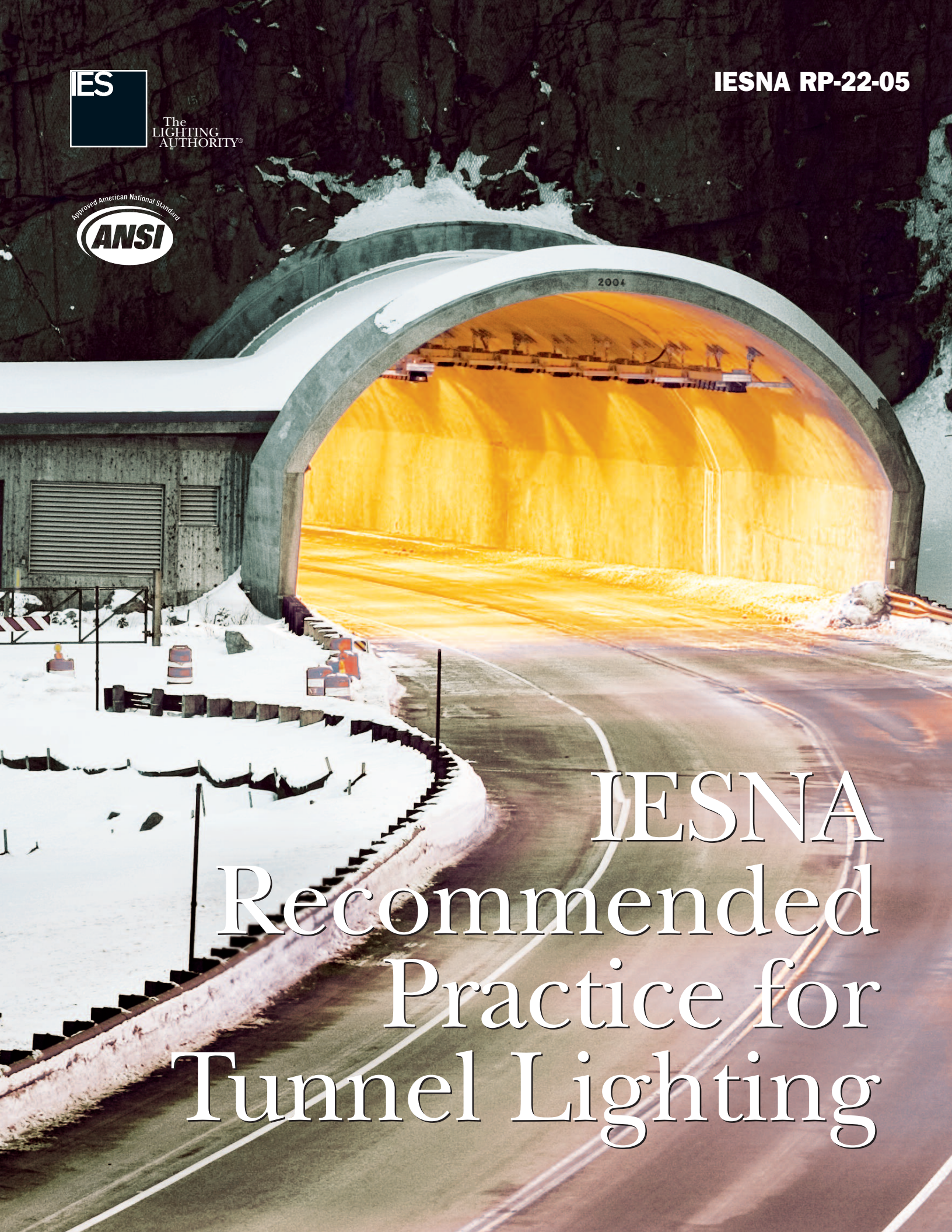




The  
LIGHTING  
AUTHORITY®

IESNA RP-22-05



# IESNA Recommended Practice for Tunnel Lighting

**American National  
Standard Practice  
for Tunnel Lighting**

Suggestions for revisions  
to this document  
should be directed to the IESNA.

Copyright 2005 by the Illuminating Engineering Society of North America.

Approved by the IESNA Board of Directors, April 11 2005, as a Transaction of the *Illuminating Engineering Society of North America*.

Approved by the American National Standards Institute as an American National Standard, May 10, 2005.

All rights reserved. No part of this publication may be reproduced in any form, in any electronic retrieval system or otherwise, without prior written permission of the IESNA.

Published by the Illuminating Engineering Society of North America, 120 Wall Street, New York, New York 10005.

IESNA Standards and Guides are developed through committee consensus and produced by the IESNA Office in New York. Careful attention is given to style and accuracy. If any errors are noted in this document, please forward them to Rita Harrold, Director Educational and Technical Development, at the above address for verification and correction. The IESNA welcomes and urges feedback and comments.

Printed in the United States of America.

ISBN # 0-87995-211-3  
978-0-87995-211-2

#### **DISCLAIMER**

IESNA publications are developed through the consensus standards development process approved by the American National Standards Institute. This process brings together volunteers representing varied viewpoints and interests to achieve consensus on lighting recommendations. While the IESNA administers the process and establishes policies and procedures to promote fairness in the development of consensus, it makes no guaranty or warranty as to the accuracy or completeness of any information published herein.

The IESNA disclaims liability for any injury to persons or 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

In issuing and making this document available, the IESNA is not undertaking to render professional or other services for or on behalf of any person or entity. Nor is the IESNA 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.

The IESNA has no power, nor does it undertake, to police or enforce compliance with the contents of this document. Nor does the IESNA list, certify, test or inspect products, designs, or installations for compliance with this document. Any certification or statement of compliance with the requirements of this document shall not be attributable to the IESNA and is solely the responsibility of the certifier or maker of the statement.

## IESNA Tunnel Lighting Subcommittee

Paul Lutkevich, Past Chair  
Ed Morel, Chair 2004 –

John Kroll, Vice Chair  
Ray Yeager, Secretary

Werner Adrian  
Carl Andersen\*  
Sam Annoh  
Joseph Bastianpillai  
John Buraczynski  
Karl Burkett  
Vincent Carney  
Bang Chau

George Chelvanayagam  
Alex Cheng  
Vince Cimino  
Peter Contos  
James Degnan  
Norm Dittmann  
Zenon Durys  
Philip Gabriel

Ronald Gibbons  
James Havard  
R. Gerald Irvine  
Antanas Ketvirtis  
Thomas Li\*  
Michael Maltezos  
Charles Oerkvitz  
Chris Pekar

Paul Sabau  
Carl Shaflik  
Jean Simard  
Jon Weaver

\*Advisory Members

## IESNA Roadway Lighting Committee

Joe Bastianpillai, Chair  
Ramesh Gupta, Vice Chair

Ed Morel, Treasurer  
Jon Hart, Secretary

Werner Adrian  
Martin Aitkenhead\*  
Balu Ananthanarayanan  
Carl Andersen  
Sam Annoh\*  
John Arens\*\*  
J. Delvin Armstrong  
Panchy Arumugasaamy  
Thomas Baker  
Tom Baker\*  
Paul Box\*\*  
Garry Bradford\*  
Reed Bradford  
Steve Braun\*  
Mario Bucci\*  
John Buraczynski\*  
Karl Burkett  
Jack Busser\*\*  
Ernesto Cacique\*  
Michael Canavan\*\*  
Vincent Carney\*  
Bang Chau\*  
George Chelvanayagam\*  
Alex Cheng\*  
Vince Cimino  
Robert Clear  
Peter Contos  
Charles Craig\*\*  
David Crawford

Scott Davis\*  
James Degnan  
Norm Dittmann  
Joseph Doyle  
Michael Dudas\*  
Kenneth Fairbanks\*\*  
Tram Fenimore\*  
Karl Fox\*  
Mark Freedman  
Moktar Gabriel\*  
Donald Garner  
Ronald Gibbons  
Ramesh Gupta  
Russell Hamm  
Grant Harlow\*  
Jon Hart  
J. Bryan Harvey\*  
Gregg Hauser\*  
James Havard  
Lynn Holste\*  
William Hughes  
Joseph Hunter\*  
Donald Husby\*\*  
R. Gerald Irvine  
Michael Janoff  
James Jewell\*\*  
Rick Kauffman  
Merle Keck\*\*  
David Keith  
Antanas Ketvirtis\*\*

Edward Kramer  
John Kroll\*  
Jean-Francois Laporte\*  
Lorence Leetzow\*  
Otto Letamendi\*  
Richard LeVere\*\*  
Ian Lewin  
Darrell Line\*  
Lance Livingston\*  
Charles Loch  
Paul Lutkevich  
Douglas Mace  
Michael Maltezos  
James McCormick\*\*  
Samuel McKnight\*\*  
Don McLean\*  
John Meyers  
John Mickel  
Craig Miller\*  
Donald Monahan  
C. Mondesir\*  
Richard Monsoor  
Edmund Morel  
Kassahun Negash  
Herbert Odle  
Charles Oerkvitz\*\*  
Donald Okon\*\*  
Chris Pekar\*  
Jose Pimenta  
Rebecca Rainer

Philip Reed  
Edward Rowsell\*\*  
Paul Sabau  
Steven Schmidt\*  
Richard Schwab\*\*  
Carl Shaflik\*  
Billy Shelby\*\*  
Andrew Silbiger  
Jean Simard  
William Smelser\*  
Stephen Spitulski  
Richard Stark  
Roman Stempok  
Donald Strong\*  
Robert Summerford\*  
Mario Tedesco\*  
Carole Thomas\*  
Radosveta Topalova\*  
Paul Van Der Pol  
Harold Van Dusen\*\*  
Richard Vincent  
Robert Vogel  
Vernon Waight\*\*  
Jeff Walters  
Cowan Watson  
Jon Weaver  
Scott Wegner  
Robert Wylie\*\*  
Raymond Yeager\*

\* Advisory Members

\*\* Honorary Member

# Contents

<b>1.0</b>	<b>Introduction</b>	1
<b>2.0</b>	<b>Physical Characteristics</b>	1
2.1	Definition of a Tunnel	1
2.2	Tunnel Classification	1
2.2.1	Tunnel	1
2.2.2	Divided and Undivided Tunnel	2
2.2.3	Underpasses	2
2.3	Tunnel Topology	2
2.3.1	Fixation Point	3
2.3.2	Approach	3
2.3.3	Adaptation Point	3
2.3.4	Adaptation Distance	3
2.3.5	Portal	3
2.3.6	Threshold Zone	3
2.3.7	Transition Zone	3
2.3.8	Interior Zone	3
2.3.9	Exit Lighting	3
<b>3.0</b>	<b>Visibility at the Tunnel Approach</b>	3
3.1	General	3
3.2	Traffic Speed	4
3.3	Night Adaptation	4
<b>4.0</b>	<b>Traffic and Roadway Geometry</b>	4
4.1	Traffic	4
4.2	Divided and Undivided Structures	4
<b>5.0</b>	<b>Eye Adaptation in the Tunnel Approach</b>	4
5.1	General	4
5.2	Solar and Tunnel Orientation	4
5.3	Sky	5
5.4	Exterior Surface Luminance	5
5.5	Lseq	7
<b>6.0</b>	<b>Lighting Design Criteria</b>	7
6.1	General	7
6.2	Lighting Requirements	7
6.3	Assessment of the Major Factors Influencing Lighting Design	8
6.4	Method of Determination of Luminance Levels	8
6.4.1	Luminance Values in Threshold Zone – Table Method	8
6.4.2	Luminance Values in Threshold Zone – Lseq Method	8
6.4.3	Threshold and Transition Zones	13
6.4.4	Tunnel Interior Zone	13
6.4.5	Nighttime Luminance	14
6.4.6	Non-Roadway Surface Luminances	15
6.4.7	Uniformity Ratios	15
6.5	Flicker Effect	15
6.6	Switching Steps in Threshold and Transition Zones	16
6.7	Emergency Lighting	16

<b>7.0</b>	<b>Light Application Techniques</b>	16
7.1	Symmetrical Light Distribution	16
7.2	Asymmetrical Light Distribution - Negative Contrast	16
7.3	Asymmetrical Light Distribution - Positive Contrast	16
7.4	Wide and Narrow Tunnels	17
<b>8.0</b>	<b>Architecture and Materials</b>	17
8.1	General	17
8.2	Pavement	17
8.3	The Portal and its Surrounding Area	17
8.4	Architectural Features	17
8.5	Reflective Characteristics of Wall and Ceiling Materials	17
<b>9.0</b>	<b>Lighting and Electrical Equipment</b>	18
9.1	Light Sources	18
9.1.1	Fluorescent	18
9.1.2	Low Pressure Sodium (LPS)	18
9.1.3	High Pressure Sodium (HPS)	18
9.1.4	Metal Halide (MH)	18
9.1.5	Other Light Sources	19
9.2	Equipment and Luminaires	19
9.3	Electric Power Supply and Distribution	19
9.4	Measurement, Control and Switching Systems	19
<b>10.0</b>	<b>Lighting System Economics</b>	20
10.1	General	20
10.2	Initial Cost	20
10.3	Life-Cycle Economic Analysis	20
<b>11.0</b>	<b>Maintenance Considerations</b>	20
11.1	General	21
11.2	Lamp Lumen Depreciation	21
11.3	Burnouts	21
11.4	Luminaire Dirt Depreciation	21
11.5	Equipment Factors	22
11.5.1	Ambient Temperature	22
11.5.2	Voltage	22
11.5.3	Ballast and Lamp Factor	22
11.5.4	Luminaire Component Depreciation	22
11.6	Maintenance of the Control Photometers	22
11.7	Tunnel Surface Reflectance Depreciation	22
11.7.1	Selection of Tunnel Surface Reflectance	22
11.7.2	Reflectance Depreciation	22
11.8	Luminaire Cleaning, Relamping and Replacement	22
11.8.1	Luminaire Cleaning	22
11.8.2	Relamping	23
11.8.3	Luminaire Replacement	23
11.9	Other Factors	23
11.9.1	Pavement Reflectance	23
11.9.2	Other Reflection Characteristics	23
11.9.3	Physical Geometry	23
11.9.4	Errors	23
	<b>References</b>	24
	<b>Glossary</b>	26

**Annex A – Calculation Method** ..... 31  
**Annex B – Contrast Method for Determining Threshold Lighting** ..... 38  
**Annex C – Black Window Method of Determining Need for Threshold Lighting** ..... 40

cover photo: Wolf Creek Tunnel, Colorado Department of Transportation

## 1.0 INTRODUCTION

This Standard Practice has the objective of providing information to assist engineers and designers in determining lighting needs, recommending solutions, and evaluating resulting visibility at vehicular tunnel approaches and interiors. This Practice is intended also for use by administrators charged with the responsibility of providing a safe visual environment within a tunnel both day and night.

The Standard Practice deals entirely with lighting and associated systems and does not give advice on construction practice. It is neither intended as, nor does it establish a legal standard for tunnel lighting systems. Its purpose is to provide recommended practices for designing new tunnel lighting systems and it is not intended to be applied to existing lighting systems until such systems are redesigned. It has been prepared to advance the art, science, and practice of illumination as it pertains to tunnel lighting in North America.

Lighting is added to vehicular tunnels to enable a motorist to maintain speed and safely navigate. The basic design criteria for tunnel lighting are outlined in **Section 6.0**. Tunnels may require considerably different treatment of the threshold zone luminance values, depending on variables such as geographic orientation, geometric design, traffic volume, traffic speed, service levels, light source used, and modes of light application. The lighting designer therefore

should consider the factors which affect the visibility conditions as outlined in **Sections 3.0, 4.0, 5.0, 7.0, and 8.0**.

Treatment of tunnel portals, wall and ceiling surfaces, and selection of lighting equipment, as well as light sources, maintenance and lighting economics are also reviewed and assessed. However, special requirements for pedestrians are not addressed in this document. For pedestrian and underpass lighting refer to ANSI/IESNA RP-8, *American National Standard Practice for Roadway Lighting*.<sup>1</sup>

## 2.0 PHYSICAL CHARACTERISTICS

### 2.1 Definition of a Tunnel

A tunnel is defined as a structure over a roadway, which restricts the normal daytime illumination of a roadway section such that the driver's visibility is substantially diminished.

### 2.2 Tunnel Classification

In determining whether a structure constitutes a tunnel or an underpass, two factors should be taken into account: structure length, and its geometric alignment and profile (visibility through the structure).

**2.2.1 Tunnel.** A tunnel is a structure covering a roadway which, by producing a shadow, limits the

Traffic Speed (estimated km/h and mph)		Estimated Safe Stopping Sight Distance (SSSD)*	
Kilometers per Hour	Miles per Hour	Meters	Feet
50	30	65	200
60	40	85	305
80	50	130	425
90	55	160	495
100	60	185	570
110	65	220	645

Refer to American Association of State Highway and Transportation Officials (AASHTO) "A Policy on Geometric Design of Highways and Streets," 2001 for accurate calculation of stopping sight distance.

The speed and distance columns only correspond to their metric or English equivalent (i.e., if determining the SSSD for a posted speed in miles per hour, use the value shown for feet, if using kilometers per hour, use the value shown for meters).

\* Assumes average prevailing speeds in a straight and level tunnel approach roadway are at, or near, the posted speed limit of the facility. For other geometric conditions, refer to the AASHTO document.

ability of a driver to see objects or obstructions within the structure. It is also of sufficient length or composition to require an adaptation of the driver's eye to the lower lighting levels within the tunnel structure. A tunnel requires supplemental daytime lighting in order to compensate for this diminished visibility as well as transition lighting to lower interior lighting levels to allow for adaptation. Refer to American Association of State Highway and Transportation Officials (AASHTO) "A Policy on Geometric Design of Highways and Streets," 2001 for accurate calculation of stopping sight distance.

The speed and distance columns only correspond to their metric or English equivalent (i.e., if determining the SSSD for a posted speed in miles per hour, use the value shown for feet, if using kilometers per hour, use the value shown for meters).

**2.2.2 Divided and Undivided Tunnels.** A structure which consists of two separate enclosures, each designated to accommodate one direction of traffic flow, is considered to be a divided tunnel.

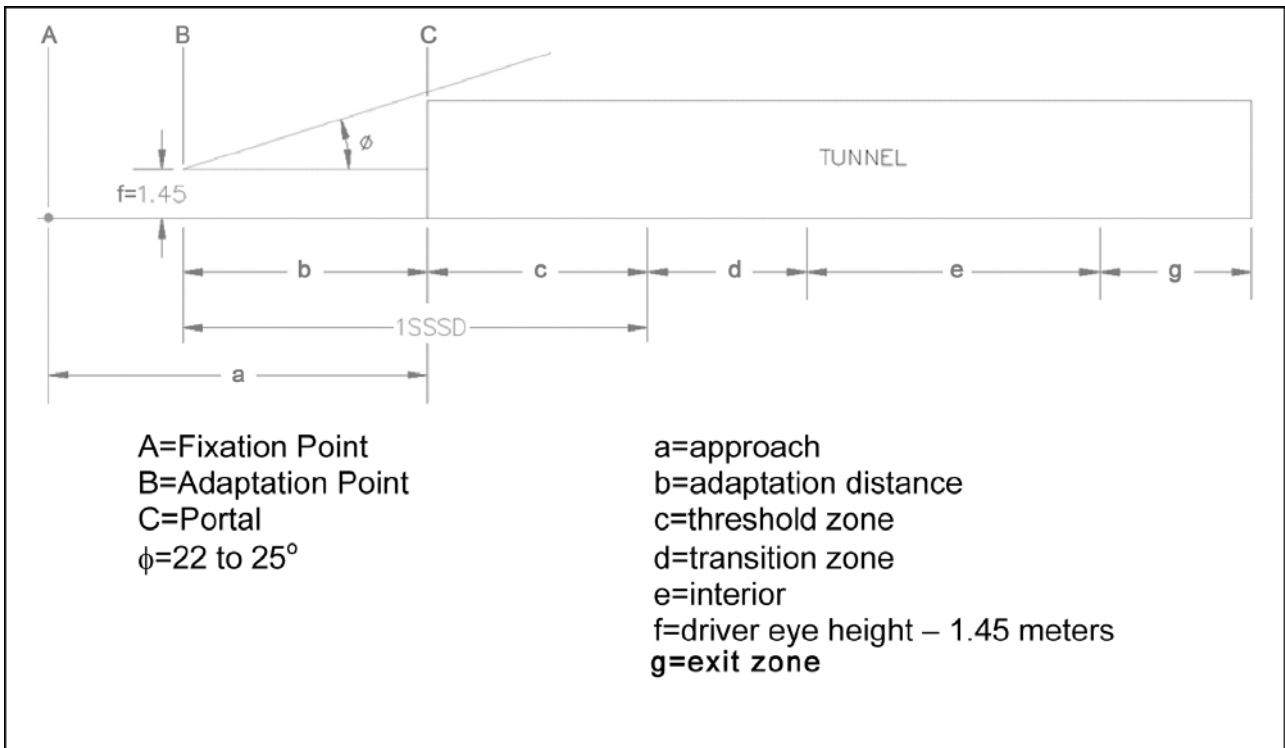
A structure which consists of a common enclosure to accommodate the traffic flow in both directions is considered an undivided tunnel.

**2.2.3 Underpasses.** Structures considered to be underpasses are those in which the length and physical configuration of the structure do not substantially limit the drivers ability to see objects within the structure. No supplemental daytime lighting is required for underpasses or structures less than 25m (80ft.) in length. The zero percent values in **Table 2** show when supplemental daytime lighting is not required.

For nighttime illumination underpasses can also be classified as short or long. Short underpasses can generally be lighted with conventional street and roadway luminaires and placements. When the lighting levels and uniformity on the roadway provided by the conventional roadway lighting system are affected by the structure, then the underpass can be classified as long and will require additional lighting. When pedestrian lanes or sidewalks are included as part of an underpass then pedestrian lighting should be considered. Lighting levels should be as recommended in ANSI/IESNA RP-8, *American National Standard Practice for Roadway Lighting*.<sup>1</sup>

### 2.3 Tunnel Topology

Terms used to describe tunnel topology are as follows, see **Figure 1**.



**Figure 1.** The primary external and internal areas associated with and affected by tunnel lighting design.