

RECOMMENDED PRACTICE FOR DESIGN AND MAINTENANCE OF ROADWAY AND PARKING FACILITY LIGHTING

Recommended Practice for Lighting Roadway and Parking Facilities

Publication of this Recommended Practice
has been approved by the IES.
Suggestions for revisions
should be directed to IES.

Prepared by:
The Roadway Lighting Committee



Copyright 2018 by the Illuminating Engineering Society.

Approved by the IES Standards Committee, September 4, 2018 as a Transaction of the Illuminating Engineering Society.

Approved by the American National Standards Institute as an American National Standard, September 20, 2018.

Addendum 1 was approved by the IES Standards Committee on October 11, 2019, and by the American National Standards Institute (ANSI) on January 16, 2020. Red font color indicates new, added language. Strike-through indicates removed text.

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 IES.

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

IES Standards and Guides are developed through committee consensus and produced by the IES Office in New York. Careful attention is given to style and accuracy. If any errors are noted in this document, please forward them to the Director of Standards, at standards@ies.org or the above address, for verification and correction. The IES welcomes and urges feedback and comments.

Printed in the United States of America.

ISBN# 978-0-87995-382-9

DISCLAIMER

IES 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 IES 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 IES 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 IES is not undertaking to render professional or other services for or on behalf of any person or entity. Nor is the IES 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 IES has no power, nor does it undertake, to police or enforce compliance with the contents of this document. Nor does the IES 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 IES and is solely the responsibility of the certifier or maker of the statement.

AMERICAN NATIONAL STANDARD

Approval of an American National Standard requires verification by ANSI that the requirements for due process, consensus, and other criteria have been met by the standards developer.

Consensus is established when, in the judgment of the ANSI Board of Standards Review, substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that a concerted effort be made toward their resolution.

The use of American National Standards is completely voluntary; their existence does not in any respect preclude anyone, whether that person has approved the standards or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standards.

The American National Standards Institute does not develop standards and will in no circumstances give an interpretation to any American National Standard. Moreover, no person shall have the right or authority to issue an interpretation of an American National Standard in the name of the American National Standards Institute. Requests for interpretations should be addressed to the secretariat or sponsor whose name appears on the title page of this standard.

CAUTION NOTICE: This American National Standard may be revised 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 approval. Purchasers of American National Standards may receive current information on all standards by calling or writing the American National Standards Institute.

Prepared by the IES Roadway Lighting Committee

Roadway Master Document Task Group

Rick Kauffman, Chair

Joel Robinson, Vice Chair

Andrew Bloomfield	Norm Dittman	Gregg Hyde	Don McLean	Mark Seppelt
Mario Bucci	Jim Frazer	Suzanne Lansford	Leora Radetsky	Raymond Yeager
Nancy Clanton	Ronald Gibbons	Paul Lutkevich		

Roadway Lighting Committee Members

Andrew Bloomfield, Chair

Jim Frazer, Vice-Chair

Martin Aitkenhead, Secretary

Carl Andersen	Nancy Clanton	Rick Kauffman	Edmund Morel	Michael Smolyansky
Lynn Asselin	Robert Clear	Suzanne Lansford	Charles-Antoine Poirier	Roman Stemprok
Marie Baginski	Shirley Coyle	Richard Larivee	Leora Radetsky	Mario Tedesco
David Baum	Christine Dibley	Lorence Leetzow	Rebecca Rainer	Geoffrey Thiesse
Rajaram Bhagavathula	Norm Dittman	Otto Letamendi	Joel Robinson	Uthayakaren
John Brown	Michael Dudas	Graeme Lister	Paul Sabau	Thurairajah
Mario Bucci	Kevin Fitzmaurice	Eric MacGill	Mark Seppelt	Scott Wegner
Karl Burkett	Amir Hirsch	Michael Maltezos	Andrew Silbiger	Scott Wentworth
George	Jianzhong Jiao	Joseph Marsh	Jason Simmers	Raymond Yeager
Chelvanayagam	Richard Jones	Don McLean	William Smelser	Catheryn Yun
Joseph Cheung	Hamid Kashani	Kimberly Molloy	Leo Smith	

Advisory Members

Joe Bastianpillai	Robin Johnson	Lionel Lutley
Rahim Benekohal	Joseph Juzwiak	Mark Mayer
Carl Bloomfield	Kulwant Kang	Donald Monahan
Guy Brunet	David Keith	Cory Ockunzzi
Mark Cunningham	Michael Kelly	Douglas Paulin
John DaCosta	Edward Kramer	Michael Pearse
Adrian Duma	Ann Kuczkowski	Chris Pekar
Robert Ebbert	Chris Kwong	John Petty
Gordon Engstrom	Eric Ladouceur	Omar Rivera
John Farsatis	Gille Lauzier	Justin Snowden
Tram Fenimore	Anne-Marie Lemieux	Michael Stevens
Ronald Gibbons	Christopher Leone	Fred Stohl
Robert Harvey	Todd Lohman	Jonathan Weaver
Rusty Hunsaker	Ziaomei Lou	Yao-Jung Wen
Gregg Hyde	Paul Lutkevich	Eric Yao

Honorary Members

J. Delvin Armstrong	Donald Husby	Samuel McKnight
Charles Craig	Michael Janoff	Herbert Odle
David Crawford	James Jewell	Donald Okon
James Havard	James McCormick	

Acknowledgment:

The IES acknowledges and thanks the Transportation Association of Canada (TAC) for its significant contribution to this Standard.

