

40360046-TDC 03-37776A

Requirements for Led2 Lamps

(Schedule of Requirements for Led2 Lamps for Road
Traffic Control Systems)

31 October 2003

Author: H.C. Koerts

KEMA T&D Consulting

Commissioned by the Ministry of Transport, Public Works and Water Management
Directorate General for Public Works - Public Works Construction Service

Author: H.C. Koerts

B 17 pp - Apps PSK

Reviewed by: M. Achterkamp

Approved by: J. Knijp



Utrechtseweg 310, 6812 AR Arnhem, The Netherlands

Tel.: +31 26 356 9111. Fax: +31 26 351 5606.

© KEMA Nederland B.V., Arnhem, the Netherlands. All rights reserved.

This document contains confidential information. The communication of such information to any third party without written consent from KEMA Nederland B.V. is forbidden, as is the copying of the document or of any part of it.

KEMA Nederland B.V. and its subsidiary companies are not liable for any direct, indirect, incidental or consequential damage arising from the use of the information or data contained in this document, or from the unsuitability of such information or data for use.

CONTENTS

	Page
1 Foreword	4
2 Requirements for Led2 Lamps	5
3 General notes	6
4 Notes regarding environmental conditions	7
5 Notes regarding electrical requirements	7
6 Notes regarding optical requirements	13
7 Notes regarding mechanical requirements	14
8 Notes regarding other requirements	17

1 FOREWORD

This Schedule of Requirements for Led2 lamps for Road Traffic Control Systems, referred to for short as the Requirements for Led2 lamps, has been produced by the specially formed Led2 Committee.

The document was drawn up to serve as a clear statement of the requirements that an Led2 lamp must meet in order to perform satisfactorily in practice in conjunction with a dedicated traffic control device. The Requirements for Led2 Lamps are linked to an Led2 lamp Testing Protocol, developed by KEMA, which specifies how such lamps should be tested.

The membership of the Led2 Committee responsible for this document was as follows:

P.C. Hermsmeyer	(IVER, RWS)
W.P. Zandvliet	(responsible for Led2 lamp purchasing at RWS and representative of LED lamp manufacturers)
J.J. van Vliet	(ASTRIN Standardisation Committee, Peek Traffic)
R.A.F. Schmidt	(optical testing specialist at KEMA)
H.C. Koerts	(specialist in the electrical testing of traffic control systems at KEMA, and secretary to the Committee).

The Led2 Committee was set up in March 2003 on the initiative of the Directorate General for Public Works (Dutch initials: RWS) and KEMA, in response to a request made to RWS by the Association of Traffic Industries in the Netherlands (ASTRIN) for joint testing of the new (ASTRIN) Interface Definition with a view to developing a uniform definition of the Led2 lamp. The Led2 Committee completed its activities in October 2003.

2 REQUIREMENTS FOR LED2 LAMPS

Cat.	No.	Variable	Required value
Environmental conditions			
NEN-EN 12368			
S	1	Operating temperature	Category B NEN-EN 12368 (-25°C < T < + 55°C)
Electrical requirements			
ID	1	Operating voltage	Nominal light intensity: 42 volts (36 volts - 50 volts) First dimming step: 31 volts (26 volts – 34 volts) Second dimming step: 20 volts (15 volts – 24 volts)
ID	2	Power consumption	Maximum 15 watts
ID	3	Current drawn (stationary)	Minimum 80 mA, maximum 450 mA
ID	4	Power factor (PF)	> 0.9
ID	5	Total harmonic distortion (THD) of current	< 33%
ID	6	Value of current when switched on	Within 50 ms: 80 mA < I < 450 mA, and consistent with requirements 3 (PF) and 4 (THD) for stationary situation. Peak switch-on current < 5 A.
ID	7	Optical response time when switched on	< 50 ms
ID	8	Residual voltage when switched off by traffic control device	Within 30 ms: U < 4 V
ID	9	Optical response time when switched off	< 50 ms
ID	10	Value of current when defective lamp switched on	Within 50 ms: I < 10 mA
ID	11	Current drawn by defective lamp (stationary)	Maximum 10 mA
ID	12	Value of current when defective lamp switches off	If light intensity < 80% of the minimum required value: Within 50 ms I < 10 mA If light intensity > 80% of the minimum required value: Within 300 ms I < 10 mA
ID	13	Relationship between current drawn and light intensity <u>outside</u> operating voltage range	Lamp without second dimming step: I < 10 mA if U < 26 V and I < 100 cd Lamp with second dimming step: I < 10 mA if U < 15 V and I < 25 cd
S	14	EMC requirements	NEN-EN 50293, Signal / Control Port
Optical requirements			
NEN-EN 12368 and NEN-EN 3322			
S	1	Light intensity undimmed	Performance level A 3/1 NEN-EN 12368 (400 < I < 1000 cd)
A	2	Light intensity of dimming steps	100 < I < 200 cd at first dimming step 25 < I < 50 cd at second dimming step
S	3	Light intensity distribution	W
S	4	Maximum phantom signal	Category 2 NEN-EN 12368 (Is/lph > 5)
S	5	Realisation of figures / symbols	By means of a stencil, by means of LEDs, or by means of both. Category S1 NEN-EN 12368
	6	Light intensity when	I < 0.05 cd

