STD.NEMA LE 5B-ENGL 1998 ■ 6470247 0514477 89T ■

NEMA STANDARDS PUBLICATION

LE 5B

PROCEDURE FOR DETERMINING LUMINAIRE EFFICACY RATINGS FOR HIGH-INTENSITY DISCHARGE INDUSTRIAL LUMINAIRES



NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

NEMA STANDARDS PUBLICATION LE 5B-1998

Procedure for Determining Luminaire Efficacy Ratings for High-Intensity Discharge Industrial Luminaires

Published by

National Electrical Manufacturers Association
1300 North 17th Street, Suite 1847
Rosslyn, Virginia 22209

© Copyright 1998 by the National Electrical Manufacturers Association. All rights including translation into other languages, reserved under the Universal Copyright Convention, the Berne Convention for the Protection of Literary and Artistic Works, and the International and Pan American Copyright Conventions.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

CONTENTS

Foreword iii
Purpose iv

Clause

Section 1 **GENERAL** 1
1.1 Scope 1
1.2 References 1
1.3 Definitions 2

Section 2 **SELECTION OF COMPONENTS** 3
2.1 Test Specimen—Lighting Fixtures 3
2.2 Test Specimen(s)—HID Lamp(s) 3
2.3 Test Specimen(s)—HID Ballast(s) 3

Section 3 **TESTING FACILITIES AND EQUIPMENT** 5
3.1 Facilities 5

Section 4 **PROCEDURE** 7
4.1 Luminaire Efficacy Rating—High-Intensity Discharge Industrial Luminaires 7
4.2 Luminaires 7
4.3 Luminaire Type and Classification 7
4.4 Exceptions 7

Section 5 **CALCULATIONS** 9
5.1 Luminaire Efficacy Rating—High-Intensity Discharge Industrial Luminaires 9
5.2 Ballast Factor for HID Ballasts 9

Section 6 **LIGHTING ENERGY COSTS—HIGH-INTENSITY DISCHARGE INDUSTRIAL LUMINAIRES** 11
6.1 Comparative Yearly Energy Cost of Light 11
6.2 Calculation 11

Section 7 **RECOMMENDED REPORTING CATEGORIES AND FORMAT** 13
7.1 Category Description 13
7.2 Recommended Reporting Format 13

Annex A **THE RATIONALE FOR HIGH-INTENSITY DISCHARGE INDUSTRIAL LUMINAIRES** 15
A.1 Ballast Factors 15
A.2 Luminaire Efficiency 15
A.3 Luminaire Wattage 15

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

Foreword

This Standards Publication was developed to assist governmental agencies, laboratories, electrical utility companies, and manufacturers in performing standardized tests to evaluate the energy efficiency of high-intensity discharge industrial luminaires.

It is not the intent of this Standards Publication to inhibit luminaire design or to impose arbitrary controls on any luminaire manufacturer.

The preparation of this Standards Publication was done by the Lighting Fixtures Section in cooperation with the Lamp and Ballast Sections of the NEMA Lighting Systems Division. Input of users and other interested parties has been sought and evaluated. Inquiries, comments, and proposed revisions should be submitted to the Lighting Fixtures Section of NEMA by contacting:

Vice President, Engineering Department
National Electrical Manufacturers Association
1300 North 17th Street, Suite 1847
Rosslyn, VA 22209-3801

This standard was developed at the request of the NEMA Lighting Fixtures Section by its Technical Committee. Section approval of the standard does not necessarily imply that all section members voted for its approval or participated in its development. At the time it was approved, the Lighting Fixtures Section was composed of the following members:

American Electric Lighting—Memphis, TN
Cooper Lighting Group—Elk Grove Village, IL
Durolite—Fairfield, NJ
GE Lighting Systems—Hendersonville, NC
Holophane Corporation—Newark, OH
Hubbell Lighting, Inc.—Christiansburg, VA
Indy Lighting, Inc.—Fishers, IN
Juno Lighting, Inc.—Des Plaines, IL
Lighting Corporation of America—San Leandro, CA
Lithonia Lighting—Conyers, GA
O-Z Gedney—Tulsa, OK
Paramount Industries, Inc.—Croswell, MI
ProLight—Holland, MI
Red Dot Division, L.E. Mason Co.—Boston, MA
Simkar Lighting Fixture Co.—Philadelphia, PA
SPI Lighting, Inc.—Mequon, WI
The Genlyte Group—Union, NJ
The Jones Metal Products Company—West Lafayette, OH
Thomas Lighting, Inc.—Tupelo, MS