Dedication:

This roadway lighting Recommended Practice is dedicated to the memory of Jon Hart, whose many contributions to the committee and the IES are greatly appreciated.

CONTENTS

Introduction to this Recommended Practice	I
Vision Statement	I
History of the Document	II
How to Use this Recommended Practice	II

Part 1 – Fundamentals

Chapter 1: Introduction to Roadway Lighting

1.1 Why Light?	1-1
1.2 Human Factors	1-1
1.3 The Value of Lighting	1-2
1.3.1 The Key Benefit – A Reduction In Crashes	1-2
1.3.2 Cost-Benefit Analysis of Roadway Lighting	1-3
1.3.3 The Need for Good Design	1-4
1.4 Lighting Warrants	1-4
1.5 Energy Conservation	1-4
1.6 Environmental Factors	1-4
1.7 Alternatives to Lighting	1-5
1.8 Reference Lighting Organizations	1-6
Additional Reading	1-7
References for Chapter 1	1-8

Chapter 2: Vision and Fundamental Concepts

2.1 Light and the Visible Spectrum	2-1
2.2 Basic Principles of Vision	2-2
2.2.1 Structure of the Eye	2-3
2.2.2 Function of the Iris and Pupil	2-3
2.2.3 Function of the Lens	2-3
2.2.4 Function of the Retina	2-3
2.2.5 Adaptation	2-4
2.2.6 Accommodation	2-4
2.3 Visibility Fundamentals and Principles	2-5
2.3.1 Contrast	2-5
2.3.2 Visual Acuity	2-6
2.3.3 Glare	2-7
2.3.4 Spectral Effects and Mesopic Vision	2-7
2.3.5 Effects of Age on Vision	2-10

2.4	Light Sources	2-10
2.5	Measurements	2-10
2.5.1	Measurement Considerations	2-10
2.5.2	Units and Terms	2-11
2.5.3	Principles of Laboratory Photometry	2-12
2.5.4	Photometric Test Reports	2-12
2.5.5	Relative and Absolute Photometry	2-15
2.6	Luminaire Classification Systems	2-16
2.6.1	Longitudinal Light Distribution (S, M, L)	2-19
2.6.2	Transverse Light Distribution (Types I – VS)	2-19
2.6.3	The IES Luminaire Classification System (LCS) and BUG Ratings	2-20
2.6.4	Variations and Comments	2-23
	References for Chapter 2	2-26

Chapter 3: Calculations

3.1	Calculation Elements	3-1
3.1.1	Road Geometrics	3-1
3.1.2	Road Type	3-1
3.1.3	Pedestrian Conflict	3-1
3.1.4	Lamp or Luminaire Lumens	3-1
3.1.5	Pavement Classification	3-1
3.1.6	Light Loss Factors (LLF)	3-2
3.1.7	Luminaire Position and Orientation	3-6
3.1.8	Impact of Vehicle Headlights	3-6
3.1.9	Change in Physical Surroundings	3-6
3.2	Roadway Lighting Metrics – General Information	3-9
3.2.1	Assumed and Standard Conditions	3-9
3.2.2	Accuracy of Calculations	3-10
3.2.3	Selection of a Grid and Luminaire Location Geometry for Calculations	3-10
3.3	Roadway Pavement Luminance	3-12
3.3.1	The r-Tables	3-12
3.3.2	Pavement Classification Systems	3-12
3.3.3	Formulas and Units	3-15
3.3.4	Summary of Pavement Luminance Data	3-15
3.4	Roadway Pavement Illuminance	3-15
3.4.1	Formulas and Units	3-16
3.4.2	Summary of Pavement Illuminance Data	3-16
3.5	Uniformity Ratios	3-16
3.6	Two Metrics of Glare in Roadway Lighting	3-16
3.6.1	Veiling Luminance	3-16
3.6.2	Threshold Increment (TI)	3-18
3.7	Small Target Visibility (STV)	3-18
3.7.1	Calculating Target Luminance	3-18
3.7.2	Calculating Target Visibility	3-19
3.7.3	Summary of Data	3-20
3.8	Vertical Illuminance	3-20

3.9	Tunnel Calculations	3-21
3.9.1	General	3-21
3.9.2	Selection of a Grid for Tunnel Lighting Calculations	3-22
3.9.3	Computation of the Direct Component	3-23
3.9.4	Discretization of the Tunnel Surfaces	3-23
3.9.5	Computation of the Indirect Component of Illuminance	3-24
3.9.6	Computation of Surface Element Luminance and Reflected Intensity	3-25
3.9.7	Computation of the Indirect Component of Veiling Luminance	3-27
	Additional Reading	3-28
	References for Chapter 3	3-30

