewear and clothing:
 - Laser alignment eyewear for visible lasers,
 - Lab coat or long sleeve shirts for UV lasers
 - ii. Whenever possible use remote viewing devices
 - iii. Replace enclosures or beam blocks removed during the alignment procedure
 - 4.3.6, *Service Personnel*. States that the confirmation of the vendor/manufacturer training may be in the form of a safety plan.
 - 4.4.1, *Visitors and Spectators*. Adds the following requirements (**shall**):
 - i. SOP must describe conditions for visitors and spectators in a Class 3B or Class 4 Laser Controlled Area.
 - ii. NHZ must be explained
 - iii. Must have direct supervision or control by an experienced, trained operator
 - 4.4.3.2, *Laser Optical Fiber Use*. States that fiber optics requiring a tool for removal is equivalent to an interlock control.
 - 4.5.2.6, *Visible Luminous Transmission*. Contains information on Visible Luminous Transmission for laser protective eyewear.
 - 4.5.2.7, *Identification of Eyewear*. Includes European Norm (EN) labeling criteria for eyewear.
 - 4.7, *Laser Disposal*. (this is described in Section 7.5.4.1 in the ".1")
 - 5.5, *LSO Training*. Requires (**shall**) that the LSO complete refresher training.
 - 5.6, *User Evaluations and Training*.
 - i. Requires (**shall**) OJT training for all personnel likely to encounter exposure levels above the Class 3R MPE.
 - ii. Removes requirement for CPR training and other safety procedures for non-beam hazards.
 - 6.3, *Medical Surveillance*. Weakens requirement for this for personnel using Class 3B and 4 lasers – this is a "should" requirement in the ".1", whereas the ".8" states this is at the discretion of the institution.
7. There were many items contained in the Z136.1 body that were moved to the Appendix in the ".8". The appendix is not considered as part of the standards requirements:
- Appendix F – Non-beam hazards (Section 7 in ".1"), including sub-sections on Physical Agents (electrical, collateral and plasma radiation, fire, explosion, mechanical, noise), Chemical Agents, Biological Agents, Human Factors.
8. The following sections of the ".1" were removed and thus are considered less restrictive than the Z136.1:
- 3.2.1 – *Multi-wavelength laser classification*.
 - 4.1.5 – *Laser Pointers*.
 - 4.3.1 – *Protective Housings*.
 - 4.3.1.2 – *Walk-in Protective Housing*
 - 4.3.7 – *Remote Interlock Connector*
 - 4.3.8 – *Beam Stop of Attenuator*.
 - 4.3.14 – *Equipment Labels*.
 - 4.4.2 – *Output Emission Limitations*
 - 4.5.1 – *Laser Demonstrations Involving the General Public*.
 - 4.6.5.2 – *Labeling of Laser Protective Windows*
 - 4.6.5.3 – *Labeling of Collecting Optics Filters*



- 4.6.5.4 – *Labeling of Laser Protective Barriers*
- 4.6.5.5 – *Labeling of Laser Protective Viewports and Films*
- 4.7.5 – *Pertinent Equipment Label Information*
- 6.2.1 – *Personnel Categories* (Medical Surveillance)
- 6.2.2 – *Incidental Personnel* (Medical Surveillance)
- 6.2.3 – *Laser Personnel* (Medical Surveillance)
- Section 8 – *Criteria for Exposures of Eye and Skin* has been reduced to a paragraph.
- Section 9 – Measurements.

9. The following changes were made to the section on Figures in the “.8”:

- Warning signs were added (Figures 1e, 1f, 1g)
- LCA configuration figures were updated (Figures 2a-2d)
- Figures related to MPE calculations were removed

The group found that though there are many items that were removed from the new Z136.8 standard, there was much clarifying and informative additions. With the MPEs not being included, both standards would be needed for compliance with contractual requirements.

A report of these findings was presented at the 2013 DOE Annual Laser Safety Officer Workshop as part of a presentation *Comparison/Evaluation of Z136.1 and Z136.8* (Attachment 2) and panel discussion.

There are many conflicting items between the “.1” and the “.8” that should be resolved in future releases of the revisions (the “.1” is scheduled for a revision release in 2014). Until that time, this group can make no recommendation as to the application of this standard for use by the individual DOE Facilities. This group does recommend the use of the Z136.8 for use as a “Guidance” document.

Attachments



Laser Safety Subgroup

Comparison/Evaluation of
Z136.1 and Z136.8

Jamie J. King – Vice Chair

ANSI Z136.1/Z136.8 Comparison

- ▶ A working group to investigate was requested by the Laser Safety Subgroup
 - ▶ Jamie King, LLNL – Chair
 - ▶ Mendy Brown, Sandia
 - ▶ Joanna Casson, LANL
 - ▶ Gary DeWinkle, PNNL
 - ▶ Mike Woods, SLAC
- ▶ Most facilities use Z136.1(2000) while some are using Z136.1(2007)
- ▶ Task was to compare the (2000) and (2007) to the new Z136.8(2012)
 - ▶ Will only show Z136.1(2007) to Z136.8(2012) comparison in this presentation
 - ▶ Individual Facilities will most likely adopt either the .8 or the next rev of the .1 (2014?)



Project

- ▶ Each member was tasked with reviewing an assigned section of the Z136.1(2000) and determine its coverage in both .1(2007) and .8(2012)
- ▶ Excel spreadsheet was used for the template
- ▶ All information was collected into one document

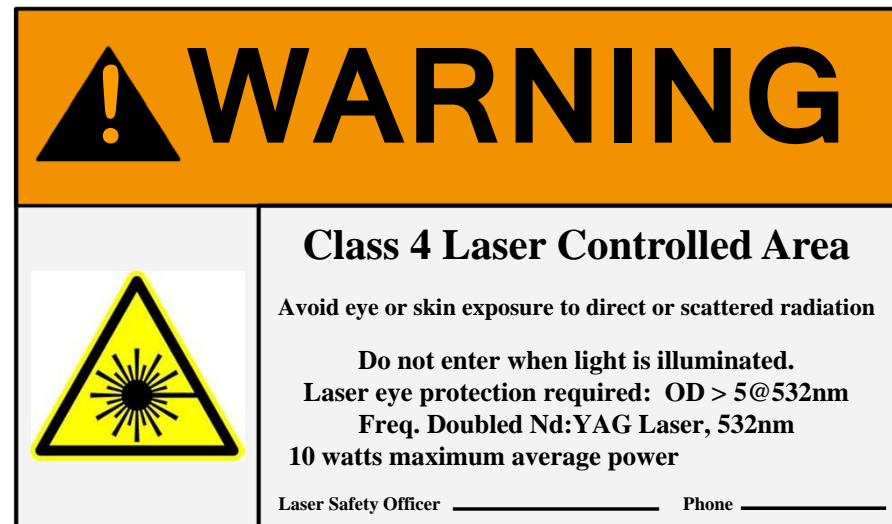


- ▶ Final report will be published to EFCOG Laser Safety webpage
 - ▶ Disclaimer – May not have covered all material 100%



“Big Picture” Findings

- ▶ Standards utilize basically same layouts (mostly same numbering)
- ▶ Most sections were identical and easy to cross reference
- ▶ Some sections have been moved from the body to the appendix
- ▶ MPEs not in the Z136.8
- ▶ Use of color illustrations



New items in Z136.8

- ▶ Introduces types of laser use areas (3.4)
 - ▶ Unrestricted, Restricted, Controlled, Exclusion, Inaccessible
- ▶ Adds **shall** require and approve an SOP for Class 3B lasers (4.3.1)
 - ▶ Exempts visible wave lasers $\leq 15\text{mW}$
- ▶ The LSO **should** review the need and use of alignment eyewear (4.3.5)
- ▶ Confirmation of vendor/manufacture training may be in the form of a safety plan (4.3.6)
- ▶ Written and approved SOP required (**shall**) for visitors/spectators in Class 3B/4 LCA. (4.4.1)
 - ▶ Also expands on controls required prior to entry authorization.



New items in Z136.8 (cont.)

- ▶ Class 3B/4 fibers requiring a tool for removal equivalent to interlock (4.4.3.2)
 - ▶ Fiber Optic Safety guidelines (4.4.3.3)
- ▶ Adds section on Export Controls (4.4.5)
- ▶ Visible Luminous Transmission(4.5.2.6)
- ▶ Includes European Norm (EN) labeling criteria for eyewear (4.5.2.7)
- ▶ For continuous wave lasers the alignment OD **shall** reduce irradiance to a Class 2 to Class 3R level. For pulse lasers the alignment OD **shall** be no more than 1.4 less than the full protection OD. (4.5.2.10)
- ▶ Limitations of Laser Eyewear (4.5.2.11)
 - ▶ Use of High Power Lasers (4.5.11.1)
 - ▶ LSO **shall** ensure that the potential for saturable absorption is evaluated (4.5.11.2)



New items in Z136.8 (cont.)