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Purpose

The purpose of this Standards Publication is to:

a. Provide governmental agencies with uniform practical metrics for evaluating the energy efficiency of high-intensity discharge (HID) industrial luminaires.

b. Preserve the ability to use laboratory facilities, testing methods, and completed test data that currently exist and are in accordance with approved industry standards.

c. Establish a luminaire efficacy rating (LER) based on *rated* lumens per watt. Rated lamp lumens are used so as not to require the use of absolute photometry and to be able to use published rated values. Rated ballast input power consumption is used in order to provide a consistent and relative rating system based on readily available data for input power.

NOTE—Photometric tests of luminaires which were completed prior to issue date of this document may be used for the calculation of LER values by substituting appropriate input power values as required from Table A-2.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Section 1
GENERAL

1.1 SCOPE

This Standards Publication provides a procedure for the determination of the luminaire efficacy rating of HID industrial luminaires under laboratory test conditions.

This is not meant for low volume or specialty luminaires. Specific exclusions include luminaires for hazardous areas as defined by the National Electrical Code (NEC), high vandal areas, luminaires utilizing automatically switched quartz standby circuits, and luminaires with less than 150 watt lamps.

This Standards Publication *does not* address suitability for application or many of the other application issues that affect the overall lighting criteria for a particular facility. Some issues for further consideration are listed below. This list is not intended to encompass all applications.

a. The specific visual tasks involved;
b. Luminaire placement;
c. Other lighting performance characteristics, such as distribution, color, glare, coefficients of utilization, etc.;
d. Lighting maintenance issues;
e. On/off or reduced level control strategies;
f. The ability of a particular ballast to regulate lamp wattage as the line voltage fluctuates.

The luminaire efficacy rating of a HID industrial luminaire must be used in conjunction with the appropriate design factors to determine if a given luminaire is suitable for a particular application.

1.2 REFERENCES

The following normative documents contain provisions, which through reference in this text constitute provisions of this Standards Publication. By reference herein, these publications are adopted, in whole or in part, as indicated in this Standards Publication.

American National Standards Institute (ANSI)
11 West 42nd Street, 13th Floor
New York, NY 10036

ANSI C78.387-1995	*Metal-Halide Lamps—Measurement of Characteristics*
ANSI C78.388-1990	*High Pressure Sodium lamps - Measurement of Characteristics*
ANSI C82.4-1985	*High-Intensity-Discharge and Low Pressure Sodium Lamp Ballasts (Multiple-Supply Type), Specifications For*
ANSI C82.6-1985	*High-Intensity Discharge Lamp Ballasts, Methods of Measurement*
ANSI /IEEE 100	*IEEE Standard Dictionary of Electrical and Electronic Terms*

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Illuminating Engineering Society of North America (IESNA)
120 Wall Street, FL 17
New York, NY 10005-4001

	IESNA Lighting Handbook, Eighth Edition, 1993
IESNA LM-51-93	*Electrical and Photometric Measurements of High-Intensity Discharge (HID) Lamps*
IESNA LM-46-92	*Photometric Testing of Indoor Luminaires Using High-Intensity Discharge or Incandescent Filament Lamps*

1.3 DEFINITIONS

ballast: A device used with an electric-discharge lamp to obtain the necessary circuit conditions (voltage, current, and wave form) for starting and operating.

ballast factor (BF): A term used to describe the percentage of light output produced when a HID lamp is energized from a commercially available ballast as compared to the light output produced when energized from a reference ballast. Ballast factor tests are run in accordance with ANSI C82.6.

fixture: The structural parts of a luminaire, including parts designed to distribute the light, to position and/or protect the lamp(s), to mount and support the ballast(s), and to provide a wire way or means of connecting the lamp(s) and ballast(s) to the power supply. A fixture includes the ballast(s), but does not include the lamp(s).

