Illuminating ENGINEERING SOCIETY

ANSI/IES RP-7-17

Recommended Practice for Lighting Industrial Facilities

Approved American National Standard ANSI

ANSI/IES RP-7-17

Recommended Practice for Lighting Industrial Facilities

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

Prepared by:
The IES Industrial Lighting Committee

Approved by the IES Standards Committee, June 16, 2017, as a Transaction of the Illuminating Engineering Society of North America.

Approved as an American National Standard July 13, 2017.

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 Brian Liebel, IES Director of Standards and Research, at the above address for verification and correction. The IES welcomes and urges feedback and comments.

ISBN # 978-0-87995-345-4

Printed in the United States of America.

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.

Prepared by the IES Industrial Lighting Committee

Doug Paulin, *Chair*
Graeme Lister, *Vice Chair*
Bill Busch, *Secretary*

F. Agraz*
T. Barnes
P. Bryant*
W. Callham*
J. Casper*
J. Castner*
P. Chavdarian*
J. Daigh
M. Drew*
A. Feldman*
J. Fetters*
S. Fortwangler*
J. Green
B. Jarnot*
T. Johnson*
R. Kauffman
V.i Kohanek*
P. Kravec*
M. Lambert*
R. Lane
R. Larivee*
H. Lee*
D. Lincoln*
A. Oreye*
G. Ortt*
C. Orozco*
C. Palmer*
B. Plekan*
M. Rahman*
A. Reyes*
J. Rice
T. Salter*
M. Santiago*
O. Scaggs*
M. Schneider*
N. Smirnov
A. Welch*

* Advisory

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 and 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.

Contents

1.0 INTRODUCTION . . . 1
1.1 Purpose and Scope . . . 1

2.0 LIGHTING THE INDUSTRIAL ENVIRONMENT . . . 1
2.1 General Design Considerations for Lighting Industrial Areas . . . 1
2.2 Code Compliance . . . 2
2.3 The IES Lighting Handbook and Industrial Lighting Design Recommendations . . . 2

3.0 QUALITY OF LIGHTING IN INDUSTRIAL FACILITIES . . . 3
3.1 Luminance and Luminance Ratios . . . 3
3.2 Modeling of Objects . . . 4
3.3 Glare and Visual Comfort . . . 4
3.4 Material Characteristics . . . 5
3.5 Shadows . . . 5
3.6 Source/Task/Eye Geometry . . . 6
3.7 Task Visibility: Flicker and Strobe . . . 6
3.8 Light Source Color . . . 8
3.8.1 Color Rendering . . . 8
3.8.2 Safety Colors . . . 9
3.9 Daylight Integration and Control . . . 10

4.0 QUANTITY OF LIGHTING IN INDUSTRIAL FACILITIES . . . 10
4.1 Illuminance: Horizontal, Vertical, and Intermediate Planes . . . 13
4.1.1 Horizontal Illuminance . . . 13
4.1.2 Vertical Illuminance . . . 13
4.1.3 Illuminance Measurements . . . 14
4.2 Initial and Maintained Illuminance . . . 16
4.3 Lighting System Maintenance . . . 16
4.3.1 Maintenance in an Industrial Environment . . . 16
4.3.2 Planned Maintenance Techniques . . . 17
4.3.3 Planning and Economics . . . 18
4.3.4 Luminaire Cleaning . . . 18
4.3.5 Troubleshooting . . . 18
4.3.6 Safety . . . 18
4.3.7 Disposal of Failed Lighting Components . . . 19

5.0 LIGHTING EQUIPMENT – LIGHT SOURCES . . . 19
5.1 Fluorescent Systems . . . 19
5.1.1 Source Characteristics . . . 19
5.1.2 Fluorescent Luminaire Characteristics and Performance . . . 19
5.1.3 Induction Systems . . . 21
5.2 High Intensity Discharge (HID) Lighting Systems . . . 22
5.2.1 Metal Halide Lamps . . . 22
5.2.2 High Pressure Sodium (HPS) Lamps . . . 23
5.3 Light Emitting Diodes (LEDs) . . . 24

5.3.1 LED Light Source Components . . . 24
5.3.2 Distinguishing Characteristics and Performance . . . 24
5.4 Other Light Sources . . . 25
5.4.1 Incandescent and Halogen Lamps . . . 25
5.4.2 Plasma Lamps . . . 25
5.4.3 Organic Light Emitting Diodes (OLEDs) . . . 25

6.0 LIGHTING EQUIPMENT - LUMINAIRES . . . 26
6.1 General Luminaire Characteristics and Performance . . . 26
6.2 Operating Considerations . . . 27
6.3 Luminaire Classifications . . . 27
6.3.1 Indoor . . . 28
6.3.2 Outdoor . . . 31

7.0 ELECTRICAL SYSTEM CONSIDERATIONS . . . 35
7.1 General Considerations . . . 35
7.2 Voltage Considerations . . . 35

8.0 LIGHTING CONTROLS . . . 35
8.1 Time Switches (“Time Clocks”) and Partial-Night Photocontrols . . . 35
8.2 Motion Detectors . . . 35
8.2.1 Passive Infrared (PIR) Detectors . . . 35
8.2.2 Ultrasonic Motion Detectors . . . 36
8.2.3 Sound-Sensing Detectors . . . 36
8.3 Networked (Remote) Control . . . 36
8.3.1 Monitored Interactive Systems . . . 36
8.3.2 Wired vs. Wireless Control Systems . . . 36
8.4 Dimming . . . 36

9.0 BUILDING CONSTRUCTION FEATURES THAT INFLUENCE LUMINAIRE SELECTION AND LUMINAIRE PLACEMENT . . . 37

10.0 LIGHTING SYSTEM ECONOMIC ANALYSIS . . . 38

11.0 SPECIAL CONSIDERATION FACTORS . . . 39
11.1 Lighting and Space Conditioning . . . 39
11.2 Classified Areas . . . 39
11.2.1 Hazardous Location Classes . . . 39
11.2.2 Hazardous Location Conditions . . . 40
11.2.3 The Nature of Hazardous Substances . . . 40
11.2.4 Classified Location Luminaires . . . 41
11.3 High Humidity or Corrosive Atmospheres . . . 41
11.4 High Ambient Temperatures . . . 41
11.5 Low Ambient Temperatures . . . 41
11.6 Clean Rooms . . . 42
11.7 Food and Drug Processing . . . 42

12.0 GENERAL LIGHTING . . . 43

13.0 SUPPLEMENTARY TASK LIGHTING 43
13.1 Portable Luminaires 45
14.0 SPECIAL EFFECTS AND TECHNIQUES 45
14.1 Classification of Visual Tasks and Lighting Techniques 45
14.2 Color Contrast 49
14.3 Lighting Techniques for Inspection Tasks 49

15.0 EMERGENCY, SAFETY AND SECURITY LIGHTING 50
15.1 Emergency Lighting 50
15.2 Safety Lighting 51
15.3 Security Lighting 51

16.0 LIGHTING FOR SPECIFIC TASKS 51
16.1 Molding of Metal and Plastic Parts 52
16.1.1 Foundry Molding (Sand Casting) 52
16.1.2 Molding Parts of Die-Cast Aluminum and Injection Molded Plastic 52
16.1.3 Inspection of Sand Castings 53
16.1.4 Inspection of Die Castings and Opaque Injection Molded Plastic Parts 53
16.2 Parts Manufacturing and Assembly 53
16.3 Machining Metal Parts 54
16.4 Lighting and Visibility Issues for Sheet Metal Fabrication 54
16.4.1 Punch Press 54
16.4.2 Shear 55
16.5 Lighting for Large Component Subassembly and Final Assembly 55
16.6 Control Rooms 56
16.7 Manufacturing Electronic Assemblies 56

17.0 LIGHTING FOR SPECIFIC VISUAL TASKS 57
17.1 Convex Surfaces 57
17.2 Flat Surfaces 57
17.3 Scribed Marks 57
17.4 Center-punch Marks 57
17.5 Concave Specular Surfaces 57
17.6 Flat Specular Surfaces 57
17.7 Convex Specular Surfaces 58

18.0 WAREHOUSE AND STORAGE AREA LIGHTING 58
18.1 Types of Warehouse Area and Storage Systems 59
18.2 Warehouse Illuminance 59
18.2.1 Vertical Illuminance 60
18.2.2 Horizontal Illuminance 60
18.3 Warehouse Lighting Design Considerations 60
18.3.1 Intermittent Use 60
18.3.2 Lighting Design Considerations by Area 60
18.3.3 Other Lighting Design Considerations 61

19.0 OUTDOOR AREA LIGHTING 61
19.1 Lighting Zones 61
19.2 Projected Lighting System 62

19.3 Distributed Lighting System. 63
19.4 Outdoor Tower Platforms, Stairways, and Ladders. 63
19.5 Special Equipment 63
19.6 Low Illuminance and Visual Acuity Outdoors 64

ANNEX A – ILLUMINANCE RECOMMENDATIONS. 64

ANNEX B – INDUSTRIAL LIGHTING DEFINITIONS 102

ANNEX C – GLARE 102

ANNEX D – ILLUMINANCE CALCLUATIONS 107

ANNEX E – CONTROL GEAR. 109

ANNEX F – INGRESS PROTECTION (IP) RATINGS 118

REFERENCES 119

1.0 INTRODUCTION

A well-designed lighting system can make an important contribution to the success of an industrial facility. The success of the well-lighted industrial environment can affect productivity, employee performance, safety, energy efficiency, maintenance costs, and the number of errors and lost-time accidents. Many features of a lighting system other than the quantity of light provided can make a significant contribution to the efficiency and safety of the industrial worker.

In the design of lighting for industrial environments, horizontal illuminance has commonly been the only consideration. However, many industrial tasks take place in planes with various orientations and in areas with overhead obstructions. Placement of the luminaires is critical to providing light of the proper quality, as well as quantity and direction, to allow fast, easy recognition of operations. These operations may be taking place at high speeds in areas of the production machinery or industrial products where ambient light cannot easily penetrate.

Selection of the luminaire and its photometric distribution can be important to rendering the visual task properly when that task is multidimensional rather than flat, and when the task occurs in a plane other than horizontal. The operation of the lighting system should be understood to ensure that the proper light sources are selected. Improper light source choice can result in difficult and potentially dangerous conditions caused by long warm-up periods or stroboscopic effects created where rotating parts are involved. The ability of the light to render colors accurately can have an effect on the recognition of colors, including safety colors, or product components. Many industrial operations take place in hostile environments, and the lighting products and hardware used in these locations should be designed and manufactured to survive in these conditions and be easy to maintain.

For these reasons, and many others, great care is required in order to provide an effective, efficient and readily maintainable lighting system for all industrial spaces, and to help modern industrial workers operate at the peak of their ability in a safe environment.

1.1 Purpose and Scope

The primary purpose of this standard is to serve as a guide and educational tool for the design of permanently installed lighting systems for industrial facilities. This Recommended Practice deals entirely with lighting and does not give advice on the construction of a facility. The scope of this practice covers the design of new indoor and outdoor lighting systems for new industrial facilities as well as the redesign of lighting systems in existing industrial facilities. Recommendations are based on quality lighting practices, including: the safe movement of vehicles and people, enhancing the productivity and comfort of employees, conserving energy, and minimizing maintenance. Recommended minimum maintained lighting levels and maximum uniformity ratio guidelines are provided but are subject to variation for special circumstances when based upon sound engineering judgment.

This Practice does not include all information for mixed application areas such as parking lots, offices, outdoor environments, commercial facilities, or daylighting design. For these crossover applications, the associated Recommended Practice documents should be used in conjunction with this Practice to provide the lighting recommendations.

In short, this Recommended Practice will help the reader make intelligent choices to achieve the lighting goals with a minimum of expense of time and capital.

2.0 LIGHTING THE INDUSTRIAL ENVIRONMENT

Providing a successful lighting design for a modern industrial facility is a complex task. In recent years, much more has been learned about lighting and its positive effects on the wellbeing of people. The goal of providing an efficient, reliable and easily maintainable lighting system, making use of all of the knowledge available to the designer today, is one that requires experience and considerable planning.

Industrial facilities include manufacturing areas, such as fabrication, assembly, sub-assembly, and finishing, as well as quality control, warehousing and logistics. Related areas can also be laboratories, pharmaceutical and/or chemical production facilities (including “clean rooms”), and vehicle maintenance and repair facilities.

2.1 General Design Considerations for Lighting Industrial Areas

The designer of an industrial lighting system should carefully consider all of the following design criteria,

which could be important in planning a successful industrial lighting installation. (These criteria are not necessarily arranged in order of importance, since priorities will vary for different industries or locations within an industrial complex.)

- Determine the *quality* of illumination for the manufacturing processes involved. (See **Section 3.0** in this document, as well as Section 4.7, Section 4.12, Table 4.1, and Section 12.5.5 in *The Lighting Handbook,* 10th ed.[8])

- Determine the *quantity* of illumination for the manufacturing processes involved. (See **Section 4.0** and **Annex A**.)

- Determine the lighting required for *safety*, and ensure that quality, quantity and safety are properly weighted and addressed in the final design.

- Select listed or approved lighting equipment that will provide the requirements of quality and quantity, including photometric characteristics, as well as the mechanical performance required to meet installation and operating conditions.

- Arrange equipment so that it will be safe, easy and practical to maintain. Evaluate operating conditions that may create dangerous or unacceptable risks to people, facility, or equipment.

- Consider the energy as well as the economic and operating characteristics of the selected lighting system, and be sure that all factors have been properly weighted and balanced against the five considerations above before finally accepting the design.

- Consider the use of lighting controls for best energy conservation: the right *amount* of light, at the right *time*.

2.2 Code Compliance

Lighting system materials and installations shall comply with all applicable national, state or provincial and local codes, ordinances and laws.

For installations within the United States of America, the construction, application and installation of lighting equipment are required to comply with all applicable provisions of the latest edition of NFPA 70, *National Electrical Code*,[1] including, but not limited to, the following Articles, or to other editions of this document which may be enforceable by the government agencies having jurisdiction at the time and place of installation:

- Article 215 Feeders
- Article 220 Branch Circuits, Feeders and service Calculations
- Article 250 Grounding and Bonding
- Article 410 Luminaires (Lighting Fixtures), Lampholders and Lamps
- Article 411 Lighting Systems Operating at 30 Volts or Less
- Articles 500 through 517 covering Hazardous Locations
- Article 700 Emergency Systems

Emergency lighting equipment, applications and installations are required to comply with the applicable provisions of NFPA 101, *Life Safety Code*, latest version; NFPA 110, *Standard for Emergency and Standby Power Systems*,[2] latest version; and NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems;*[3] or to other editions of these documents that may be enforceable by the government agencies having jurisdiction at the time and place of installation. Battery powered unit equipment emergency and exit lighting shall comply with UL 924 and, if necessary, other UL requirements.

Lighting systems in Canada[4] and Mexico[5,6] shall comply with all applicable codes, laws and ordinances in their respective locations.

2.3 The IES Lighting Handbook and Industrial Lighting Design Recommendations

Historically, the IES recommended illuminance criteria for specific applications or visual tasks. Such recommendations were often mistaken as the primary or even sole criterion for lighting design. Beginning with the publication of *The IESNA Lighting Handbook,* 9th ed.[7] and continuing with the 10th edition,[8] the approach has been to consider a wide range of lighting design criteria important for a high quality visual environment. In addition to illuminance, the lighting designer is also encouraged to consider the age range of the users of the space, whether the visual task is in a horizontal or vertical plane, or somewhere in between, and the importance of illuminance uniformity. The recommended horizontal and vertical illuminance values for a diverse group of industrial tasks, broken down by visual task, are provided in **Annex A**.