Chapter 4: Obtrusive Light

4.1	Defining Obtrusive Light	4-1
4.2	Light Trespass	4-1
4.2.1	Recommended Acceptable Levels of Spill Light	4-3
4.2.2	Measurement and Calculation of Spill Light	4-3
4.2.3	Mitigation of Spill Light	4-3
4.3	Glare	4-4
4.3.1	Calculation and Measurement of Offsite Glare	4-5
4.3.2	Mitigation of Glare	4-5
4.4	Sky Glow	4-5
4.4.1	Sources of Sky Glow	4-6
4.4.2	Sky Glow Models	4-8
4.4.3	Mitigation of Sky Glow	4-8
4.5	Obtrusive Light Regulations	4-9
4.6	Impacts From Off-Roadway Obtrusive Light	4-9
4.6.1	Some Conditions Wherein Obtrusive Light Might Be Created for Road Users	4-9
4.6.2	Mitigating the Effects of Obtrusive Light from Off-Roadway Sources	4-9
4.7	Lighting Impacts on Species and Habitat	4-10
4.8	Potential Health Impacts of Lighting on Humans	4-10
4.9	Impacts of Exterior Lighting on Airports	4-10
	References for Chapter 4	4-11

Chapter 5: The Planning and Design Process

5.1	Typical Situations Requiring Lighting Design	5-1
5.2	Design Issues	5-2
5.2.1	Safety	5-2
5.2.2	Cost	5-2
5.2.3	Optimization of Lighting	5-3
5.2.4	Aesthetics	5-3
5.2.5	Environmental Considerations	5-3
5.2.6	Site Conditions	5-4
5.2.7	Collision Data and Investigations	5-5
5.2.8	Adaptive Lighting	5-6
5.2.9	Prioritizing	5-6

5.3	Lighting Master Plans	5-6
5.4	The Design Process	5-7
5.4.1	Perform Pre-design	5-7
5.4.2	Investigate Site Conditions	5-10
5.4.3	Define Lighting Design Criteria	5-12
5.4.4	Perform Lighting Design	5-12
5.4.5	Perform Electrical Design	5-15
5.4.6	Perform Geotechnical and Structural Design	5-16
5.4.7	Prepare Plans, Specifications and Estimates (PS&E)	5-16
5.4.8	Bid or Tender	5-18
5.4.9	Construction	5-18
5.5	Calculating Costs	5-19
5.5.1	Capital Cost	5-19
5.5.2	Operating Costs	5-19
5.5.3	Life Cycle Cost	5-20
5.5.4	Life Cycle Cost Calculation Example	5-20
5.6	Verification of Lighting Levels	5-20
5.6.1	Verification by Calculation	5-20
5.6.2	Field Verification	5-20
5.6.3	Electrical System Verifications	5-23
5.6.4	Field Verification of Lighting Performance	5-23
References for Chapter 5		5-23

Chapter 6: System Components

6.1	Selecting and Specifying Products	6-1
6.1.1	Sources for Information on Available Equipment	6-1
6.1.2	The Importance of Quality in Product Selection	6-1
6.1.3	Other Key Selection Criteria	6-1
6.1.4	Capital (Supply) Cost in Product Selection	6-2
6.2	Types Of Lighting And Mounting	6-2
6.2.1	Bollard Lighting	6-2
6.2.2	Post-Top Lighting	6-3
6.2.3	Davit-Style, Truss-Style and Mast-Arm Lighting	6-4
6.2.4	High-Mast Lighting	6-6
6.2.5	Wall Mounted Lighting	6-10
6.2.6	Roadway Lighting on Utility Poles	6-12
6.2.7	Floodlighting	6-12
6.2.8	In-Roadway Lights (IRLs)	6-14
6.3	Light Sources	6-15
6.3.1	Light Emitting Diode (LED)	6-17
6.3.2	High Intensity Discharge (HID)	6-18
6.3.3	Induction (E)	6-19
6.3.4	Plasma	6-20
6.3.5	Fluorescent	6-21
6.3.6	Low Pressure Sodium (LPS)	6-21
6.3.7	Incandescent	6-22

6.4	Luminaires	6-22
6.4.1	Luminaire Photometric Performance	6-23
6.4.2	Special Considerations for Roadway Luminaires	6-23
6.4.3	Alternative Power Sources	6-23
6.5	Luminaire Components	6-23
6.5.1	Components Common to All Luminaires	6-23
6.5.2	LED System Components	6-23
6.5.3	HID and Fluorescent System Components	6-25
6.6	Electrical Power Supply	6-26
6.6.1	Electrical System Components	6-27
6.6.2	Power Supply	6-27
6.6.3	Metering	6-28
6.6.4	Power Distribution Cabinets	6-28
6.6.5	Power Quality Considerations	6-29
6.7	Wiring	6-30
6.7.1	Typical Conductor Types	6-30
6.7.2	Overcurrent Protection	6-30
6.7.3	Voltage Drop and Fault Current Calculations	6-30
6.7.4	Grounding and Bonding	6-31
6.7.5	Conduit	6-31
6.7.6	Junction Boxes	6-31
6.8	Foundations	6-32
6.8.1	Concrete Foundations	6-32
6.8.2	Steel Screw-In Type Foundations	6-33
6.8.3	Direct-Burial Poles	6-33
6.9	Poles And Related Hardware	6-33
6.9.1	Pole Materials	6-33
6.9.2	Pole Placement (Spacing)	6-35
6.9.3	Clear Zone Requirements	6-35
6.9.4	Breakaway Bases	6-37
6.9.5	Pole Attachment Hardware	6-38
6.10	Roadway Lighting Control Systems	6-39
6.10.1	Goals and Best Practices	6-39
6.10.2	Control Technologies	6-48
6.10.3	Adaptive Lighting Design	6-53
6.10.4	Adaptive Lighting Operations	6-57
6.10.5	Integration and Commissioning	6-59
	References For Chapter 6	6-61