high-intensity discharge (HID) lamp: An electric discharge lamp in which the light producing arc is stabilized by wall temperature, and the arc tube has a bulb wall loading in excess of three watts per square centimeter. HID lamps include groups of lamps known as mercury, metal halide, and high pressure sodium.

industrial luminaire: A luminaire type designed specifically for the task requirements of an industrial application.

lumen: The SI unit of luminous flux.

luminaire efficacy rating (LER): A rating used to evaluate the lighting and energy performance of a luminaire.

luminaire efficiency: The ratio of luminous flux (lumens) emitted by a luminaire to that emitted by the lamp or lamps used therein.

typical HID lamp lumens: The established industry standard lumen value for the typical, average, initial lamp lumen output.

upward efficiency: The ratio of luminous flux (lumens) emitted by a luminaire in the 90- to 180-degree zone to the total luminous flux emitted by the lamp or lamps used therein.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Section 2
SELECTION OF COMPONENTS

2.1 TEST SPECIMEN—LIGHTING FIXTURE

The fixture selected for test shall be clean and representative of the manufacturer's current and regular production.

2.2 TEST SPECIMEN(S)—HID LAMP(S)

Lamp(s) of stable output shall be used. They should be constant in light output for constant line voltage and repeated operation and typical of current production.

2.3 TEST SPECIMEN(S)—HID BALLAST(S)

HID ballast(s) used for the photometric test shall be adjusted to supply rated lamp watts as specified in IESNA LM-46.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

Section 3
TESTING FACILITIES AND EQUIPMENT

3.1 FACILITIES

The photometric laboratory shall have facilities for performing tests in accordance with all applicable sections of the IESNA LM-46.

Because of the importance of obtaining accurate and repeatable measurements, a photometric laboratory accredited by the National Voluntary Laboratory Accreditation Program or another third party certification organization is recommended for testing.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

Section 4
PROCEDURE

4.1 LUMINAIRE EFFICACY RATING—HIGH-INTENSITY DISCHARGE INDUSTRIAL LUMINAIRES

Luminaire efficacy rating shall be specified as a minimum value, a value which cannot be lowered by changing the type of applicable lamp after original installation, for each type and classification shown in 4.3. The input wattage used in the LER calculation should be the rated input wattage for the ballast that is used in the manufacturer's standard product offering.

4.2 LUMINAIRES

The luminaire efficiency shall be determined by photometric tests in accordance with IESNA LM-46.

4.3 LUMINAIRE TYPE AND CLASSIFICATION

a. Open luminaire;
b. Closed luminaire.

4.4 EXCEPTIONS

Luminaires for special applications (such as hazardous areas as defined by the National Electrical Code and high vandal areas), luminaires utilizing automatically switched quartz standby circuits, and luminaires with less than 150 watt lamp are excluded.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

Section 5
CALCULATIONS

5.1 LUMINAIRE EFFICACY RATING—HIGH-INTENSITY DISCHARGE INDUSTRIAL LUMINAIRES

Luminaire Efficacy Rating (LER) shall be calculated for a given luminaire by the following formula:

LER = (EFF x TLL x BF) / Watts Input

where:

LER = Luminaire Efficacy Rating, expressed in rated lumens per watt. This value shall be shown as a whole number, rounding up (≥0.5) or down (<0.5) as required.

EFF = Luminaire Efficiency, expressed as a two-place decimal rounding up (≥0.005) or down (<0.005) as required.

TLL = Total Lamp Lumens. Total number of lamps in the test fixture multiplied by the rated lamp lumens of the tested lamp(s), in accordance with Table 5-1.

BF = Ballast factor of test ballast or the average ballast factor of test ballasts used in the photometric test.*

Watts Input = Total published rated input wattage of the ballast(s) used in the luminaire as determined, in accordance with ANSI C82.6. This value is to be shown as a whole number, rounding up (≥0.5) or down (<0.5) as required.

5.2 BALLAST FACTOR FOR HID BALLASTS

HID luminaire photometric testing is based on IESNA LM-46 and, in accordance with this test method ballast performance, is based on nominal wattage delivered to reference lamp instead of light output. Under these methods of ANSI C82.4, ballast factor is assumed to be 1.0.