- ▶ Allows Use of Warning Sign for 3B and some Class 4 (4.6.3.4)
 - ▶ Also used for unattended operations and open beam crossing aisles
- ▶ New section calls OJT Training “essential” (5.3)
- ▶ LSO **shall** be required to complete refresher training (5.5)
- ▶ OJT training **shall** be required for all personnel likely to encounter exposure levels above the Class 3R MPE (5.6)
 - ▶ Training **shall** include safety procedures for applicable non-beam hazards associated with laser systems in use.
- ▶ Chronically exposed individuals to UV radiation **should** receive annual skin cancer screening (6.5)



Items Moved

- ▶ **Items moved to appendix are non-normative (not part of the standard's requirements.**
 - ▶ Non-Beam hazards moved to Appendix F
 - ▶ Protective Housing(4.3.1) moved to Appendix H
 - ▶ Remote Interlock Connector(4.3.7) moved to Appendix H
 - ▶ Warning Logotype Label for Equipment (All Classes Except Class I) (4.3.14.1) moved to Appendix H
 - ▶ Protective Housing Equipment Label (All Classes) (4.3.14.2) moved to Appendix H
 - ▶ Chemical Agents (7.3) moved to Appendix F
 - ▶ Biological Agents (7.4) moved to Appendix F
 - ▶ Human Factors (7.5) moved to Appendix F



Items Removed

- ▶ Requirement for CPR training removed (5.6)
- ▶ Multi-wavelength laser classification (3.2.1)
- ▶ Substitution of Alternate Control Measures (4.2)
 - ▶ “...which provides equivalent protection”
- ▶ Laser Pointers (4.1.5)
- ▶ Beam Stop or Attenuator(4.3.8)
- ▶ Long Distance Beam Conduit Label (All Classes Except Class I) (4.3.14.3)
- ▶ Laser Demonstrations Involving the General Public (4.5.1)
- ▶ Criteria for Exposures of Eye and Skin(8) reduced to paragraph
- ▶ Measurements (9) Totally removed



Discussion Panel

- ▶ Bill Ertle, Rockwell Laser Industries
- ▶ Bob Fairchild, LBNL
- ▶ Karen Kelley, University of Maryland
- ▶ Mike Woods, SLAC



Z136.1(2000)/Z136.1(2007)/Z136.8(2012) Standards Comparison

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
1	LSO authority and responsibility	Control and evaluation of laser hazards	1.3.1 & 4.2	An individual shall be designated the Laser Safety Officer (LSO) with the authority and responsibility to monitor and enforce the control of laser hazards and to effect the knowledgeable evaluation and control of laser hazards	1.3.2 & A1.1 ~same description	1.3.2 same as Z136.1-2007	no differences
2		Classification	1.3.2.1	The LSO shall classify, or verify classifications of, lasers and laser systems used under the LSO's jurisdiction	A1.2 (2)	A2.2b	no differences
3		Hazard Evaluation	1.3.2.2 & 4.2	The LSO shall be responsible for hazard evaluation of laser work areas, including the establishment of Nominal Hazard Zones	A1.2 (3)	A2.2c	no differences
4		Control Measures	1.3.2.3	The LSO shall be responsible for assuring that the prescribed control measures are in effect, recommending or approving substitute or alternate control measures when the primary ones are not feasible or practical, and periodically auditing the functionality of those control measures in use.	A1.2(4)	A2.2d	no differences
5		Procedure Approvals	1.3.2.4 & 4.2	The LSO shall approve SOPs, alignment procedures, and other procedures that may be a part of the requirements for administrative and procedural controls.	A1.2(5)	A2.2e	no differences
6		Protective Equipment	1.3.2.5	The LSO shall recommend or approve protective equipment i.e., eyewear, clothing, barriers, screens, etc., as may be required to assure personnel safety. The LSO shall assure that protective equipment is audited periodically to ensure proper working order.	A1.2(6)	A2.2f	no differences
7		Signs and labels	1.3.2.6	The LSO shall approve the wording of area signs and equipment labels.	A1.2(7)The LSO shall review the wording of area signs and equipment labels	A2.2g same as Z136.1-2007	"approve" is changed to "review" in both Z136.1-2007 and Z136.8-2012
8		Facility and Equipment	1.3.2.7	The LSO shall approve laser installation facilities and laser equipment prior to use. This also applies to the modification of existing facilities or equipment.	A1.2(8)	A2.2h	no differences
9		Safety Features audits	1.3.2.8	The LSO shall ensure that the safety features of the laser installation facilities and laser equipment are audited periodically to assure proper operation.	A1.2(12) same, except restricted to Class 3B and Class 4 facilities/equipment	A2.2m same as Z136.1-2007	Z136.1-2007 and Z136.8-2012 restrict the audits to Class 3B and Class 4 laser
10		Training	1.3.2.9	The LSO shall assure that adequate safety education and training are provided to laser area personnel.	A1.2(9) but just to "laser personnel"	A2.2i + should provide training for personnel working near lasers with exposures below the MPE	some differences but concept same
11		Medical Surveillance	1.3.2.10	The LSO shall determine the personnel categories for medical surveillance.	A1.2(10)	A2.2k	
12		Records	-	The LSO shall assure that the necessary records required by applicable government regulations are maintained. Other records documenting the maintenance of the safety program, such as training records, audits, SOP approvals, etc., shall be maintained. (*	A1.2(11)	A2.2l	new LSO responsibility in Z136.1-2007 and Z136.8-2012
13		Accidents	-	The LSO should develop a plan to respond to notifications of incidents of actual or suspected exposure to potentially harmful laser radiation. (* Z136.1-2007 and Z136.8 only)	A1.2(13)	A2.2n	new LSO responsibility in Z136.1-2007 and Z136.8-2012

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
14		Operations Approval	-	Approval of Class 3B or Class 4 lasers shall only be given if the LSO is satisfied that control measures are adequate. (* Z136.1-2007 and Z136.8 only)	A1.2(14)	A2.2o	new LSO responsibility in Z136.1-2007 and Z136.8-2012
15		Alignment Eyewear	-	The LSO should review the need and use of alignment eyewear. (* Z136.8 only)	-	A2.2j	new LSO responsibility in Z136.8-2012, but can argue is already discussed in item 6. should is too weak in Z136.8; LSO review/approval of alignment eyewear
16	Hazard Evaluation and	Classification	3.1	Any laser or laser system shall be classified according to its accessible radiation during operation.	3.1 same description	A2.2 b) The LSO shall classify, or verify classifications of lasers	very similar
17		Classification	3.2	The LSO or knowledgeable individual responsible for laser classification shall ensure that laser output data are valid in accordance with section 9 (Measurements). Classification shall be based on the maximum output available for intended use.	3.2 same description	-	not described in Z136.8
18		Classification	3.2.1	The classification of lasers or laser systems capable of emitting numerous wavelengths shall be based on the most hazardous	3.2.1 same description	-	not described in Z136.8
19		Classification	3.2.1.1	A multiwavelength laser which by design can operate as a single-wavelength laser shall be classified as a single wavelength laser.	3.2.1.1 same description	-	not described in Z136.8
20		Classification	3.2.1.2	A multiwavelength laser which by design can operate over two or more wavelength regions shall require classification in each region of operation. The appropriate control measures for each region shall be taken.	3.2.1.2 same description	-	not described in Z136.8
17		Environment - Nominal Hazard Zone	3.4.1	Where applicable, e.g., in the presence of unenclosed Class 3b and Class 4 beams, the LSO shall be responsible for establishing the Nominal Hazard Zone...The LSO shall assure that consideration is given to direct, reflected and scattered radiation in the establishment of boundaries for the laser controlled area.	3.4.1 same description	3.2.1 text is changed	Z136.8 has longer description and more guidance.
		Environment - Indoor Laser	3.4.2	6-step procedure recommended for NHZ evaluation	3.4.2 same description	3.2.2 similar 5-step procedure recommended	very similar
		Environment - Outdoor Laser	3.4.3	6-step procedure recommended for hazard controls evaluation	3.4.3 same description with 2 steps added: i) determine if beam will visually interfere with critical tasks, and ii) determine whether optical aids could be used near beam path	3.2.3 same 8-step procedure as Z136.1-2007	no differences
		Environment - Laser Process Interactions	-	-	-	-	new section added in Z136.8, but covered by evaluating for non-beam hazards as described in 3.4.2

3.3

Z136.1(2000)/Z136.1(2007)/Z136.8(2012) Standards Comparison

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
		Environment - Laser Use Location	-	-	-	3.4 new section added in Z136.8. Defines 5 different use locations based on access considerations	Useful guidance, but requirements are adequately described in Z136.1 sections 3.4 and 3.5 for having hazard evaluation depend on environment and personnel
		Personnel	3.5	Hazard evaluation can depend on characteristics of personnel in vicinity of laser. Gives 8 characteristics to consider.	3.5 same description	3.5 but only 1 sentence description without noting specific characteristics to consider.	much shorter description in Z136.8
18	Control Measures	General Considerations	4.1	Control measures shall be devised to reduce the possibility of exposure of the eye and skin to hazardous levels of laser radiation and other hazards associated with laser devices during operation and maintenance.	4.1 same description	4.1 but modifies sentence to include service as well as operation and maintenance	very similar
19			4.1	Engineering controls shall be given primary consideration in instituting a control measure program for limiting access to laser radiation.	4.1 same description	4.1 same description	no differences
20			4.1	If engineering controls are impractical or inadequate, administrative and procedural controls and personal protective	4.1 same description	4.1 same description	no differences
21		General - operation, maintenance and service	4.1.1.1	...during periods of service or maintenance, control measures appropriate to the class of the embedded laser shall be implemented when the beam enclosures are removed and beam access is possible.	4.1.1.1 same description	4.1.1.1.1 same description	no differences
22			4.1.1.1	Instructions for the safe operation of lasers and laser systems are provided by the manufacturer. However, under some conditions, such instructions may not be sufficiently detailed for specific operations due to special use conditions. In this case, the LSO shall provide additional safety instructions.	4.1.1.1 same description	4.1.1.1.1 same description	no differences
23		General - supervised laser operation	4.1.1.2	Class 3b and Class 4 lasers or laser systems shall be operated at all times under the direct supervision or control of an experienced, trained operator who shall maintain visual surveillance of conditions for safe use and terminate laser emissions in the event of equipment malfunction or any other condition of unsafe use. The operator shall maintain visual access to the entire laser controlled area during all conditions of operations.	4.1.1.2 same description	4.1.1.2 same description	no differences
24		General - unattended laser operation	4.1.1.3	Only Class 1 laser or laser systems shall be used for unattended operation in unsupervised areas without the implementation of additional control measure requirements.	4.1.1.3 same description	4.1.1.3 same description	no differences