Chapter 7: Standards and Codes

7.1	Local, Regional, and National Codes	7-1
7.2	Origins of Standards	7-1
7.3	North American Standards Organizations	7-2
7.3.1	Canadian Organizations	7-2
7.3.2	U.S. Organizations	7-3
7.3.3	Mexican Organizations	7-4

7.3.4	Multinational Organizations	7-4
References for Chapter 7		7-5

Chapter 8: Computer Applications

8.1	Overview	8-1
8.2	Limitations of Computer Calculations	8-1
8.3	Calculated Digital Renderings	8-1
8.4	Complex Roadway Calculations	8-2
8.5	Typical Illuminance Application	8-2
8.6	Calculated Digital Renderings	8-2
8.6.1	The Rendering Process	8-4
8.6.2	Uses for Renderings	8-4
8.6.3	Limitations of Renderings	8-4

Chapter 9: Maintenance and Operations

9.1	Factors Affecting Maintenance	9-1
9.1.1	Luminaires, Components, and Accessories	9-1
9.1.2	Light Source Life	9-1
9.1.3	Light Source Lumen Depreciation	9-2
9.1.4	Lumen Dirt Depreciation	9-2
9.1.5	Basic Relamping Practices and Choices	9-2
9.1.6	Leveling, Alignment, and Socket Settings	9-3
9.1.7	Controls	9-4
9.1.8	Line Voltage	9-4
9.1.9	Obstruction of Light and Photocontrols by Foliage	9-4
9.2	Light Source Failure Mode	9-5
9.2.1	Light Emitting Diode (LED) Failure	9-7
9.2.2	Metal Halide (MH) Lamp Failure	9-7
9.2.3	High Pressure Sodium (HPS) Lamp Failure	9-7
9.2.4	Low Pressure Sodium (LPS) Lamp Failure	9-7
9.2.5	Incandescent Lamp Failure	9-7
9.3	Troubleshooting, Repair, and Replacement	9-7
9.3.1	Information Gathering	9-8
9.3.2	Basic Inspection Procedure When Responding to a Luminaire Malfunction Report	9-8
9.3.3	Procedures for Night Patrol Service	9-8
9.3.4	Troubleshooting Guide for HPS Luminaires and Photocontrols	9-8
9.4	Pole and Luminaire Materials	9-9
9.5	Paint or Coating	9-9
9.6	Safety	9-10
9.6.1	General	9-10
9.6.2	Electrical	9-11
9.6.3	Equipment	9-11
9.6.4	Traffic Control	9-11
9.6.5	Environmental Protection and Health and Safety Hazards	9-11

9.7	Vibration	9-12
9.8	Maintenance of Conventional Lighting Systems	9-12
9.8.1	General	9-12
9.8.2	Preventive Maintenance	9-12
9.9	Maintenance of High-Mast Lighting Systems	9-12
9.9.1	General	9-12
9.9.2	Preventive Maintenance	9-12
9.9.3	Corrective Maintenance	9-13
9.10	Maintenance of Tunnel Lighting Systems	9-13
9.10.1	General	9-13
9.10.2	Tunnel Luminaire Maintenance	9-13
9.10.3	Tunnel Washing	9-14
9.10.4	Replacing luminaires or Their Components	9-15
9.10.5	Light Level Verification	9-15
9.10.6	Structural Support Inspection	9-15
9.10.7	Maintenance of Control Devices	9-15
9.11	Methods of Contracting	9-16
9.12	Disposal of Components	9-16
9.13	New Light Sources and Components	9-16
9.14	Economics	9-17
9.14.1	Light Loss Factors	9-17
9.14.2	Record Keeping	9-17
9.14.3	Group versus Spot Relamping	9-17
9.14.4	Maintenance Budgets	9-17
9.14.5	Energy Costs	9-18
9.15	Maintenance Management System Guidelines	9-18
9.15.1	Inspections, Patrols, and Public Reporting	9-18
9.15.2	Requirements	9-18
9.15.3	Operations and Asset Management via Networked Systems	9-20
9.16	Equipment Testing	9-20
	Chapter 9 Glossary	9-21
	Additional Reading	9-22
	References for Chapter 9	9-22

Part 2 – Design

Chapter 10: Highway and Interchange Lighting

10.1	Roadway Lighting – General	10-1
10.1.1	The Purpose of Roadway Lighting	10-1
10.1.2	Highway Lighting vs. Street Lighting	10-1
10.2	Classifications and Definitions	10-2
10.2.1	Highway Classifications	10-2
10.2.2	Pavement Classifications	10-2

10.3 Design Considerations	10-3
10.3.1 Visual Task	10-3
10.3.2 Glare, Light Trespass, and Sky Glow Issues	10-3
10.3.3 Impact of Headlights	10-3
10.3.4 Spectral Considerations	10-3
10.4 Design Issues	10-3
10.4.1 Curves and Steep Grades	10-3
10.4.2 Highway Interchanges	10-4
10.4.3 High-Mast Lighting	10-4
10.5 Lighting Recommendations	10-7
10.5.1 General	10-7
10.5.2 Lighting Criteria	10-9
10.6 Design Calculations	10-9
10.6.1 Recommended Calculation Methods	10-9
10.6.2 Recommended Luminance Calculation Method for Highways	10-9
10.7 Design Example – Freeway	10-10
Additional Reading	10-12
References for Chapter 10	10-12

Chapter 11: Street Lighting

11.1 Purpose of Roadway Lighting	11-1
11.2 Highway and Street Lighting	11-1
11.3 Classifications and Definitions	11-2
11.3.1 Street Classifications	11-2
11.3.2 Pavement Classifications	11-3
11.3.3 Pedestrian Activity Classifications	11-3
11.4 Design Considerations	11-3
11.4.1 Appearance and Scale	11-3
11.4.2 Visual Task	11-3
11.4.3 Integration with Non-lighting Elements	11-3
11.4.4 Vertical Surface Illumination	11-4
11.4.5 Glare, Light Trespass, and Sky Glow Issues	11-5
11.4.6 Impact of Headlights	11-5
11.4.7 Impact of Trees on Lighting	11-6
11.4.8 Spectral Considerations	11-6
11.5 Design Issues	11-6
11.5.1 Curves and Steep Grades	11-6
11.5.2 Trees Adjacent to Roadway	11-6
11.6 Residential Street Lighting: Particular Considerations and Recommendations	11-6
11.6.1 Residential Street Lighting Considerations	11-7
11.6.2 Safety and Security	11-7
11.6.3 When Residential Street Lighting May Not Be Needed	11-8
11.6.4 Luminaire Types for Residential Streets	11-8

11.7	Lighting Recommendations	11-9
11.7.1	General	11-9
11.7.2	Lighting Criteria	11-10
11.8	Design Calculations	11-10
11.8.1	Recommended Calculation Methods	11-10
11.8.2	Recommended Luminance Calculation Method for Streets	11-11
11.8.3	Recommended Illuminance Calculation Method for Cul-de-Sacs	11-11
11.9	Design Example – A Major Street	11-11
	Additional Reading	11-13
	References for Chapter 11	11-13

Chapter 12: Intersections, Roundabouts and Crosswalks

12.1	Definitions	12-1
12.1.1	Land Use Definitions	12-1
12.1.2	Intersection Definitions	12-1
12.1.3	Pedestrian Conflict Definitions	12-2
12.1.4	Lighting Definitions	12-2
12.2	Design Considerations	12-3
12.2.1	Safety	12-3
12.2.2	Site Conditions	12-3
12.2.3	Design Criteria	12-3
12.2.4	Identification of Design Elements	12-3
12.3	Intersections	12-3
12.3.1	Intersection Design Issues	12-3
12.3.2	Intersection Lighting Requirements	12-5
12.4	Roundabouts	12-7
12.4.1	Key Dimensions and Categories	12-9
12.4.2	Roundabouts and Other Circular Intersections	12-9
12.4.3	Roundabout Traffic Operations	12-10
12.4.4	Design Considerations for Roundabouts	12-12
12.4.5	Lighting Recommendations for Roundabouts	12-12
12.4.6	Roundabout Calculation Example	12-14
12.5	Crosswalks at Intersections	12-16
12.5.1	FHWA and VTTI Study	12-16
12.5.2	Vertical Illuminance Recommendations	12-17
12.6	Midblock Crosswalks	12-18
12.6.1	Design Considerations for Midblock Crosswalks	12-18
12.6.2	Midblock Crosswalk Design Issues	12-19
12.6.3	Lighting Recommendations for Midblock Crosswalks	12-19
12.6.4	Design Calculations	12-19
12.6.5	Midblock Crosswalk Design Example	12-20
	References for Chapter 12	12-21

Chapter 13: At-Grade Railway Crossings

13.1 Design Considerations	13-1
13.1.1 General Considerations	13-1
13.1.2 The Purpose of the Lighting	13-1
13.1.3 Light Sources and Controls	13-1
13.1.4 Pole and Luminaire Placement	13-1
13.2 Design Issues	13-2
13.2.1 Coordination with Other Elements	13-2
13.2.2 Clear Zone	13-2
13.2.3 Obtrusive Light	13-2
13.2.4 Local Requirements	13-2
13.3 Lighting Recommendations	13-2
13.4 Lighting Calculations	13-2
13.4.1 Horizontal Calculations for the Railway Crossing	13-2
13.4.2 Vertical Illuminance Calculations for the Train Cars	13-2
13.4.3 Glare Calculations	13-2
13.4.4 Calculation Grids	13-2
13.5 At-Grade Railway Crossing Design Example	13-3
References for Chapter 13	13-5