---

* The photometric test for luminaire efficiency shall be in accordance with IESNA LM-46.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Table 5-1
TYPICAL RATED HID LAMP LUMENS*

Lamp Type**	Watts	Operating Position	Approximate Initial Lumens
Metal Halide	175	Base up	14,000
	250	Base up	21,000
	400	Base up	36,000
	1,000	Base up	110,000
High Pressure Sodium	150	Any	16,000
	200	Any	22,000
	250	Any	27,500
	310	Any	37,000
	400	Any	50,000
	750	Any	110,000
	1000	Any	140,000

*Typical rated lamp lumens are measured after 100 hours when tested, in accordance with industry Standard IESNA LM-51. The values in Table 5-1 are for use in establishing reasonably comparative LER values and do not imply that the approximate initial lumens will be the same for a given lamp type from each manufacturer.

**Lamp types have clear envelopes and mogul bases.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Section 6
LIGHTING ENERGY COST—HIGH-INTENSITY DISCHARGE INDUSTRIAL LUMINAIRES

6.1 COMPARATIVE YEARLY ENERGY COST OF LIGHT

The yearly lighting energy cost for comparative purposes in this procedure is to be based on 1000 lumens and the following:

a. 3000 average burning hours per year;
b. $0.08/kwh average electrical energy rate.

Thus, the constant "K" for the comparative yearly lighting energy cost per watt for HID industrial luminaires equals $0.24.

6.2 CALCULATION

Comparative yearly lighting energy cost = (K / LER) x 1000

where:

K = $0.24/watt
(3000 average burning hours per year x $0.08/kwh average electrical energy cost / 1000 watts/kw)

LER = The LER value for the given luminaire under consideration in lumens/watt

1000 = Comparative constant representing 1000 lumens

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

Section 7
RECOMMENDED REPORTING CATEGORIES AND FORMAT

7.1 CATEGORY DESCRIPTION

LER values and comparative yearly lighting energy cost values should be shown in promotional literature and catalogs, in conjunction with other pertinent information, as shown below.

a. Catalog number;
b. Luminaire category;
c. Lamp type and rated lumen value;
d. Ballast type/catalog number;
e. Luminaire lumen output;
f. Total ballast(s) rated input wattage;
g. LER;
h. Comparative yearly lighting energy cost per 1000 lumens (The Cost of Light).

A two-letter designation for the luminaire category should be included with the luminaire efficacy rating value whenever it is given. The first letter of the designation should be H for HID luminaires. The following letter C for a closed luminaire or O for open luminaire, representing categories as set forth in Section 4.3.

7.2 RECOMMENDED REPORTING FORMAT

An example of the recommended format for reporting is shown in Table 7-1.

Table 7-1
REPORTING FORMAT

1	2	3	4	5	6	7	8
Luminaire Catalog #	Luminaire Category	Lamp Type	Ballast Type	Luminaire Lumen Output	Luminaire Watts Input	LER	Energy Cost*
ABC	HO	M400/U 36,000 lu.	CWA/HPF	30,228	458	66	$3.64

* Comparative yearly lighting energy cost per 1000 lumens.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

Annex A
(Informative)
THE RATIONALE FOR HIGH-INTENSITY DISCHARGE INDUSTRIAL LUMINAIRES

A.1 BALLAST FACTORS

Ballast factors are considered to be 1.0 because they:

a. Are generally near 1.0 for bench test conditions;
b. Generally do not have a significant effect on HID lamp efficacy or HID luminaire efficiency.

A.2 LUMINAIRE EFFICIENCY

Luminaire efficiency is used in lieu of coefficients of utilization because the latter is so application dependent.

A.3 LUMINAIRE WATTAGE

Calculating the LER using rated ballast(s) input wattage, which is readily available from ballast manufacturers, ensures that all luminaire manufacturers are doing the calculations in the same fashion. While a specific ballast's input wattage can vary depending on operating conditions, such as ambient temperatures, these variables are application sensitive and cannot be quantified. The use of rated ballast(s) input wattage addresses the differences in power consumption between different ballast designs, but does not attempt to quantify the application sensitive variables.

Since rated ballast(s) input wattage, as determined in accordance with ANSI C82.6, is generated independently from photometric testing, existing photometric tests that have been done per IESNA LM-46 can be used to generate LER values.