Cat.	No.	Variable	Required value
		defective lamp switched on	
Mechanical requirements and tests			
NEN-EN 12368			
A	1	Preferred lamp dimensions	See drawing with the notes
A	2	Sealing	IP 65 or: IP 55 plus requirement 4. Lamp to form a structurally integrated closed unit
S	3	Impact resistance (lens)	IR3 (table 9 in NEN EN 12368)
A	4	Damp heat test	Lamp to pass a more exacting version of the test defined in table 12 of NEN-EN 12368; see Dd test in IEC 60068-2-30
Other requirements			
	1	Diminution in light intensity due to ageing	I > 80% of the requirement for entire service life, assuming a clean lamp
	2	Failure criterion	Light intensity 80% of the minimum required value
	3	Risk of unsafe failure	Less than one event per million years

3 GENERAL NOTES

An Led2 lamp should meet the requirements set out in this Schedule of Requirements (SoR) throughout its service life.

The table contained in the SoR refers to various standards. An Led2 lamp should meet the requirements of the standards thus indicated. The requirements of the standards are not themselves itemised in the table.

The abbreviations in the column headed "Cat." indicate the category of each requirement, as follows:

S

Indicates a requirement contained in a legal standard. The requirement is specified because the relevant standard allows for selection between various categories with regard to the variable in question.

A

Indicates a requirement that is additional to the requirements contained in a standard.

ID

Indicates a requirement contained in the ASTRIN Interface Definitions. (In Dutch called: Grensvlakdefinities.) The purpose of the definitions is to ensure that any Led2 lamp can function successfully with any traffic control device that also complies with the Interface

Definitions. All references to the ASTRIN Interface Definitions document contained in this SoR relate to Edition 2, published in April 2003. References to the document entitled "RWS Requirements for Led2 Lamps" relate to the edition published in April 2002.

4 NOTES REGARDING ENVIRONMENTAL CONDITIONS

1 Operating temperature

The category specified for the Netherlands in subsection 5.1 of EN 12368 has been selected.

NEN-EN 12368 covers the lamp unit as a whole, i.e. light source plus housing.

NEN-EN 12368 (table 12) requires that a test be performed under direct sunlight at 40°C. It is only possible to test an Led2 lamp under such conditions when it is mounted in a housing.

Since it is not possible to translate the situation involving a lamp-unit in a housing under direct sunlight into an operating temperature for an Led2 lamp, it was decided that a higher operating temperature should not be specified.

With regard to environmental conditions, subsection 2.1 of the ASTRIN Interface Definitions refers to category B, as defined in NEN-EN 12368.

5 NOTES REGARDING ELECTRICAL REQUIREMENTS

1 Operating voltage

The value specified is the nominal voltage. The figures between brackets indicate the range within which the lamp should meet all the requirements. Outside the stated voltage ranges, the lamp must satisfy requirement 13.

The lamp should run on alternating current.

The second dimming step is optional.

Origin / Reasoning:

The voltages specified are the nominal voltages given in the ASTRIN Interface Definitions and the RWS Led2 document.

The voltage ranges are derived from the permissible mains voltage variations given in NEN 3384, and are consistent with the ASTRIN Interface Definitions and the RWS Led2 document, with the exception of the second dimming step, which is not referred to in the ASTRIN Interface Definitions.