Z136.1(2000)/Z136.1(2007)/Z136.8(2012) Standards Comparison

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
			4.1.1.3	If a Class 2, Class 3a, Class 3b, or Class 4 laser or laser system is not operated at all times under the direct supervision or control of an experienced, trained operator, the laser radiation levels to which access can be gained shall be limited by control measures such as beam traps, barriers, windows, or other means of area control so that unprotected spectators in the area shall not be exposed to levels that exceed applicable MPE limits in any space in the area that they may occupy.	requirement eliminated for Class 2 and 3a	same as Z136.1-2007	Z136.1-2007 and Z136.8 consistent, but differ from Z136.1-2000
25			4.1.1.3	The unattended use of Class 2 and Class 3a lasers or laser systems in unsupervised areas shall be limited to installations which prevent access to the direct or specularly reflected beams, or where the beam(s) is only accessible by unprotected spectators at levels which do not exceed the applicable MPE.	4.1.1.3 modified to just require a warning sign/label	4.1.1.3 similar as Z136.1-2007	Z136.1-2007 and Z136.8 consistent, but differ from Z136.1-2000
26			4.1.1.3 (originally 4.1.3)	The unattended use of Class 3b or Class 4 lasers and laser systems shall be permitted only when the LSO has implemented appropriate control measures that provide adequate protection and laser safety training to those who may enter the laser controlled area during times of unattended use...All areas where unattended Class 3b or Class 4 lasers and laser systems operated shall be provided with standard laser safety warning signs with the "Danger" signal work with appropriate instructions regarding that hazards of entry into the space when no operator is present.	4.1.1.3 No change	Changed to: The unattended use of Class 3b or Class 4 lasers and laser systems shall be permitted only when: 1) The laser user or laser operator has implemented appropriate control measures that provide adequate protection. This may include enclosures, limiting open beam access points, securing access to the area (e.g. electronic lock), posting of sign(s) warning about unattended laser operation, posting the immediate open unattended zone, or; b) Laser safety training is provided and documented to those who may enter the LCA during times of unattended use. c)The control area should be under interlock access control, which will reduce laser exposure to at or below the MPE if an unauthorized person should gain entry; and d) The LSO has approved the operation.	Very similar

Z136.1(2000)/Z136.1(2007)/Z136.8(2012) Standards Comparison

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
27		Substitution of Alternate Control Measures	4.1.3	The LSO may substitute engineering control measures with procedural, administrative, or other alternate engineering controls which provide equivalent protection...Accordingly, if alternate control measures are instituted, then those personnel directly affected by the measures shall be provided the appropriate laser safety and operations training,	4.2-Upon review and approval by the LSO, the engineering control measures specified in 4.3 and administrative controls specified in 4.4 for Class 3B and Class 4 lasers or laser systems, may be replaced by procedural, administrative (see Section 4.4), or other alternate engineering controls which provide equivalent protection. This situation could occur, for example, in medical or research and development environments. Accordingly, if alternate control measures are instituted, then those personnel directly affected by the measures shall be provided the appropriate laser safety and operational training	4.1. eliminates clause that alternate controls must "provide equivalent protection"	Elimination of this clause in Z136.8 significantly weakens the requirements for alternate controls
28		Laser Pointers	4.1.6	The power limit of laser pointers shall not exceed 5mW.	4.1.5-laser pointers are technically limited to the maximum Class 3R (5mW) output	No section.	Not covered in 136.8, but not vital to intent of document.
29	Engineering controls	Protective Housing	4.3.1	A protective housing shall be provided for all classes of lasers or laser systems.	Same as 2000.	No section.	Not covered in 136.8, but representative of commercial lasers.
30		Operating without Protective Housing	4.3.1.1	In cases of operating a laser without a protective housing, The LSO shall effect a hazard analysis and ensure that control measures are instituted appropriate to the class of maximum accessible emission level to assure safe operation.	Same as 2000.	4.2.1 No change	No differences
31		Walk-in Protective Housing	4.3.1.2	Class 1 lasers or laser systems which contain embedded Class 3 b or Class 4 lasers with protective housings which are of sufficient size to allow personnel within the working space shall be provided with an area warning systems which is activated upon entry by personnel into the protective housing. the sensors shall be designed to interlock with the lasers power supply or laser shutter so as to prevent access to laser radiation above the applicable MPE. Only authorized personnel shall be provided means to override the sensors for alignment or testing procedures if beam access is required for beam diagnostic purposes, If overridden, an appropriate warning shall be activated.	Same as 2000.	No section.	Not covered in 136.8

Z136.1(2000)/Z136.1(2007)/Z136.8(2012) Standards Comparison

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
32		Interlocks on removable protective housing	4.3.2	Protective housings which enclose Class 3b and Class 4 lasers or laser systems shall be provided with an interlock system which is activated when the protective housing is opened or removed during operation and maintenance. The interlock or interlock system shall be designed to prevent access to laser radiation above the applicable MPE.	Same as 2000.	4.2.2 Same as Z136.1-2007	No differences
33			4.3.2	Fail safe interlocks shall be provided for any portion of the protective housing which, by design, can be removed or displaced during operation and maintenance, and thereby allows access to Class 3b or Class 4 laser radiation.	Same as 2000.	4.2.2 Same as Z136.1-2007. But adds statement "An alternative to fulfill the fail-safe requirement is requiring a tool for removing the housing or covering; an appropriate warning label shall be included on the panel/covering."	Alternative described is not an interlock and weakens the requirement.
34			4.3.2	The protective housing interlock shall not be defeated or overridden during operation unless the provisions of 4.3.1.1 have been fully implemented.	Same as 2000.	4.2.2 Same as Z136.1-2007	No difference
35		Service Access panels	4.3.3	Portions of the protective housing that are only intended to be removed from any laser or laser system by service personnel, which then permits direct access to laser radiation associated with a Class 3b or Class 4 laser or laser system, shall either: (1) be interlocked, or (2) require a tool for removal and shall have an appropriate warning label.	Same as 2000.	4.2.3 Same as Z136.1-2007	No difference
36			4.3.3	If the interlock can be bypassed or defeated, a warning label with the appropriate indications shall be located on the protective housing near the interlock. The label shall include language appropriate to the laser hazard. The interlock design shall not permit the service access panel to be replaced with the interlock bypassed or defeated.	Same as 2000.	4.2.3 Same as Z136.1-2007	No difference
37		Key Control	4.3.4	A Class 4 laser or laser system shall be provided with a master switch. This master switch shall effect beam termination and/or system shutoff and shall be operated by a key, or a coded access. The authority for access to the master switch shall be vested in the appropriate supervisory personnel. During periods of prolonged non-use, the master switch shall be left in a disabled condition.	Changed Class 4 laser to "should be provided."	4.2.4 Master Switch: Commercial Class 3B and Class 4 lasers or laser systems should be provide with a master switch by the manufacturer...and may be operated with a key, or by a coded access	Shall in .2000 changed to should in .2007 and 136.8. ".8" only notes this requirement for commercial laser systems.
38			4.3.4	A single master switch on a main control unit shall be acceptable for multiple laser installations where the operations controls have been integrated.	Same as 2000.	4.2.4. no changes	No difference
39			4.3.4	All energy sources associated with Class 3b or Class 4 lasers or laser systems shall be designed to permit lockout/tagout procedures required by the Occupational Safety and Health Administration of the U.S. Department of Labor.	Same as 2000.	4.2.4 changes "shall" to "should"	"Should" requirement in ".8" may not comply with OSHA

Z136.1(2000)/Z136.1(2007)/Z136.8(2012) Standards Comparison

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
40		Viewing windows and diffuse display screens	4.3.5.1	All viewing windows and diffuse display screens included as an integral part of a laser or laser system shall incorporate a suitable means to maintain the laser radiation at the viewing positions at or below the applicable MPE as determined by the LSO for all conditions of operation and maintenance.	Removed "for all conditions of operation and maintenance."	4.2.5.1 Same as Z136.1-2007 and added: In cases where this is not possible remote viewing shall be utilized.	No differences
41		Collecting optics	4.3.5.2	All collecting optics intended for viewing use with laser or laser system shall incorporate suitable means to maintain the laser radiation transmitted through the collecting optics to levels at or below the appropriate MPE, as determined by the LSO. Collecting optics shall be labeled.	Replaced with: All collecting optics (such as lenses, telescopes, microscopes, endoscopes, eye-loupes, etc.) that integrate the use of a laser or laser system shall incorporate suitable means (such as interlocks, filters, attenuators) to maintain the laser radiation transmitted through the collecting optics to levels at or below the appropriate MPE, AMERICAN NATIONAL STANDARD Z136.1-2007 30 as determined by the LSO (see Section 4.6.2.5.2). Collecting optics filter housings shall be labeled in accordance with Section 4.6.5.3.	4.2.5.3 -limit substituted for maintain	very similar
42		Fully open beam path	4.3.6.1	In applications of Class 3b or Class 4 lasers or laser systems where a beam path is unenclosed, a laser hazard analysis shall be effected by the LSO to establish the NHZ	No change	4.2.6.1 Same	No differences
43		Limited open beam path	4.3.6.2	In applications of Class 3b or Class 4 lasers or laser systems where the beam path is confined by design to significantly limit the degree of accessibility of the open beam, a hazard analysis shall be effected by the LSO to establish the NHZ...The LSO shall establish controls appropriate to the magnitude and extent of the accessible radiation	No change	4.2.6.1 Under Open Beam Path: class 1 conditions shall be considered as fulfilled in two cases: 1) for those limited open beam path lasers or laser systems where analysis, including measurements when necessary, confirms that the accessible levels during operation are at or below applicable MPEs, and 2) where limited open beam paths are such that human access or the placement of a tool as a normal part of operation is restricted.	very similar

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
44		Class 1 conditions	4.3.6.2.1	Frequently the hazard analysis will define an extremely limited NHZ and procedural controls can provide adequate protections. Class 1 conditions shall be considered as fulfilled for those limited open beam path lasers or laser systems where analysis, including measurements when necessary, confirms that the accessible levels during operation are at or below applicable MPE levels.	No change	4.2.6.1 Under Open Beam Path: "Class 1 conditions shall be considered as fulfilled in two cases: 1) for those limited open beam path lasers or laser systems where analysis, including measurements when necessary, confirms that the accessible levels during operation are at or below applicable MPEs, and 2) where limited open beam paths are such that human access or the placement of a tool as a normal part of operation is restricted." Also see 4.2.6.2	very similar
45		Remote Interlock Connector	4.3.7	...Class 4 laser or laser systems shall be provided with a remote interlock connector... When the terminals of the connector are open circuited, the accessible radiation shall not exceed the	No change	No section.	Not covered in 136.8
46		Beam Stop or Attenuator	4.3.8	A Class 4 laser or laser system shall be provided with a permanently attached beam stop or attenuator...The beam stop or attenuator shall be capable of preventing access to laser radiation in excess of the appropriate MPE level when the laser or laser system output is not required	No change	No section.	Not covered in 136.8
47		Warning Signs	4.3.9.1	Laser warning signs shall utilize warning statements as defined in Section 5 of ANSI Z535.2-1998	No change	This wording is not present.	Not covered in 136.8
48		Activation Warning Systems	4.3.9.4	An alarm (for example, an audible sound such as a bell or chime), a warning light (visible through protective eyewear), or a verbal "countdown" command for single pulse or intermittent operations shall be used with Class 4 lasers or laser systems during activation or startup.	Changed to: An activation warning system should be used with Class 3B, and shall be used with Class 4 lasers or laser systems during activation or startup.	Changed to: An activation warning system should be used with Class 3B and Class 4 lasers and laser systems during activation.	Reduced from a shall to should in 136.8 for Class 4 systems
49			4.3.9.4.2	For Warning systems, Only a green light shall be used to indicate a safe condition . The LSO shall consider alternative control measures for the hearing and visually impaired.	4.3.9.4.2 No change	4.2.7.2 same, section adds LED lights. Same Reference to only green light for safety.	No Change

Z136.1(2000)/Z136.1(2007)/Z136.8(2012) Standards Comparison

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
50		Class 3B Indoor LCA	4.3.10.1	The Class 3b laser controlled area shall : (1) Be controlled to permit lasers and laser systems to be operated only by personnel who have been trained in the operation of the laser, laser system and laser safety (2) Be posted with the appropriate warning sign(s), except as detailed in Section 4.5.1.10. An appropriate warning sign shall be posted at the entryway(s) and, if deemed necessary by the LSO, should be posted within the laser controlled area. (3) Be operated in a manner such that the path is well defined and projects into a controlled airspace when the laser beam must extend beyond an indoor controlled area, particularly to the outdoors under adverse atmospheric conditions, i.e., rain, fog, snow, etc.	4.3.10.1 divides (3) into (3) and (4)	4.2.8.1, a) - d). B) allows exemption for posting requirement if exclusions apply but doesn't specify exclusions.	Very similar in ".8" except for permitting unspecified exclusions for posting requirement.
51		Indoor Class 4 LCA	4.3.10.1 & 4.3.10.2.2	In addition to the above, a Class 4 controlled area shall : (4) Be under the direct supervision of an individual knowledgeable in laser safety. (5) Be located so that access to the area by spectators is limited and requires approval, except as detailed in 4.5. (6) Have any potentially hazardous beam terminated in a beamstop of an appropriate material. (7) Have only diffusely reflecting materials in or near the beam path, where feasible. (8) Provide personnel within the laser controlled area with the appropriate eye protection as specified in section 4.6. (9) Have the laser secured such that the exposed beampath is above or below eye level of a person in any standing or seated position, except as required for medical use. (10) Have all windows, doorways, open portals, etc. from an indoor facility be either covered or restricted in such a manner as to reduce the transmitted laser radiation to levels at or below the applicable ocular MPE. (11) Require storage or disabling (for example, removal of the key) of the laser or laser system when not in use to prevent unauthorized use.	4.3.10.1 former (4)-(11) now (5)-(12).	4.2.8.1 sections now are a)-d) and a)-h)	very similar
52			4.3.10.2	All Class 4 area or entryway safety controls shall be designed to allow both rapid egress by laser personnel at all times and admittance to the laser controlled area under emergency conditions. All personnel who require entry into a laser controlled area shall be appropriately trained, provided with appropriate protective equipment, and shall follow all applicable administrative and procedural controls.	4.3.10.2 No changes	4.2.8.2 title change to Indoor LCA (Class 4); "protective equipment" changed to "PPE"; removed reference to spectators	very similar

Z136.1(2000)/Z136.1(2007)/Z136.8(2012) Standards Comparison

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
53			4.3.10.2.1	For emergency conditions there shall be a clearly marked "Panic Button" (remote controlled connector or equivalent device) available for deactivating the laser or reducing the output to levels at or below the applicable MPE.	4.3.10.2.1 (removed reference to Red Mushroom type button)	4.2.8.2.1 changed to performance standard determined by the LSO.	Section revised, allows LSO to evaluate if emergency stop or other devices are necessary for emergency shutdown.
54			4.3.10.2.2	A Class 4 laser controlled area shall also incorporate one of the following alternatives: (1) Non-Defeatable (non-override) Area or Entryway Safety Controls. Non-defeatable safety latches, entryway or area interlocks (e.g., electrical switches, pressure sensitive floor mats, infrared, or sonic detectors) shall be used to deactivate the laser or reduce the output to levels at or below the applicable MPE in the event of unexpected into the laser controlled area. (2) Defeatable Area or Entryway Safety Controls. Defeatable safety latches, entryway, or area interlocks shall be used if non-defeatable area/entryway safety controls limit the intended use of the laser or laser system. For example, during normal usage requiring operation without interruption (e.g., long term testing, medical procedures, surgery), if it is clearly evident that there is no laser radiation hazard at the point of entry, override of the safety controls shall be permitted to allow access to authorized personnel provided that they have been adequately trained and provided with adequate personal protective equipment	4.3.10.2.2 same	4.2.8.2.2 a) & b) replaced example of "medical procedures, surgery" with "and warm up periods"	very similar
55			4.3.10.2.2 cont.	(3) Procedural Area or Entryway Safety Controls. Where safety latches or interlocks are not feasible or are inappropriate, for example during medical procedures, surgery, etc., the following shall apply: (a) All authorized personnel shall be adequately trained and adequate personal protective equipment shall be provided upon entry. (b) A door, blocking barrier, screen, curtains, etc. shall be used to block, screen, or attenuate the laser radiation at the entryway. The level of laser radiation at the exterior of these devices shall not exceed the applicable MPE, nor shall personnel experience any exposure above the MPE immediately upon entry. (c) At the entryway there shall be a visible or audible signal indicating that the laser is energized and operating at Class 4 levels.	4.3.10.2.2 same	4.2.8.2.2 c)	Very similar In 4.2.8.2.2 c)3, "activation warning system" replaces "visible or audible signal"

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
56		Outdoor Control Measures - General	4.3.11.1	<p>A Class 3b or Class 4 laser or laser system used outdoors shall meet the following requirements:</p> <p>(1) The LSO shall effect an analysis to establish the NHZ if not provided as part of the documentation furnished by the manufacturer.</p> <p>(2) If visible lasers are used at night, the LSO will effect an analysis to determine if the laser beams will visually interfere with critical tasks. For operation of visible lasers at night near airports, refer to FAA Order 7400.2 and ANSI Z136.6.</p> <p>(3) The NHZ shall be clearly posted with laser warning signs and demarcated and identified as the laser hazard area</p> <p>(4) All personnel authorized to enter the NHZ shall be appropriately trained.</p> <p>(5) Only personnel who have been authorized shall operate a laser or laser system.</p> <p>(6) Appropriate combinations of physical barriers, screening, and personnel protective equipment shall be provided and used by those personnel authorized within the NHZ.</p> <p>(7) Appropriate administrative controls shall be used if personnel are permitted within the NHZ.</p>	4.3.11.1 No changes	4.2.9 (new section - references back to 136.1 for systems involving general public) 4.2.9.1 a)-g) replaces (1)-(7)	Very similar
57			4.3.11.1 cont.	<p>(8) Directing the laser beam toward automobiles, aircraft, or other manned structures or vehicles shall be prohibited within the NHZ unless adequate training and protective equipment is provided and used by all personnel within these targets, or as authorized by the LSO and permitted by FAA Order 7400.2. In such authorized cases, it is essential that adequate training and protective equipment are provided and used by all personnel within these areas.</p> <p>(9) The exposed laser beam path shall not be maintained at or near personnel eye level without specific authorization of the LSO.</p> <p>(10) The beam path shall be confined and terminated wherever possible.</p> <p>(11) When the laser is not being used, it shall be disabled in a manner that prevents unauthorized use.</p> <p>(12) The operation of Class 4 lasers or laser systems during rain, snow-fall, fog, or dusty atmosphere may produce hazardous scattering near the beam. In such conditions, the LSO shall evaluate the need for, and specify the use of, appropriate personal protective equipment.</p>		4.2.9.1 h) - l)	No differences

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
58		Temporary LCA	4.3.12	In those conditions where removal of panels or protective housings, over-riding of protective housing interlocks, or entry into the NHZ becomes necessary, and the accessible laser radiation exceeds the applicable MPE, a temporary laser controlled area shall be devised for the laser or laser system. Such an area, which by its nature will not have the built in protective features as defined for a laser controlled area, shall provide all safety requirements for all personnel, both within and outside the area. A Notice sign shall be posted outside the temporary laser controlled area to warn of the potential hazard.	4.3.12 same	4.2.10 title expanded to include Temporary Laser Work Area - TLWA	Same, and expands section, adds use of TLCA for system acceptance.
59		Equipment Labels	4.3.14.1	All lasers or laser systems (except Class I) shall have appropriate warning labels with the laser sunburst logotype symbol and the appropriate cautionary statement. The label shall be affixed to a conspicuous place on the laser housing or control panel. Such labels should be placed on both the housing and the control panel if these are separated by more than 2 meters.	4.3.14.1 same	4.6.2.1.1 (ANSI Z35 design) and 4.6.2.1.2 (IEC 60825-1 design)	Removed 4.3.14.1 as written in 2000, 2007 revisions. Removed 4.7.5, "Pertinent Equipment Label Information" from 2000 & 2007 revisions. Equipment labeling addressed in Appendix H, Information Only
60			4.3.14.2	An advisory protective housing label that indicates the relative hazard of laser radiation contained within the housing shall be placed on all removable protective housings which have no safety interlock and which can be removed or displaced during maintenance, or service, and thereby allow access to laser radiation	4.13.4.2 same	Not specifically addressed	All under 4.6, "Warning Signs", no separate label section in standard, labeling requirements in Appendix H(g), information only
61			4.3.14.3	The LSO shall effect posting advisory protective housing labeling on long distance (>3 meters) beam conduits that contain beams operating above Class 1 levels. Such labeling shall be placed on the outside of the conduit at appropriate intervals (approximately 3 meters), to provide warning of the relative hazards of laser radiation contained within the conduit. The laser sunburst logotype symbol is not required on such advisory protective housing labels.	4.3.14.3 same	Not specifically addressed	Only in section (g)(6) of Appendix H, information only
62	Administrative and Procedure Controls		4.4	Unless otherwise specified, administrative and procedural controls shall apply only to Class 3b and Class 4 lasers or laser systems.	4.4 same	4.3	No changes
63		SOPs	4.4.1	The LSO shall (should) require and approve written SOPs for Class 4 (Class 3) lasers or laser systems. These written SOPs shall be maintained with the laser equipment for reference by the operator, and maintenance or service personnel	4.4.1 same	4.3.1 changes "should" to "shall" for Class 3B, but adds exemption for continuous wave visible lasers at or below 15 mW.	Adds SOP required for Class 3B as well as class 4. SOP for 3B was only recommendation ("should") in 2000 & 2007 revisions. But gives exemption for cw visible lasers below 15 mW.

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
64		Output emission limitations	4.4.2	If, in the opinion of the LSO, excessive power or radiant energy is accessible during operation or maintenance of a Class 3a, 3b, or Class 4 laser or laser system, the LSO shall take such action as required to reduce the levels of accessible power or radiant energy to that which is commensurate with the required application.	4.4.2, same, changes 3a designation to 3R	Not specifically addressed	Not covered in 136.8
65		education and training	4.4.3	Education and training shall be provided for operators, maintenance, and service personnel for Class 3b or Class 4 lasers or laser systems.	4.4.3 same	4.3.2	No changes
66		Authorized Personnel	4.4.4	Class 3b or Class 4 lasers or laser systems shall be operated, maintained, or serviced only by authorized personnel. Lasers or laser systems with enclosed Class 3b or Class 4 lasers shall be maintained or serviced only by authorized personnel if such procedures would permit access to levels which exceed the appropriate MPE.	4.4.4 same, changes MPE to Class 3R AEL	4.3.3	Section revised, more definitive for what "Authorized Personnel" means
67		Alignment Procedures	4.4.5	Alignment of Class 2, 3a, 3b, or Class 4 laser optical systems (mirrors, lenses, beam deflectors, etc.) shall be performed in such a manner that the primary beam, or a specular or diffuse reflection of a beam, does not expose the eye to a level above the applicable MPE. Written standard operating procedures (SOPs) outlining alignment methods shall be approved for Class 4 lasers or laser systems.	4.4.5 same	4.3.4	Deletes reference to Class 2, adds reference to 3R. Adds SOP required for Class 3B as well as class 4. SOP for aligning 3B was only recommendation ("should") in 2000 & 2007 revisions
		Alignment Procedures for Class 3B and Class 4 Lasers	4.4.5.1	not present in 2000 version	"Alignments should be done only by those who have received laser safety training. In addition, the following actions should be taken: "...then lists 12 items including to exclude unnecessary personnel, use low power alignment lasers etc.	4.3.5 has same 12 items as 2007 section and adds 2 new ones; changes 1 item description. Changes description for wearing protective equipment: use laser alignment eyewear for visible lasers, and use lab coat or long sleeve shirts for UV lasers. 2 new items are: whenever possible use remote viewing devices, and replace enclosures or beam blocks removed during the alignment procedure	More restrictive- adds additional "should" requirements

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
68		Spectators (Visitors)	4.4.6	Spectators shall not be permitted within a laser controlled area which contains a Class 4 laser or laser system unless: (1) appropriate approval from the supervisor has been obtained. (2) the degree of hazard and avoidance procedure has been explained. (3) appropriate protective measures are taken. Laser demonstrations involving the general public shall be governed by the requirements of 4.5.	4.4.6 same	4.4.1 addresses visitors and spectators in Class 3b and 4 LCAs. Adds 3 "shall" requirements : i) NHZ is explained, ii) direct supervision by experienced operator, and iii) LSO has approved SOP for visitors/spectators	More restrictive- covers Class 3b and 4, with 6 conditions that must be met, SOP approval by LSO required for visitor/spectator access
69		Service Personnel	4.4.7	Personnel who require access to Class 3b or Class 4 lasers or laser systems enclosed within a protective housing or protected area enclosure shall comply with the appropriate control measures of the enclosed or embedded laser or laser system. The LSO shall require that service personnel shall have the education and safety training commensurate with the class of the laser or laser system contained within the protective housing.	4.4.7 replaces "The LSO shall require that service personnel..." with "The LSO shall confirm that service personnel..."	4.3.6 same as Z136.1-2007, except that states the confirmation of vendor/manufacture training may be in form of a safety plan	This places the burden on the LSO to confirm but allows the LSO to request a safety plan from the vendor or manufacturer for confirmation
70		Laser Demonstrations Involving the General Public	4.5.1.1	Only Class 1 laser or laser systems shall be used for general public demonstration, display, or entertainment in unsupervised areas without additional requirements. If unsupervised, the use of Class 2 and Class 3a lasers or laser systems shall be limited to installations which prevent access to the direct or specularly reflected beams or where the accessible radiation is maintained at the distance requirements specified in 4.5.1.6. The use of Class 3b or Class 4 lasers or laser systems shall be permitted only when the LSO has assured that appropriate controls are incorporated which provide for adequate protection to the general public, and under the following conditions: (1) When the laser operation is under the control of an experienced, trained operator as specified in 4.5.1.7.	4.5.1.1 & 4.5.1.2 same	Not specifically addressed	Not covered in 136.8
71			4.5.1.1 cont.	(2) When the laser is operated in an unsupervised laser installation provided that a designated person, present at all times at the show or display, is responsible for the immediate termination of the laser equipment in the event of equipment malfunction, audience unruliness, or other unsafe conditions. For training of operators see Section 5. (3) When all Federal, State, and local requirements for a safe operation have been met prior to the operation of the laser or laser system. (4) When pre-show alignment and verification have been completed.			
72			4.5.1.2	The general public shall not be exposed nor have access to laser radiation emission at wavelengths outside the visible range (0.4 to 0.7 um) at levels exceeding the applicable MPE levels under any reasonably foreseeable conditions of operation.	4.5.1.3 same	Not specifically addressed	Requirements for the General Public have been removed

Z136.1(2000)/Z136.1(2007)/Z136.8(2012) Standards Comparison

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
73			4.5.1.3	Laser radiation in the location where the general public is normally allowed shall not exceed the applicable MPE levels during operation. Laser radiation to be considered shall include reflections from all possible surfaces and scattering materials.	Section has been removed	Not specifically addressed	Requirements for the General Public have been removed
74			4.5.1.4	All operators, performers, and employees shall be able to perform their required functions without the need for exposure to laser radiation levels in excess of the applicable MPE level.	4.5.1.4 same	Not specifically addressed	Requirements for the General Public have been removed
75			4.5.1.5	Scanning devices, rotating mirrored balls, shall incorporate a means to prevent laser emission if scan failure or other failure resulting in a change in either scan velocity or amplitude would result in failure to fulfill the criteria given in 4.5.1.3 and 4.5.1.4.	4.5.1.5 same	Not specifically addressed	Requirements for the General Public have been removed
76			4.5.1.6	If a laser demonstration using a Class 2, Class 3a, Class 3b, or Class 4 laser does not operate at all times under the direct supervision or control of an experienced, trained operator, the laser radiation levels to which access can be gained shall be limited by barriers, windows, or other means so as not to exceed the limits of the applicable MPE. This limitation applies at any point less than 6 m above any surface upon which a person in the general public is permitted to stand and to any point less than 2.5 m in lateral separation from any position where a person in the general public is permitted to be present during the performance or display	Applies to Class 3B and Class 4 lasers only.	Not specifically addressed	Requirements for the General Public have been removed
77			4.5.1.7	Laser demonstrations which do not meet the criteria stated in 4.5.1.6 shall be operated at all times under the direct supervision or control of an experienced, trained operator who shall maintain constant surveillance of the laser display and terminate the laser emission in the event of equipment malfunction, audience unruliness, or other unsafe conditions.	Includes further guidance on vertical and lateral separation distances.	No directly correlating requirements in this standard.	Not covered in 136.8
78			4.5.1.7 cont.	The operator shall have visual access to the entire area of concern. If obstacles or size preclude visual access by the operator, then multiple observers shall be used, with a communication link to the operator. In such supervised installations accessible laser radiation shall be limited by barriers, windows, or other means so as to not exceed the applicable MPE (see Section 4.5.1) at any point unless the following requirements are met: (1) The accessible laser radiation is maintained a minimum distance of 3.0m above any surface upon which the general public would be able to stand during a performance. (2) The accessible laser radiation is maintained a minimum distance of 2.5 m in lateral separation from any position where the general public is permitted to be present during the performance or demonstration			