The LER should be calculated using the ballast that is the standard product offering for a given luminaire. Because many luminaire designs can accommodate a variety of ballasts, the ballast type must be reported in conjunction with the LER. Optional ballast offerings could list a multiplier to adjust the base LER to the value that would be obtained when using the optional ballast in the luminaire.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Table A-1
MINIMUM LER

Upward Efficiency (%)	Lamp Wattage	Minimum LER Closed (HC)	Minimum LER Open (HO)
0%	>=150 Watts and > 400	40	40
	>= 400 Watts and < 1000	45	50
	>= 1000 Watts	65	70
>0% and <10%	>=150 Watts and > 400	40	40
	>= 400 Watts and < 1000	45	55
	>= 1000 Watts	65	70
>=10% and <20%	>=150 Watts and > 400	45	45
	>= 400 Watts and < 1000	50	55
	>= 1000 Watts	75	80
>=20%	>=150 Watts and > 400	45	45
	>= 400 Watts and < 1000	55	60
	>= 1000 Watts	80	85

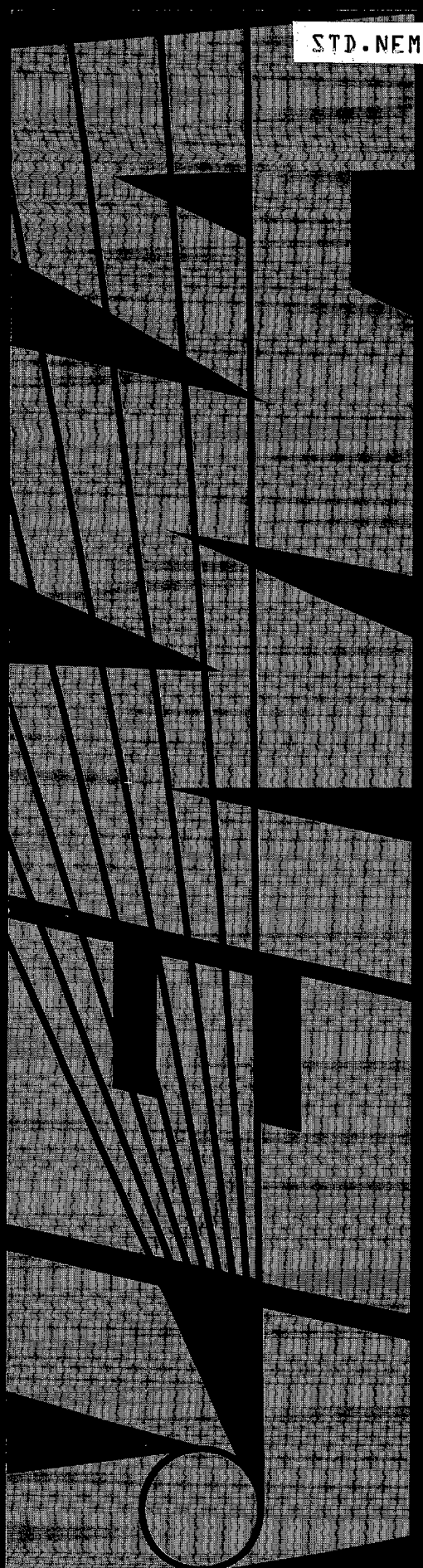
Table A-2
TYPICAL BALLAST RATED INPUT WATTAGE
(As Determined in Accordance with ANSI C82.6)

Lamp Type	Lamp Wattage	Ballast Type	Power Factor	Rated Wattage
Metal Halide	175	CWA	HPF	210
	250	CWA	HPF	295
	400	CWA	HPF	458
	1000	CWA	HPF	1080
High Pressure Sodium	150	R	NPF	170
	150	R	HPF	170
	150	HX	HPF	188
	150	CWA	HPF	188
	150	CW	HPF	196
	200	CWA	HPF	245
	250	CWA	HPF	295
	310	CWA	HPF	365
	400	CWA	HPF	457
	400	CW	HPF	480
	750	CWA	HPF	850
	1000	CWA	HPF	1100

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

STD.NEMA LE 5B-ENGL 1998 ■ 6470247 0514499 450 ■



NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION • 1300 NORTH 17TH STREET • SUITE 1847 • ROSSLYN, VA 22209

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale