

American National Standard

*American National Standard for
Safe Use of Optical Fiber
Communication Systems Utilizing
Laser Diode and LED Sources*

ANSI Z136.2-1997



11 West 42nd Street
New York, New York
10036

ANSI®
Z136.2 - 1997
Revision of
ANSI Z136.2-1988

**American National Standard for
Safe Use of Optical Fiber Communication Systems
Utilizing Laser Diode and LED Sources**

Secretariat

The Laser Institute of America

Approved August 12, 1997

American National Standards Institute, Inc.

American National Standard

An American National Standard implies a consensus of those substantially concerned with its scope and provisions. An American National Standard is intended as a guide to aid the manufacturer, the consumer and the general public. The existence of an American National Standard does not in any respect preclude anyone, whether he has approved the standard or not, from manufacturing, marketing, purchasing, or using products, processes or procedures not conforming to the standard. American National Standards are subject to periodic review and users are cautioned to obtain the latest editions.

CAUTION NOTICE: This American National Standard may be revised or withdrawn at any time. The procedures of the American National Standards Institute require that action be taken to reaffirm, revise, or withdraw this standard no later than five years from the date of publication. Purchasers of American National Standards may receive current information on all standards by calling or writing the American National Standards Institute.

Published by

**The Laser Institute of America, Suite 125
12424 Research Parkway, Orlando, FL 32826
Tel:(407) 380-1553**

Copyright © 1997 by Laser Institute of America, Inc.
All rights reserved.

No part of this publication may be reproduced in any form
in an electronic retrieval system or otherwise, without
the prior written permission of the publisher.

Printed in the United States of America

First Printing November 1997

Notice (This notice is not part of the American National Standard Z136 series of laser safety standards.)

Z136 standards and recommended practices are developed through a consensus standards development process approved by the American National Standards Institute. The process brings together volunteers representing varied viewpoints and interests to achieve consensus on laser safety related issues. As Secretariat to ASC Z136, the Laser Institute of America (LIA) administers the process and provides financial and clerical support to the committee.

The LIA and its directors, officers, employees, members, affiliates and sponsors, expressly disclaim liability for any personal injury, property or other damages of any nature whatsoever, whether special, indirect, consequential or compensatory, directly or indirectly resulting from the publication, use of, or reliance on this document or these standards. The LIA's service as Secretariat does not constitute, and LIA does not make, any endorsement, warranty or referral of any particular standards, practices, goods, or services that may be referenced in this document. The LIA also makes no guaranty or warranty as to the accuracy or completeness of any information published herein. The LIA has no power, nor does it undertake to police or enforce compliance with the contents of this document.

In issuing and making this document available, the LIA is not undertaking to render professional or other services for or on behalf of any person or entity. Nor is the LIA undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

Foreword

(This foreword is not part of American National Standard Z136.2-1997)

This American National Standard provides guidance for the safe use of optical fiber communications systems (OFCS) utilizing laser diode and/or light emitting diode (LED) sources by defining control measures for each of four service group classifications. Once an OFCS is assigned the appropriate service group classification, there should be no need to carry out tedious measurements or calculations to meet the provisions of the standard. This standard provides the information necessary to assign a service group to unclassified OFCS, or modified OFCS requiring reclassification.

During normal system operation OFCS are completely enclosed, there is no accessible emission and, therefore, no hazard. During service, however, there may be accessible emission. Consequently, each OFCS is assigned a service group classification based on potential hazard. Service group determination is based solely on output characteristics regardless of the type of source, i.e., laser diode or LED.

Since this standard was first published, advances in technology have led to lasers used for OFCS that operate at power levels greater than 50 mW. Guidance is provided for higher power levels and is compatible with ANSI Z136.1.

This standard has been published as part of the American National Standard Z136 series. The basic document is American National Standard for the Safe Use of Lasers, ANSI Z136.1. In general, this standard may be used independently of ANSI Z136.1. Instances where additional guidance contained in ANSI Z136.1 is required are noted in this document.

Every effort has been made to make this standard compatible with ANSI Z136.1 and IEC 825-1 and 825-2-1993. The KX3A hazard level of IEC 825-2-1993 has not been adopted, however.

While there is considerable compatibility among existing laser safety standards, some requirements differ among state, federal and international standards, particularly with respect to signs, symbols and control measures.

Suggestions for improvement of this standard will be welcome. They should be sent to the American National Standards Institute, Inc., 11 West 42nd Street, New York, N.Y. 10036.

This standard was processed and approved for submittal to ANSI by Accredited Standards Committee Z136 on the Safe Use of Lasers, whose scope covers protection against hazards associated with the use of lasers and optically radiating diodes. Committee approval of the standard does not necessarily imply that all members voted for its approval. At the time it approved this standard, the Z136 Committee had the following members:

Sidney S. Charschan, Chairman
Ami Kestenbaum, Secretary

At the time it approved this standard, the Z136 Committee had the following members:

<i>Organization Represented</i>	<i>Name of Representative</i>
Academy of Laser Dentistry	Leo J. Miserendino
American Automobile Manufacturers Association	Faye Holmes
	Patrick R. Frazee (Alt)
American Glaucoma Society	Michael S. Berlin
American Industrial Hygiene Association	R. Timothy Hitchcock
	Martin R. Horowitz (Alt)
American Insurance Services Group	Stewart M. Fastman
American Optometric Association	Donald Pitts
American Society for Laser Medicine and Surgery	R. V. Lobraico
	James S. McCaughan, Jr. (Alt)
American Society of Safety Engineers	Walter M. Nickens
American Society for Testing and Materials (ASTM)	John Detrio

American Iron and Steel Institute	Anthony LaMastra Peter A. Hernandez (Alt)
American Welding Society	Robert J. Tucker
Association of Operating Room Nurses	Penny J. Smalley
Camden County College	Fred P. Seeber
Cincinnati State Technical and Community College	Prem Batra
Computer and Business Equipment Manufacturers Association	Peter J. Namisnak
Electronics Industries Association	H. David Edmunds John M. Kin (Alt)
Health Physics Society	David Sliney
Illuminating Engineering Society	John E. Kaufman
Institute of Electrical and Electronics Engineers, Inc. (SCC-28)	Ronald C. Petersen
Institute of Electrical and Electronics Engineers, Inc. (LEOS)	R. Wangemann
Laser and Electro-Optic Manufacturers Association	Breck Hitz
Laser Institute of America	Sidney S. Charschan Robert Weiner (Alt)
Los Alamos Scientific Laboratory	Ronald C. Hyer Dan K. Thomas(Alt)
Medical College of Virginia	A. M. Clarke
National Aeronautics & Space Administration	Gene Proctor George Marmaro (Alt)
National Association of Photographic Manufacturers	Joseph M. Grecco Richard Hittner (Alt)
National Institute of Standards and Technology	Thomas R. Scott
National Institute for Occupational Safety and Health	C. Eugene Moss William Murray (Alt)
National Safety Council	Allen G. Macenski
National Society for the Prevention of Blindness	Charles J. Koester Charles Campbell (Alt)
Optical Society of America	James Zavislan
Society of the Plastics Industry Inc.	J. P. Carrol
Society of the Photo-Optical Instrumentation Engineers	Lincoln Endelman Robert Parks (Alt)
Underwriters Laboratories	John Drengenberg Larry Homa (Alt)
U. S. Department of the Air Force Air Force Information Warfare Center	W. Patrick Roach Jack A. Labo (Alt)
U. S. Department of the Army, Medical Research and Materiel Command	Bruce E. Stuck
U. S. Department of the Army, U. S. Army Environmental Hygiene Agency	James K. Franks David Sliney (Alt)
U. S. Department of Health and Human Services, Center for Devices and Radiological Health	Jerry Dennis Richard Felton (Alt)
U. S. Department of Labor, Occupational Safety and Health Administration	Robert A. Curtis
U. S. Department of the Navy, Bureau of Medicine and Surgery	Robert Yacovissi
U. S. Department of the Navy, Naval Surface Warfare Center	Sheldon Zimmerman Robert Aldrich(Alt)
Individual Members	Robert Handren Donald A. Hanson Darrell M. Hull Ami Kestenbaum

Individual Members (Cont.) Wesley Marshall
Charles W. Mickel
R. James Rockwell, Jr.
James F. Smith
Stephen L. Trokel
Robert Weiner
Myron L. Wolbarsht

The various subcommittees which participated in developing this standard had the following members:

(1) Biological Effects

Myron L. Wolbarsht, Chairman

Janusz Z. Beer
Michael W. Berns
Alexander M. Clarke
Francois C. Delori
Donald N. Farrer
Victoria Hitchins
Maurice B. Landers, III
David. J. Lund
Wesley J. Marshall
Donald G. Pitts
R. James Rockwell, Jr.
David H. Sliney
H. G. Sperling
Bruce E. Stuck
Arthur Vassilliadis
Robert Weiner
Joseph Zuchich

(2) Hazard Evaluation and Classification

David H. Sliney, Chairman

H. David Edmunds
Dennis Hadlock
S. Mike Held
R. Timothy Hitchcock
Robert James
Jack A. Labo
David J. Lund
Terry Lyon
Wesley J. Marshall
Richard W. O'Neil
Ronald C. Petersen
R. James Rockwell, Jr.
Mark E. Rogers
Robert Weiner

(3) Measurements and Instrumentation

Thomas R. Scott, Co-Chairman
John Lehman, Co-Chairman

Jerry Dennis
James Franks
R. Timothy Hitchcock
Ami Kestenbaum
Horacio M. Marcos
Wesley J. Marshall
Ronald C. Petersen
R. James Rockwell, Jr.
David H. Sliney
Dan K. Thomas

(4) Control Measures

R. James Rockwell, Jr., Chairman

J. D. Brown
J. Richard Buys
Eugene Dymek
H. David Edmunds
Judie Garrity
Gregory M. Geary
Robert Handren
Patricia Hartwig
James R. Johnson
Jack A. Labo
Michael W. Mayo
Robert Miniutti
C. Eugene Moss
William E. Murray
R. W. O'Neil
Wordie H. Parr
Martin Randall
Alan K. Recter
David H. Sliney
Penny J. Smalley
James F. Smith
R. J. Tucker
J. D. Webb
Robert Weiner
Dean Wilson

(5) Elements of Safety and Training Program

James F. Smith, Co-Chairman

H. David Edmunds
Darrell Hull
James R. Johnson

R. James Rockwell, Jr.
Fred P. Seeber
David H. Sliney

(6) Medical Surveillance

Bruce E. Stuck, Chairman

John W. Copeman
Bruce A. Dalton
Alan M. Ducatman
Maurice B. Landers, III

Elmer M. Soles
Stephen L. Trokel
Myron L. Wolbarsht

(7) Non-Beam Hazards

R. Timothy Hitchcock, Co-Chairman
C. Eugene Moss, Co-Chairman

C. Jeffery Bryant
J. Richard Buys
Betty Carrell
Daryl J. Doyle
H. David Edmunds
Cindy Gifford
Richard S. Hughes

Richard O'Neil
Douglas E. Ott
Penny J. Smalley
James F. Smith
Dan K. Thomas
Arthur G. Varanelli

(8) Terminology

H. David Edmunds, Chairman

Marcus D. Benedetto
Jerry Dennis

James F. Smith

(9) Editorial

Ami Kestenbaum, Chairman

Sidney S. Charschan
Horacio M. Marcos

Ronald C. Petersen
Paul A. Testagrossa

(10) Fiber Optics

Ronald C. Petersen, Chairman

Jerry Dennis
Jane E. Ehgott
Ami Kestenbaum
Terry Lyon
C. Mao
Wesley Marshall
C. Eugene Moss
Andrew Roberts

R. James Rockwell, Jr.
Thomas R. Scott
David H. Sliney
James F. Smith
Paul A. Testagrossa
Robert Weiner
Myron L. Wolbarsht

(11) Safety in Health Care Facilities

Stephen L. Trokel, Chairman

George S. Abela
Bruce A. Carlson
Leonard J. Cerullo
Marcus D. Benedetto
Jerry Dennis
Richard Felton
Donald A. Gagliano
Jerome M. Garden
Richard O. Gregory
Robert T. Handren
James Hathaway
Timothy Hitchcock
Raymond J. Lanzafame
James Larson
Rocco Lobraico
Dan C. Martin

Leo J. Miserendino
C. Eugene Moss
Martin L. Norton
Robert H. Ossoff
Douglas E. Ott
R. James Rockwell, Jr.
B. H. G. Rogers
Eric J. Sacknoff
Fred Seeber
Darrell L. Seeley
David H. Sliney
Penny J. Smalley
Stephen M. Waldow
Harvey Wigdor
Myron L. Wolbarsht

(12) Safety in Educational Institutions

Fred P. Seeber, Chairman

**Kenneth L. Barat
Thomas A. Cellucci
William A. Deutschman
H. David Edmunds
Robert Handren**

**Dan Hull
James Johnson
Walter M. Nickens
James F. Smith**

(13) Analysis and Applications

Wesley J. Marshall, Chairman

**C. W. Connor
Mollie Foster
James Franks
Greg Gorsuch
Ken Keppler
Greg Makhov**

**Ronald C. Petersen
Darrell Seeley
Tony Sliwa
R. Yacovissi
Sheldon Zimmerman**

(14) Nursing & Allied Health

Penny J. Smalley, Chair Person

Contents

SECTION	PAGE
1. General	1
1.1 Scope	1
1.2 Intended Use	1
1.3 Application	1
1.4 OFCS Utilizing Laser Diodes	3
1.5 OFCS Utilizing LEDs	4
1.6 Optical Fiber Test Sets	4
2. Definitions	4
3. Hazard Evaluation and Service Group Classification	9
3.1 General	9
3.2 Laser and LED Consideration	10
3.3 OFCS Service Group Classification	11
3.4 Environment in Which the OFCS is Used	12
3.5 Personnel	13
4. Control Measures	13
4.1 General Considerations	13
4.2 Uncontrolled Area	14
4.3 Controlled Area	15
5. Safety and Training Programs	16
5.1 Organizations	16
5.2 Training	16
5.3 Responsibilities of Individuals Working with OFCS	16
6. Medical Surveillance of OFCS Personnel	16
6.1 Purpose	16
6.2 Rationale	16
6.3 Coverage	16
7. Non-Beam Hazards	17
7.1 Glass Particle Hazards	17
7.2 Photocuring Hazards	17
7.3 Solvents and Chemicals	17
8. Criteria for Exposure of the Eye and Skin	17
8.1 Small Source and Extended (Large) Source Ocular Exposures	17
8.2 MPE for Ocular Exposures	18
8.3 Skin Exposure	19
9. Measurements	19
9.1 General	19
9.2 Measurement of Power	19
10. Revision of American National Standards Referred to in this Document	20
Tables	
Table 1 Potential Risk Associated with Each Service Group	21
Table 2(a) Measurement Criteria for Service Group Classification	22
Table 2(b) Limiting Apertures for Hazard Evaluation	22
Table 3 MPE for Small Source Viewing for OFCS	23
Table 4 Parameters and Correction Factors	24
Table 5 OFCS MPEs for Selected Exposure Durations	25

SECTION	PAGE
Table 6	Accessible Emission Limits 26
Table 7	SG1 Accessible Emission Limits for Selected Wavelengths and Optical Fibers 27
Table 8	SG3a Accessible Emission Limits for Selected Wavelengths and Optical Fibers 28
Figures	
Fig. 1	Ocular MPE for "Small Source" Viewing for Visible and Near Infrared Radiation (Wavelengths Between 0.4 and 1.4 μm) 29
Fig. 2a	Accessible Emission Limits for SG1 Singlemode Fiber 30
Fig. 2b	Accessible Emission Limits for SG1 Multimode Fiber 31
Fig. 3a	Accessible Emission Limits (Irradiance) for SG3a Singlemode Fiber 32
Fig. 3b	Accessible Emission Limits (Irradiance) for SG3a Multimode Fiber .. 33
Fig. 4a	Accessible Emission Limits (Power) for SG3a Singlemode Fiber 34
Fig. 4b	Accessible Emission Limits (Power) for SG3a Multimode Fiber 35
Appendixes	
Appendix A	Example of Typical Viewing Conditions, Nominal Ocular Hazard Distances (NOHDs) and AELs for OFCS 36
Figures	
Fig. A1	Unaided Viewing 37
Fig. A2	Optically Aided Viewing 37
Fig. A3	Measurement Arrangement Used for Purpose of Service Group Classification 37
Fig. A4	NOHD as a Function of Output Power for a Singlemode Optical Fiber with a Mode Field Diameter ω_0 equal to 8.8 μm 38
Fig. A5	NOHD as a Function of Output Power for a Multimode Optical Fiber (Wavelength = 0.825 μm) 39
Fig. A6	NOHD as a Function of Output Power for a Singlemode Optical Fiber (Wavelength = 0.980 μm) 40
Fig. A7	NOHD as a Function of Output Power for a Multimode Optical Fiber (Wavelength = 0.980 μm) 41
Fig. A8	NOHD as a Function of Output Power for a Singlemode Optical Fiber (Wavelength = 1.310 μm) 42
Fig. A9	NOHD as a Function of Output Power for a Multimode Optical Fiber (Wavelength = 1.310 μm) 43
Fig. A10	NOHD as a Function of Output Power for a Singlemode Optical Fiber (Wavelength = 1.48 and 1.550 μm) 44
Fig. A11	NOHD as a Function of Output Power for a Multimode Optical Fiber (Wavelength = 1.48 and 1.550 μm) 45

SECTION		PAGE
Appendix B	Calculations for Hazard Evaluation and Classification	46
B.1	General	46
B.2	Symbols	46
B.3	Examples of MPE Determination and Service Group Classification ...	46
B.4	Determining the Beam Divergence	52
B.5	Determining the Safe Viewing Distance	52
B.6	Optically Aided Viewing	53
B.7	Large Source Conditions	54
Appendix C	Work Practices	56
Appendix D	Reference Source Material	57
D.1	General References	57
Appendix E	Examination Protocols	58
E.1	Ocular History	58
E.2	Visual Acuity	58
E.3	Macular Function	58
E.4	Further Examinations	58
E.5	Frequency of Medical Examinations	58
E.6	Records and Records Retention	58
E.7	Access to Records	58