Chapter 14: Tunnels

14.1 Definitions	14-1
14.1.1 Types of Tunnels	14-1
14.1.2 Tunnel Topology Terms	14-1
14.2 Tunnel Design Considerations	14-2
14.2.1 Traffic and Roadway Geometry	14-2
14.2.2 Tunnel Architecture and Materials	14-3
14.2.3 Visibility at the Tunnel Approach	14-4
14.2.4 Ease of Maintenance	14-5
14.3 Tunnel Design Issues	14-5
14.3.1 Nighttime Adaptation	14-5
14.3.2 Visual Adaptation at the Tunnel Approach	14-5
14.3.3 Tunnel Physical Conditions and Characteristics	14-7
14.4 Tunnel Lighting Recommendations	14-8
14.4.1 General	14-8
14.4.2 Threshold Zone Lighting Requirements	14-8
14.4.3 Nighttime Luminance	14-8
14.4.4 Non-roadway Surface Illumination	14-11
14.4.5 Curved Tunnels	14-11
14.4.6 Uniformity Ratios	14-11
14.4.7 Veiling Luminance Ratios in Tunnels	14-11
14.4.8 Mitigating Flicker Effects	14-11
14.4.9 Switching Steps in Threshold and Transition Zones	14-12
14.4.10 Tunnel Emergency Lighting	14-12

14.5	Light Application Techniques	14-12
14.5.1	Symmetrical Light Distribution	14-12
14.5.2	Asymmetrical Light Distribution – Negative Contrast (ALD-NC)	14-12
14.5.3	Asymmetrical Light Distribution – Positive Contrast (ALD-PC)	14-13
14.5.4	and Narrow Tunnels.....	14-13
14.6	Tunnel Calculations: Methods of Determination of Luminance Criteria	14-13
14.6.1	Luminance Values in Threshold Zone	14-13
14.6.2	Threshold and Transition Zones	14-16
14.6.3	Tunnel Interior Zone	14-18
14.7	Lighting and Electrical Equipment for Tunnels	14-18
14.7.1	Light Sources	14-18
14.7.2	Equipment and Luminaires	14-20
14.7.3	Electric Power Supply and Distribution	14-20
14.7.4	Measurement, Control, and Switching Systems.....	14-20
14.8	Maintenance Considerations	14-21
14.8.1	General.....	14-21
14.8.2	Other Factors	14-21
14.9	Calculation Example – L_{SEQ} Method for Determining L_{TH}	14-22
	References for Chapter 14	14-23

Chapter 15: Toll Plazas

15.1	The Plaza Defined	15-1
15.1.1	Toll Roads.....	15-1
15.1.2	Toll Plazas.....	15-1
15.1.3	Approach Road (Ramp) and Departure Road	15-2
15.1.4	Approach and Departure Zones	15-2
15.1.5	Toll Collection Island	15-2
15.1.6	Infield	15-3
15.1.7	Administration and Maintenance Buildings	15-3
15.2	Design Considerations	15-3
15.2.1	Current Standards.....	15-3
15.2.2	Other Design Considerations	15-4
15.3	Design Issues	15-6
15.3.1	Security Lighting.....	15-6
15.3.2	Lighting Zones and Community Responsive Design.....	15-6
15.3.3	Obtrusive Light	15-6
15.4	Lighting Recommendations	15-7
	Additional Reading	15-8
	References for Chapter 15	15-8

Chapter 16: Off-Roadway Facilities

16.1 Walkways and Bikeways in the Public Right of Way	16-1
16.1.1 Definitions	16-1
16.1.2 Design Considerations	16-2
16.1.3 Design Issues	16-2
16.1.4 Lighting Recommendations	16-2
16.1.5 Design Calculations	16-5
16.2 Weigh Stations	16-5
16.2.1 Definitions	16-6
16.2.2 Design Considerations	16-6
16.2.2 Design Issues	16-6
16.2.3 Lighting Recommendations	16-6
16.2.4 Equipment	16-8
16.3 Public Rest And Service Areas	16-8
16.3.1 Definitions	16-8
16.3.2 Design Considerations	16-8
16.3.3 Design Issues	16-9
16.3.4 Lighting Recommendations	16-9
References for Chapter 16	16-11

Chapter 17: Parking Lots and Parking Garages

17.1 Purpose and Scope	17-1
17.2 Definitions	17-1
17.3 General Considerations Common to All Parking Facilities	17-2
17.3.1 Metrics	17-2
17.3.2 Vision Considerations	17-3
17.3.3 Site Considerations	17-4
17.3.4 Luminaire and Light Source Considerations	17-5
17.3.5 Lighting Quality	17-6
17.4 Parking Lots and Top (Open) Parking Decks of Garages	17-7
17.4.1 Design Considerations for Parking Lots	17-7
17.4.2 Design Issues for Parking Lots	17-8
17.4.3 Lighting Recommendations	17-8
17.4.4 Lighting Equipment for Parking Lots	17-10
17.4.5 Lighting Controls	17-12
17.4.6 Maintenance of Parking Lot Lighting	17-12
17.5 Parking Garages	17-12
17.5.1 Design Considerations for Parking Garages	17-12
17.5.2 Design Issues for Parking Garages	17-14
17.5.3 Lighting Recommendations	17-16
17.5.4 Lighting Equipment for Parking Garages	17-16
17.5.5 Lighting Controls	17-18
17.5.6 Maintenance of Parking Garage Lighting	17-18
References for Chapter 17	17-19

Chapter 18: Roadway Sign Lighting

18.1	Sign Types	18-1
18.1.1	Static Signs	18-1
18.1.2	Signs with Variable or Changeable Messages	18-1
18.1.3	Mounting Types	18-2
18.2	Sign Lighting Economics	18-2
18.3	External Sign Lighting	18-2
18.3.1	Equipment	18-2
18.3.2	Lighting Design for Externally Illuminated Signs	18-2
18.4	Internal Sign Lighting	18-4
18.4.1	Equipment	18-4
18.4.2	Design of Internally Illuminated Signs	18-4
18.5	Led Message Signs	18-4
	References for Chapter 18	18-5

Chapter 19: Temporary and Work Zone Lighting

19.1	Definitions	19-1
19.1.1	Work Zone Categories	19-1
19.1.2	Work Zone Lighting Systems	19-1
19.2	Design Considerations	19-2
19.3	Design Issues	19-3
19.3.1	Glare	19-3
19.3.2	Transient Adaptation	19-3
19.4	Lighting Recommendations	19-3
19.4.1	General	19-3
19.4.2	Avoiding Glare	19-3
19.4.3	Providing Transition Lighting	19-3
19.4.4	Recommendations for Rural Highways with Long-Duration Work Zones	19-4
19.4.5	Recommendations For Urban Highways with Long-Duration Work Zones	19-4
19.4.6	Recommendations For Urban Surface Streets with Street Lighting and Long-Duration Work Zones	19-5
19.4.7	Lighting For Flagging Stations	19-5
	Additional Reading	19-5
	References For Chapter 19	19-5

Annexes

ANNEX A	Roadway and Tunnel Field Measurements	A-1
ANNEX B	Outdoor Lighting Controls: Additional Information	B-1
ANNEX C	Contrast Method for Determining Threshold Lighting in a Tunnel	C-1
ANNEX D	Calculation of Tunnel Wall Luminance Using BRDFs for Typical Tunnel Wall Materials	D-1
ANNEX E	Evaluation of L_{seq} : Correct Use of a Camera	E-1
ANNEX F	Conversion Factors, Acronyms and Symbols	F-1
ANNEX G	Visibility Based Analysis of Parking Facility Lighting	G-1
ANNEX H	General Procedure for Calculating Maintained Illum in Pkg Lots and Garages	H-1
ANNEX I	Environmental Ratings for Enclosures	I-1
ANNEX J	Roadway Lighting Operations and Maintenance Example	J-1

For ANSI/IES Continuous Maintenance Forms, please use this link: www.ies.org/standards

Introduction to This Recommended Practice

ANSI/IES RP-8-18 is a substantial revision to previous versions of ANSI/IES RP-8 in that it is an aggregation of several IES Standards covering roadway and parking facility lighting. This document supersedes the following IES Standards:

- RP-8-14, *Roadway Lighting*
- RP-20-14, *Lighting for Parking Facilities* (revised 2016)
- RP-22-11, *Tunnel Lighting*
- DG-4-14, *Design Guide for Roadway Lighting Maintenance*
- DG-19-08, *Design Guide for Roundabout Lighting*
- DG-21-15, *Design Guide for Residential Street Lighting*
- DG-23-14, *Design Guide for Toll Plazas*
- DG-26-16, *Design Guide for Lighting the Roadway in Work Zones*
- DG-28-15, *Design Guide for Selection, Installation, Operations and Maintenance of Roadway Lighting Control Systems*
- LM-50-13, *Photometric Measurement of Roadway and Street Lighting Installations*
- LM-71-14, *Photometric Measurement of Tunnel Lighting Installations*
- TM-10-00(R2011), *Addressing Obtrusive Light (Urban Sky Glow and Light Trespass) in Conjunction with Roadway Lighting*

This Recommended Practice is a compilation of lighting design techniques and criteria, all offered for quality roadway lighting solutions. Each chapter should not be taken in isolation but used as a whole for quality lighting design for roadways and other environments where vehicles are present, such as tunnels, intersections, and parking lots.

A lighting designer will often simplify the design criteria to lighting level and uniformity. However, impacts on visual quality go beyond these simple criteria and encompass minimizing glare and providing spectral contrast on pedestrians, hazards, and other vehicles. All design criteria are important in order to achieve these goals

1. Improve motorist visual quality
2. Provide quality light and increased contrast for seeing hazards
3. Illuminate conflict areas
4. Minimize environmental impacts of light at night
5. Employ lighting systems that are easily maintained and minimize energy use

This Standard was prepared with the objective of providing lighting design guidance for most kinds of roadway and roadway-related applications. The recommendations contained in this document, however, may not reflect specific local factors or situations that are not typical and require special treatment. The contents of this Standard are based upon consensus of roadway lighting experts. It has no legislative authority unless adopted by an authority having jurisdiction. This Recommended Practice is not intended to establish a basis for civil liability.

This Standard is intended to be a single source of reference for roadway lighting; however, additional documents such as electric codes, transportation design guides and other codes and standards are often required design references.

History of the Document

This Recommended Practice is a compilation by IES staff and the Roadway Lighting Committee's Special Task Group of documents authorized by several lighting organizations and authorities. The majority of topics are from the 12 roadway lighting documents of the Illuminating Engineering Society listed in the **Introduction to This Recommended Practice**, along with the Transportation Association of Canada (TAC) *Guide for the Design of Roadway Lighting* and the TAC *Roadway Lighting Efficiency & Power Reduction Guide*.

CONTENTS

17.1	Purpose and Scope	17-1	17.4.4	Lighting Equipment for Parking Lots.	17-10
17.2	Definitions	17-1	17.4.5	Lighting Controls	17-12
17.3	General Considerations Common to All Parking Facilities	17-2	17.4.6	Maintenance of Parking Lot Lighting	17-12
17.3.1	Metrics	17-2	17.5	Parking Garages	17-12
17.3.2	Vision Considerations	17-3	17.5.1	Design Considerations for Parking Garages	17-12
17.3.3	Site Considerations	17-4	17.5.2	Design Issues for Parking Garages	17-14
17.3.4	Luminaire and Light Source Considerations	17-5	17.5.3	Lighting Recommendations	17-16
17.3.5	Lighting Quality	17-6	17.5.4	Lighting Equipment for Parking Garages	17-16
17.4	Parking Lots and Top (Open) Parking Decks of Garages	17-7	17.5.5	Lighting Controls	17-19
17.4.1	Design Considerations for Parking Lots.	17-7	17.5.6	Maintenance of Parking Garage Lighting	17-19
17.4.2	Design Issues for Parking Lots	17-8		References for Chapter 17.	17-20
17.4.3	Lighting Recommendations	17-8			

Part 1 – Fundamentals

Introduction to Roadway Lighting

Chapter 1

CONTENTS

1.1	Why Light?	1-1	1.4	Lighting Warrants.	1-4
1.2	Human Factors.	1-1	1.5	Energy Conservation.	1-4
1.3	The Value of Lighting	1-2	1.6	Environmental Factors	1-5
1.3.1	The Key Benefit – A Reduction In Crashes	1-2	1.7	Alternatives to Lighting	1-5
1.3.2	Cost-Benefit Analysis of Roadway Lighting	1-3	1.8	Reference Lighting Organizations	1-6
1.3.3	The Need for Good Design	1-4		Additional Reading	1-7
				References for Chapter 1	1-8

Driving at night is a necessity in our modern, 24-hour society. As a result, roadway lighting has also become a modern reality. The main purpose for lighting roadways and other transportation related facilities is to provide an enhanced visual environment for people to safely use the road system during hours of darkness. An enhanced visual environment reduces motor vehicle collisions and provides a safer environment for pedestrians, cyclists, and drivers.^{1,2,3} In providing some knowledge of what lies ahead on the road, lighting also provides a level of psychological comfort for those using roadways.

1.1 Why Light?

Collision statistics gathered throughout North America show that more than 50% of fatal collisions happen during nighttime hours. Even though an estimated 25% of travel takes place during these hours, the fatality rate is three times higher than during daytime hours. Properly designed roadway lighting aids in improving visibility of roadway features and helps the road user locate objects on the roadway as well as other vehicles, pedestrians, and cyclists. This results in increased safety for all.²

There is a consensus of statistics indicating that roadway lighting substantially decreases nighttime collision rates. Most important, the number of fatalities is reduced. Pedestrian fatalities account for approximately one quarter of all roadway related fatalities; hence, lighting of urban areas with large numbers of pedestrians is also important.^{4,5}

Lighting of roadways and other transportation facilities may have a number of benefits not directly related to driving. These include:

- **Personal security:** Although there is some controversy over whether lighting improves security, there is no question that individuals feel more secure when walking, cycling or driving in a well-lighted area. Though some studies have shown that adding luminaires or increasing light levels can reduce crime in a given area, the actual long-term benefits and community-wide impacts are unknown.⁶ By creating a safe feeling, lighting may draw people into an area, and increased pedestrian circulation will typically improve security. Social and economic factors of a given area, as well as police presence, will also have impacts on personal security. *Note:* For non-right-of-way areas where security is of particular concern, the reader is referred to IES G-1-16, *Security Lighting for People, Property, and Critical Infrastructure*.

- **Economics:** Lighting may draw people into a commercial area by providing increased visibility of businesses and a sense of personal security, and may thereby lead to an increase in commerce. Decorative lighting can be used for the economic revitalization of an area by contributing to a “sense of place” or by supporting a community architectural or urban design theme. *Note:* The benefits listed above may not necessarily apply to residential roads where there is little or no pedestrian activity during the hours of darkness.
- **Aesthetics:** Lighting may draw attention to architecture and other aesthetic features such as streetscapes, monuments, or parks. These features can enhance the nighttime use of facilities and improve the experience of roadway users at adjacent locations.

This Recommended Practice is intended to recommend proper techniques to allow motorists, pedestrians and cyclists within the right of way to benefit from the value of lighting. If designed or installed improperly, the benefits of lighting may be reduced. Improper pole heights may lead to excessive spill light on adjacent properties. Poles placed within the clear zone without breakaway bases may pose safety concerns. Over-lighting may reduce visibility while consuming excessive amounts of energy.

1.2 Human Factors

The human factors associated with lighting, including physical and psychological aspects, are complex. For roadway lighting, some of these include the condition of the driver’s eyes, the constantly changing level of eye adaptation, the driver’s level of fatigue, and his or her sensitivity to light.

Visual cues are estimated to comprise about 90 percent of a driver’s information, including critical