Z136.1(2000)/Z136.1(2007)/Z136.8(2012) Standards Comparison

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
79			4.5.1.8	All laser demonstration systems shall be provided with a readily accessible means to effect immediate termination of the laser radiation. If the demonstration does not require continuous supervision or operator control during its operation, there must be a designated person at all times at the show or display who is responsible for the immediate termination of the laser radiation in the event of equipment malfunction, audience unruliness, or other unsafe conditions.	Identical to text in 2000 version of standard. Only applicable to Class 3B & Class 4 lasers.	No directly correlating requirements in this standard.	Not covered in 136.8
80			4.5.1.9	The maximum output power of the laser shall be limited to the level required to produce the desired and intended effect within the limitations outlined in 4.5.1.1 through 4.5.1.8.	Identical to text in 2000 version of standard. Only applicable to Class 3B & Class 4 lasers.	No directly correlating requirements in this standard.	Not covered in 136.8
81			4.5.1.11	The laser operator or LSO responsible for producing the laser demonstration shall determine that any applicable federal, state, or local requirements are satisfied.	Identical to text in 2000 version of standard. Only applicable to Class 3B & Class 4 lasers.	No directly correlating requirements in this standard.	Not covered in 136.8
82		Laser Optical Fiber Transmission Systems	4.5.2	Laser transmission systems which employ optical cables shall be considered enclosed systems with the optical cable forming part of the enclosure. When the system provides access to laser radiation above the applicable MPE via a connector, the conditions given in 4.5.2.1 or 4.5.2.2 shall apply.	Identical to text in 2000 version of standard. Only applicable to Class 3B & Class 4 lasers.	4.4.3 Identical to requirements in 2007 version of ANSI Z136.1.	No Difference
83			4.5.2.1	Connection or disconnection during operation shall take place in an appropriate laser controlled area when MPE is exceeded	Identical to text in 2000 version of standard. Only applicable to Class 3B & Class 4 lasers.	4.4.3.1 Identical to requirements in 2007 version of ANSI Z136.1.	No Difference
84				Connection or disconnection during maintenance, modification, or service shall take place in a temporary laser controlled area when MPE is exceeded	Identical to text in 2000 version of standard. Only applicable to Class 3B & Class 4 lasers.	This particular paragraph on maintenance is not discussed in Z136.8	Not covered in 136.8
85			4.5.2.2	Fibers attached to Class 3b or Class 4 lasers or laser systems shall not be disconnected prior to termination of transmission of the beam into the fiber. In this case, if laser radiation above the applicable MPE levels can be made accessible by disconnection of a connector, the connector shall bear a label or tag bearing the words "Hazardous Laser Radiation when Disconnected." When the connection or disconnection is made within a secured enclosure, no tool for connector disconnection shall be required, but a warning sign appropriate to the class of laser or laser	Identical to text in 2000 version of standard. Only applicable to Class 3B & Class 4 lasers.	4.4.3.2 Identical to requirements in 2007 version of ANSI Z136.1. Except states connector requiring a specific tool is equivalent to an interlocked system.	ANSI Z136.8 - Slightly different wording in the paragraph. End of paragraph has a statement on disconnecting fiber with a tool and they equivalency to an interlocked system.

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
86	Protective Equipment	Protective Eyewear	4.6.2.1	Eye protection devices which are specifically designed for protection against radiation from Class 4 lasers or laser systems shall be administratively required and their use enforced when engineering or other procedural and administrative controls are inadequate to eliminate potential exposure in excess of the applicable MPE. Laser protective eyewear shall be specifically selected to withstand either direct or diffusely scattered beams. In this case, the protective filter shall exhibit a damage threshold for a specified exposure time, typically 10 seconds. The eyewear shall be used in a manner so that the damage threshold is not exceeded in the "worst case" exposure scenario.	Identical to text in 2000 version of standard. Only applicable to Class 3B & Class 4 lasers.	4.5.2.1 Identical to requirements in 2007 version of ANSI Z136.1.	ANSI Z136.8 - Further elaboration regarding variations within same pair of laser protective eyewear based on coating/incident angle.
87			4.6.2.2.1	Exposure to UV radiation shall be minimized by using beam shields and clothing which attenuate the radiation to levels below the MPE for the specific UV wavelengths.	Section 4.6.2.2 combined sections 4.6.2.2.1 & 4.6.2.2.2 from 2000 version of standard	Identical to requirements in 2007 version of ANSI Z136.1.	No Difference
88			4.6.2.2.2	Hazardous byproducts: Special attention shall be given to the possibility of producing undesirable reactions in the presence of UV radiation. For example, formation of skin sensitizing agents, ozone, LGACs, etc.	Incorporated into section 4.6.2.2 in this version of the standard.	Identical to requirements in 2007 version of ANSI Z136.1.	No Difference
89			4.6.2.2.3	Personnel Protective Equipment (PPE), shall be used when working with open beam Class 3b or Class 4 UV lasers. This shall include both face and skin protection.	Incorporated into section 4.6.2.2 in this version of the standard.	Identical to requirements in 2007 version of ANSI Z136.1.	
90			4.6.2.2.4	The following factors shall be considered in selecting the appropriate laser protective eyewear to be used: (1) Laser power and/or pulse energy (2) Wavelength(s) of laser output (3) Potential for multi-wavelength operation (4) Radiant exposure or irradiance levels for which protection (worst case) is required (5) Exposure time criteria (see Section 4.6.2.5.2) (6) Maximum permissible exposure (MPE) (see Section 8, Criteria for Exposure of the Eye and Skin) (7) Optical density requirement of eyewear filters at laser output wavelength (8) Angular dependence of protection afforded (9) Visible light transmission requirement and assessment of the effect of the eyewear on the ability to perform tasks while wearing the eyewear (10) Need for side-shield protection and maximum peripheral vision requirement	Identical to text in 2000 version of standard. Only applicable to Class 3B & Class 4 lasers.	Identical to requirements in 2007 version of ANSI Z136.1.	ANSI Z136.8 - Information is in slightly different order, but the same elements are included.

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
91			4.6.2.2.4 cont.	(11) Radiant exposure or irradiance and the corresponding time factors at which laser safety filter characteristics change occurs, including transient bleaching especially for ultrashort pulse lengths (12) Need for prescription glasses (13) Comfort and fit (14) Degradation of filter media, such as photobleaching (15) Strength of materials (resistance to mechanical trauma and shock) (see ANSI Z87-1989 for appropriate criteria) (16) Capability of the front surface to produce a hazardous specular reflection (17) Requirement for antifogging design or coatings			
92			4.6.2.5.1	The optical density (attenuation), OD, of laser protective eyewear at a specific wavelength shall be specified. The optical density of the protective material shall be determined for all anticipated viewing angles and wavelengths.	Identical to text in 2000 version of standard. Only applicable to Class 3B & Class 4 lasers.	Identical to requirements in 2007 version of ANSI Z136.1.	No Difference
93			4.6.5.2.2	The time of intended use of the laser or laser system shall be used as the time factor upon which the MPE computation is based. When long-term exposure to any laser is possible, the applicable MPE used to establish the optical density requirement for eye protection shall be based on a 30,000 second exposure.	Identical to text in 2000 version of standard. Only applicable to Class 3B & Class 4 lasers.	Identical to requirements in 2007 version of ANSI Z136.1.	No Difference
94			4.6.2.6	Adequate optical density, OD, at the laser wavelength of interest shall be weighed with the need for adequate visible transmission.	Identical to text in 2000 version of standard. Only applicable to Class 3B & Class 4 lasers.	Identical to requirements in 2007 version of ANSI Z136.1.	ANSI Z136.8 - Expands on Visible Light Transmission (VLT). States minimum VLT for most applications is 20%.
95			4.6.2.7	All laser protective eyewear shall be clearly labeled with the optical density and wavelength for which protection is afforded. Color coding or other distinctive identification of laser protective eyewear is recommended in multi-laser environments.	Identical to text in 2000 version of standard. Only applicable to Class 3B & Class 4 lasers.	Identical to requirements in 2007 version of ANSI Z136.1.	ANSI Z136.8 - Multiple laser environment labels worded differently. Also includes European Norm (EN) labelling criteria.
96			4.6.2.8	Periodic cleaning and inspection shall be made of p.rotective eyewear to ensure the maintenance of satisfactory condition. The frequency of the safety inspection should be once per year, or as determined by the LSO. This shall include: (1) Periodic cleaning of laser eyewear. Care should be observed when cleaning lenses of protective eyewear to avoid damage to the absorbing and reflecting surfaces. (2) Inspection of the attenuation material for pitting, crazing, cracking, discoloration etc. (3) Inspection of the frame for mechanical integrity. (4) Inspection for light leaks and coating damage. Eyewear in suspicious condition should be tested for acceptability or	Identical to text in 2000 version of standard. Only applicable to Class 3B & Class 4 lasers.	Identical to requirements in 2007 version of ANSI Z136.1.	Cleaning and inspection is only a should

Z136.1(2000)/Z136.1(2007)/Z136.8(2012) Standards Comparison

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
97			4.6.2.9	Facility windows (exterior or interior) that are located within the NHZ of a Class 3b or Class 4 laser or laser system shall be provided with appropriate absorbing filter, scattering filter, blocking barrier, or screen which reduces any transmitted laser radiation to levels below the applicable MPE level. Such laser windows shall be specifically selected to withstand direct and diffusely scattered beams. In this case, the window barrier shall exhibit a damage threshold for beam penetration for a specified exposure time commensurate with the total hazard evaluation for the facility and specific application.	Identical to text in 2000 version of standard. Only applicable to Class 3B & Class 4 lasers.	Identical to requirements in 2007 version of ANSI Z136.1.	ANSI Z136.8 - Uses the term laser generated airborne contaminant (LGAC) versus toxic airborne contaminants, which is used in the ANSI Z136.1 standard
		Labeling of protective windows (Class 3B or Class 4)	4.6.5.2	All laser protective windows, sold other than as an integral part of a product, shall be labeled with the optical density and wavelength(s) for which protection is afforded (see Section 4.6.2.4). Such windows should also be labeled with the exposure time for which the limit applies and the conditions under which protection is afforded.	Identical to text in 2000 version of standard.	No labelling requirement mentioned in this standard.	Not covered in 136.8
		Labeling of Collecting Optics Filters (Class 3B or Class 4)	4.6.5.3	All permanently mounted collecting optics housings containing laser protective filters sold other than as an integral part of a product shall be labeled with the optical density and wavelength(s) for which protection is afforded (see Section 4.6.2.5). All collecting optics filter housings should also be labeled with the threshold limit (TL) and exposure time for which the limit applies and the conditions under which protection is afforded.	Identical to text in 2000 version of standard.	No labelling requirement mentioned in this standard.	Not covered in 136.8
98		Labeling of protective barriers (Class 3B or Class 4)	4.6.5.4	All laser protective barriers shall be labeled with the barrier threshold limit (TL) and exposure time for which the limit applies and the beam exposure conditions under which protection is afforded	Identical to text in 2000 version of standard.	No labelling requirement mentioned in this standard.	Not covered in 136.8
99			4.6.6	In some laser applications, such as use of excimer lasers operating in the ultraviolet, the use of a skin cover shall be employed if chronic (repeated) exposures are anticipated at exposure levels at or near the applicable MPE limits for skin.	Identical to text in 2000 version of standard. Only applicable to Class 3B & Class 4 lasers.	Identical to requirements in 2007 version of ANSI Z136.1.	No Difference
100	Area Warning Signs and Equipment Labels		4.7.1	Sign dimensions, letter size and color, etc., shall be in accordance with American National Standard Specification for Accident Prevention Signs, ANSI Z535 series (latest revision thereof).	Identical to text in 2000 version of standard. Only applicable to Class 3B & Class 4 lasers.	Identical to requirements in 2007 version of ANSI Z136.1.	No Difference
101			4.7.2.1.1	The laser hazard symbol shall be a sunburst pattern consisting of two sets of radial spokes of different lengths and one long spoke, radiating from a common center. This is as specified in ANSI Z535 series of the National Standard Specification for Accident Prevention Signs, latest revision thereof.	Identical to text in 2000 version of standard. Only applicable to Class 3B & Class 4 lasers.	Identical to requirements in 2007 version of ANSI Z136.1.	ANSI Z136.8 - Applies only to Warning signs or alternate specifications in Section 4.7.3 of ANSI Z136.1 standard.

Z136.1(2000)/Z136.1(2007)/Z136.8(2012) Standards Comparison

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
102			4.7.2.1.2	The laser hazard symbol shall be composed of an equilateral triangle surrounding a sunburst pattern consisting of two sets of radial spokes of different lengths and one spoke, radiating from a common center (see Figure 1c). This is as specified in IEC 60825-1 (1998-01), or latest revision thereof.	Identical to text in 2000 version of standard. Only applicable to Class 3B & Class 4 lasers.	Identical to requirements in 2007 version of ANSI Z136.1.	No Difference
103			4.7.3.1	The signal word "Danger" shall be used with all signs and labels associated with all Class 3a lasers and laser systems that exceed the appropriate MPE for irradiance and all Class 3b and Class 4 lasers and laser systems.	Same	4.6.3.1	No Difference
104			4.7.3.2	The signal word "Caution" shall be used with all signs and labels associated with Class 2 lasers and laser systems and all Class 3a lasers and laser systems that do not exceed the appropriate MPE for irradiance.	Same	4.6.3.2	No Difference
105			4.7.3.3	The signal word "Notice" shall be used on signs posted outside a temporary laser controlled area for example, during periods of service.	Same	4.6.3.3	No difference
106			4.7.4.3	All signs shall be conspicuously displayed in locations where they best will serve to warn onlookers	Same	4.6.4.3 Same. New section 4.6.3.4 allows use of WARNING sign	No difference
107		Pertinent equipment label information	4.7.5	All equipment warning labels shall be conspicuously displayed in locations on the equipment where they best will serve to warn onlookers	Same	No labelling requirement mentioned in this standard.	Not covered in 136.8
108	Employee Training	General	5.1	The management (employer) has the fundamental responsibility for the assurance of the safe use of lasers owned and/or operated by the employer. The management (employer) shall establish and maintain an adequate program for the control of laser hazards. Employer and/or facility safety programs and employee training programs shall be required for Class 3b or Class 4 lasers and laser systems.	Added Class 1M, 2M, 3R to the " should " requirement. Also added here was that training " shall " be commensurate with the degree of potential hazard both from laser radiation and non-beam hazards. Appendix D greatly simplified.	Requirement for CPR training removed from Appendix D. Added OJT to Appendix D as a should.	Shall be commensurate with the degree of potential hazard and calling out OJT training as something that should be done.

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
109	Employee Training	Laser Safety Programs	5.2	The laser safety program established by the employer shall include provisions for the following: (1) Delegation of authority and responsibility to the LSO for the monitoring and enforcement of hazard evaluation and control of laser hazards. Responsibility without adequate accompanying authority greatly dilutes the effectiveness of the program. Depending on the number of lasers in use, and the complexity of the lasers and their associated use, the position of LSO may or may not be a full-time assignment. Where the number and/or diversity of laser operations warrants, an associated Laser Safety Committee may be formed and utilized. When there is normally no requirement for an LSO, such as the operation of Class 1, Class 2, or Class 3a lasers and laser systems which contain lasers with a higher classification, the designation of LSO for temporary periods of access for servicing, training, etc. may be the responsibility of the organization requiring access, such as a service organization. However, there shall be a designated LSO for all circumstances of operations of a laser or laser system where there is human access to greater than Class 3a levels of laser radiation.	This section has changed to "Refresher Training". The employer shall address the needs for maintaining the appropriate level of laser safety proficiency through the use of periodic training. The implementation and frequency of refresher training shall be considered on the basis of the total hazard evaluation criteria presented in Section 3 of this standard.	same as Z136.1-2007	This section has significantly changed from 2000-2007 revs.
110			5.2 cont.	(2) Education of authorized personnel (LSOs, operators, service personnel and others) in the safe use of lasers and laser systems, and, as applicable, the assessment and control of laser hazards. This may be accomplished through training programs. Employers may consider the benefits of initiating awareness training for employees working with or exposed to Class 1 lasers and laser systems. (3) Application of adequate protective measures for the control of laser hazards as required in Section 4. (4) Incident investigation, including reporting of alleged accidents, and preparation of action plans for the future prevention of accidents following a known or suspected incident. (5) Provide an appropriate medical surveillance program in			
111	Employee Training	Education	5.3	The employer shall consider the guidance in Appendix D when determining the requirements for a laser safety training program. The employer shall consider the needs for maintaining the appropriate level of laser safety proficiency through the use of periodic retraining.	This has been changed to Trainer Qualifications. Education and training programs shall be conducted by individuals with training skills adequate and appropriate wo the subject matter being taught (5.3.1 - 2000)	Changed to Hands-on Training (OJT)	OJT training being specified
112	Employee Training	Trainer Qualifications	5.3.1	Education and training programs shall be conducted by individuals with training skills adequate and appropriate to the subject matter being taught.	same as 5.3	this is Section 5.4 in ".8"	

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
113	Employee Training	Traning Authorization	5.3.2	The management shall provide the authorization of those conducting the training programs.	Not specifically addressed	Not specifically addressed	the Z136.1 (2007) nor the Z136.8 state that the management shall provide authorization for thos conducting training programs.
114	Employee Training	LSO	5.3.2.1	The management shall provide for training to the LSO on the potential hazards (including bioeffects), control measures, applicable standards, medical surveillance (if applicable) and any other pertinent information pertaining to laser safety and applicable standards, or provide to the LSO adequate consultative services. The training shall be commensurate to at least the highest class of laser under the jurisdiction of the LSO. The training shall also include consideration for the evaluation and control of any non-beam hazards associated with the lasers and the laser systems under the jurisdiction of the LSO.	Section 5.4	Section 5.5 LSO shall be required to complete refresher training	Biggest change here is the requirement for LSO refresher training in the Z136.8.
115	Employee Training	Users	5.3.2.2	Laser safety training program(s) shall be provided to the users of Class 3b or Class 4 lasers and laser systems...Users shall include operators, technicians, engmeers, maintenance and service personnel, and any other personnel, working with or around lasers. The training shall ensure that the users are knowledgeable of the potential hazards and the control measures for laser equipment they may have occasion to use. All training shall be commensurate with the greatest potential for hazards associated with each laser operation, and shall be consistent with the results of the completed hazard evaluation as performed in accordance with Section 3 of this standard (considers the laser, the environment and the personnel). Where appropriate, training shall include electrical safety and cardiopulmonary resuscitation (CPR).	Section 5.5. The language in the 2007 revision has been cleaned up and easier to read, but basically states same requirements.	Section 5.6 OJT training shall be required for all personnel likely to encounter exposure levels above the Class 3R MPE. Removes the requirement for CPR training.	Difference here from 2007 to Z136.8 is that in 2007 states The training shall ensure that the users are knowledgeable of the potential hazards and the control measures for the laser equipment they may have <i>occasion to use</i> . In the ".8" it states <i>occasion to encounter</i> . ".8" calls out the requirement for OJT training. It also removes the requirement for CPR Training.
116	Medical Surveillance	General	6.1	Medical surveillance shall be required for users of Class 3b and Class 4 lasers and laser systems. Requires initial exam prior to starting laser work and then to repeat that following any suspected injury.	Changes "shall" to "should" for initial exam. Medical Examinations shall be performed as soon as practical (usually within 48 hours) when a suspected injury or adverse effect from a laser exposure occurs.	Removes " should " requirement for initial exam and states this is at discretion of the institution.	2007 and ".8" do not require initial laser eye exam. All state requirements for eye exam following exposure
117	Medical Surveillance	Personnel Categories	6.2	Each employees category shall be determined by the LSO in charge of the installation involved	6.2.1-6.2.3	No longer categories. Only refers to those working with lasers	Similar

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
117	General Procedures		6.3.1	Incidental personnel shall have an eye examination for visual acuity.	same	Section 6.3 Medical laser surveillance is at the discretion of the institution for Class 3B and Class 4 lasers and laser systems.	Reduced from shall to the discretion of institution
118	General Procedures		6.3.2	Laser personnel shall be subject to the following baseline eye examination: Ocular history (E2.2.1). If the ocular history shows no problems and visual acuity (E2.2.2) is found to be 20/20 (6/6 in each eye for far, and Jaeger 1 + for near) with corrections (whether worn or not), and Amsler Grid Test (E2.2.3) and Color Vision (E2.2.4) responses are normal, no further examination is required.	same	Section 6.4	Same
119	General Procedures	Frequency of Medical Examinations	6.4	For both incidental and laser personnel, required examinations shall be performed prior to participation in laser work. Following any suspected laser injury, the pertinent required examinations will be repeated, in addition to whatever other examinations may be desired by the attending physician. Periodic examinations are not required.	shall statement changed to should	Not specifically addressed	Eye exam changed from shall to should
120	Non-Beam Hazards	LGACs	7.3	The LSO shall ensure that industrial hygiene aspects of exposure to LGAC are addressed and that appropriate control measures are effected. The LSO shall ensure that appropriate industrial hygiene characterizations of exposure to LGAC are effected in accordance with applicable federal, state, and local requirements.	7.3 Same	Apendix F - F2.1	Section moved to appendix for information only in ".8"
121	Non-Beam Hazards	Exhaust Ventilation	7.3.1.1	Exhaust ventilation shall ensure that all personnel exposures to hazardous concentrations of LGAC are maintained at or below the allowable levels specified by OSHA, NIOSH, ACGIH, or other applicable authorities.	7.3.5.1 Same	Appendix F2.1	Section moved to appendix for information only in ".8"
122	Non-Beam Hazards	Assist Gasses	7.3.2	In addition to controlling for LGAC, the LSO shall be aware of the possible hazards from associated gases used to assist laser/ workpiece interactions and their related fume production.	7.3.4 Same	Apendix F2.2	Section moved to appendix for information only in ".8"
123	Non-Beam Hazards	UV and Visible Radiation	7.4.1.2	Collateral UV emitted from laser discharge tubes and pump lamps shall be suitably shielded so that personnel exposures are maintained within exposure limits specified by the ACGIH	Not specifically addressed	Appendix F1.2.1.2	Section moved to appendix for information only in ".8"
124	Non-Beam Hazards	Explosion Hazard	7.6	High-pressure arc lamps, filament lamps, and capacitor banks in laser equipment shall be enclosed in housings which can withstand the maximum explosive pressure resulting from component disintegration. The laser target and elements of the optical train which may shatter during laser operation shall also be enclosed or equivalently protected to prevent injury to operators and	Section 7.2.4	Appendix F1.4	Section moved to appendix for information only in ".8"
125	Non-Beam Hazards	Laser Dyes and Solvents	7.8	An MSDS for dye compounds shall be available to all appropriate workers. Dye lasers containing at least 100 milliliters of flammable liquids shall be in conformance with the provisions of the NFPA (NFPA 30 and 45), and the NEC (Article 500 - Hazardous(classified)Locations). Laser dyes shall be prepared in a laboratory fume hood.	Section 7.3.3	Appendix F2.3	Section moved to appendix for information only in ".8"

Z136.1(2000)/Z136.1(2007)/Z136.8(2012) Standards Comparison

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
126	Non-Beam Hazards	Waste Disposal	7.11	Proper waste disposal of contaminated laser-related material, such as flue and smoke filters, organic dyes, and solvent solutions shall be handled in conformance with appropriate local, state, and federal guidelines.	Section 7.5.4.2	Section 7.2.2	Section moved to appendix for information only in ".8"
127	Non-Beam Hazards	Limited Work Space	7.12	Whenever lasers or laser systems are used in limited work space, local exhaust, mechanical ventilation and respiratory protection shall be used if LGACs are present.	Section 7.5.2	Appendix F2.1.2	Section moved to appendix for information only in ".8"
128	Non-Beam Hazards	Ergonomics	7.13	The LSO shall be aware of hazards created by neglecting ergonomic principles in laser system designs, such as positioning of the laser system and area illumination. Painful arm, hand, and wrist injuries (e.g., carpal tunnel syndrome) may result from repetitive motions occurring during the use of some laser products.	Section 7.5.1	Covered in Appenix F4 - Human Factors	Section moved to appendix for information only in ".8"
129	Criteria for Exposures to		8	A limiting aperture or cone angle γ shall be used for measurements or calculations with all MPE values.	Same	Not specifically addressed	This section drastically reduced in the ".8"
130	Criteria for Exposures to Eye and Skin	Ocular Exposure from small sources and extended sources	8.1	Each independent subsource of the extended source shall be considered as a separate source and the results compared to the MPE based on the source size of the separate source. Then, the entire source (or any combination of subsources) shall be considered as a single source and compared to the MPE based on the size of the entire source (or combination of subsources). Combinations of sources whose centers are separated by an angle greater than α_{max} (100 mrad) are considered independent.	Same	Not specifically addressed	This section drastically reduced in the ".8"

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
131	Criteria for Exposures to Eye and Skin	Repeated Exposures	8.2.3	<p>Rule 1: Single-Pulse MPE. The exposure from any single pulse in a train of pulses shall not exceed the MPE for a single pulse of that pulse duration. (Rule 1 protects against thermal injury from any single pulse having greater than average energy.)</p> <p>Rule 2: Average Power MPE for Thermal and Photochemical Hazards. The exposure from any group of pulses (or sub-group of pulses in a train) delivered in time T shall not exceed the MPE for time T. That is, the average power for any duration shall not exceed the MPE of a single pulse of train duration T and the total energy of all pulses within the train. Depending upon the complexity of the pulse train, the calculation of several potential MPEs (for different pulse groupings) may be required. The calculation of Rule 2 usually provides a lower MPE value for lasers with a high duty cycle than by applying Rule 3 below. (Rule 2 protects against cumulative injury from photochemical damage mechanisms and also against heat buildup from average power for thermal injury.)</p> <p>Rule 3: Multiple-pulse MPE for Thermal Hazards. The exposure for any single pulse within a group of pulses (each separated by at least t_{min}) shall not exceed the single-pulse MPE (for $t > t_{min}$) multiplied by a multiple-pulse correction factor C_p. The multiple-pulse correction factor C_p is $n^{-0.25}$, where n is the number of pulses. Rule 3 applies only to MPEs for thermal injury, where all pulses delivered in less than t_{min} are treated as a single pulse. (Rule 3 protects against sub-threshold pulse-cumulative thermal injury.)</p>	Same	Not specifically addressed	This section drastically reduced in the ".8"
132	Criteria for Exposures to Eye and Skin	MPE for skin, Repeated Exposures	8.4.1	For repetitive-pulse lasers the MPEs for skin exposure are applied as follows: Exposure of the skin shall not exceed the MPE based upon a single-pulse exposure, and the average irradiance of the pulse train shall not exceed the MPE applicable for the total pulse train, duration T.	Same	Not specifically addressed	This section drastically reduced in the ".8"
133	Measurements	General	9.1	When comparing measured results to the MPE or AEL, the combined uncertainty due to all sources of inaccuracy shall not exceed $\pm 20\%$, or, if this is not possible, the best that the state of the art reasonably will permit. Measurements shall be made with the laser adjusted to produce the most hazardous exposure conditions for the intended use.	Same	Not specifically addressed	No section in ".8"
134	Measurements	Small-source and extended-source measurements	9.2	If measurements or calculations are required, distinction shall first be made between small-source viewing and extended-source viewing in the 0.4 to 1.4 μm wavelength region. For photochemical MPEs and AELs over the wavelength range from 400 nm to 600 nm, the specified field of view γ shall be used for averaging radiance.	Same	Not specifically addressed	No section in ".8"

Z136.1(2000)/Z136.1(2007)/Z136.8(2012) Standards Comparison

Item No.	Requirement Topic	Requirement SubTopic	Z136.1-2000 (Section)	Requirement Statement in Z136.1-2000 (* except as noted)	Z136.1-2007 Comparison	Z136.8-2012 Comparison	Comments
135	Measurements	Radiant Energy or Power	9.2.1.1	That radiant energy or power which can be collected in a circular limiting aperture having a diameter as given in Table 8 shall be measured for comparison with the MPE or AEL. The aperture shall be placed at a distance of 10 cm from the location of the apparent source. However, if the apparent source is at a location within the product that is more than 10 cm from a window or nearest point of ocular approach, the collecting aperture shall be placed at the window or the nearest point of ocular approach. If the product is intended for use in an environment where the use of optical instruments such as telescopes and binoculars is likely, a measurement aperture as specified in Table 9 shall be placed at a distance of 2 m from the exit aperture of the product for emissions in the wavelength range from 0.302 to 2.8 um.	Pretty much the same with use of Table 9 (Condition 1 or 2)	Not specifically addressed	No section in ".8"
136	Measurements	Limiting aperture	9.2.2.1	The measurement of irradiance or radiant exposure shall be made with instruments that average over circular areas defined by the effective limiting aperture diameters given in Table 8 or smaller diameters. The sensitivity per unit area shall be sufficiently uniform, when mapped with a 1 mm diameter beam, to ensure the required accuracy of measurement. No correction for beam size or homogeneity is necessary in cases where the entire beam enters the effective limiting aperture. For larger beams, the measurement shall be made in the area of the beam that gives the maximum reading. For distinguishing between Class 3b and Class 4 pulsed lasers, the maximum radiant power or energy which is transmitted through the measurement apertures listed in Table 9 shall be used.	Same	Not specifically addressed	No section in ".8"
137	Measurements	Instruments	9.3	Instruments shall be calibrated sufficiently well to permit overall measurement accuracies of $\pm 20\%$ wherever possible.	Same	Not specifically addressed	No section in ".8"