2 Power consumption

This requirement is included with a view to assuring the quality of the LEDs used and to promoting energy conservation.

3 Current drawn (stationary)

The requirement relates to the stationary current, i.e. excluding any switching-related phenomena.

Origin / Reasoning:

Maximum current:

The ASTRIN Interface Definitions specify a maximum power (undimmed) of 15 watts; at 36 volts (the lowest undimmed voltage) this corresponds to 417 mA.

Minimum current:

As technical advances are made, Led2 lamps tend to draw less current. Specifying an unduly high value for the minimum current would be liable to lead to contrived solutions, such as the inclusion of resistors in LED lamps. On the other hand, specifying an unduly low value for the minimum current would be liable to make it difficult for a control device to detect a defective final (red) lamp in a signal group. There needs to be an adequate interval between the minimum current drawn by a functional Led2 lamp and the maximum current drawn by a defective Led2 lamp. Having consulted manufacturers of Led2 lamps and of control devices, it was concluded that 80 mA was a suitable value, enabling the trip current for defective final (red) lamp detection purposes to be set at a distinctive value.

See also requirement 11: current drawn by a defective lamp.

Specifications made in the ASTRIN Interface Definitions:

Minimum power undimmed 7 W; at 50 V this equates to 140 mA

Minimum power dimmed 4 W; at 34 V this equates to 117 mA

The minimum holding current given for Triacs is 50 mA.

4+5 Power factor and total harmonic distortion

The purpose of setting requirements regarding these two variables is to ensure that the current drawn is reasonably close to being sinusoidal and that there is only modest phase displacement between the supply voltage and the current drawn. This is important for various reasons; for example, it facilitates lamp current measurement by the control device (e.g. instantaneous measurements), reliable operation of semiconductor switches (triacs) and the control of harmonic currents transferred from the traffic control system into the grid.

The variables are defined as follows:

Power factor:

The ratio between the active power (power in watts) and the apparent power (power in VAs). All harmonics are included.

Total Harmonic Distortion (THD):

(Sum of the effective values of the harmonic currents) / (Effective value of the fundamental wave)

This definition of THD is taken from IEC 61000-3-4 , IEC 61000-2-1 and IEC 61000-2-2.

The IEC 61000-3-2 standard specifies limits on the emission of harmonic currents by appliances drawing a current of less than 16 A from the grid. The requirements for category C (lighting equipment), power > 25 watts, as specified in table 2, yield a THD requirement of 32.6 per cent. Although the power of a single Led2 lamp is less than 25 watts, the combined power of all the LED lamps in a traffic control system would exceed 25 watts. Indeed, the majority of the current drawn by a large system would be taken by the LED lamps.

6 Change in current when switched on

Origin / Reasoning:

This requirement places a limit on the duration of any current abnormalities associated with switching the lamp on. The lower limit is of particular importance, in order that the control device can detect that the lamp is "on". The requirement that the current should take on the

form of the stationary current within a certain space of time is important in the context of current measurement by the control device and the reliable operation of semiconductor switches (triacs).

The time requirement has been set at 50 ms on the basis of the measured response times of safety monitors in control devices. The lower current limit is the minimum current requirement for a properly functioning lamp; this is a clear value.

The peak value of the switch-on current should not exceed 5 amps. This requirement is made to prevent supply problems and problems with automatic limiters or fuses.

Requirement contained in subsection 2.2 of the ASTRIN Interface Definitions: within 100 ms 80 –120% of I nominal.

7 Optical response time when switched on

Definition: the time interval between connection of the (nominal) supply voltage and 80 per cent of the required minimum light intensity (400 cd undimmed) being reached.

Origin / Reasoning:

The purpose of this requirement is to prevent excessive delay between the moment that the control device sends a control signal and the moment that the corresponding lamp illuminates. This requirement is linked to requirement 9. It is important to take account of the possibility that a traffic control system may incorporate LED lamps made by more than one manufacturer.

According to ASTRIN members, 50 ms is technically feasible.

In practice, an absence of illumination of 80 ms (during phase transition) has been found to illicit comments from road users.

Requirement contained in subsection 2.2 of the ASTRIN Interface Definitions: 100 ms.

Requirement contained in the RWS Led2 document is 50 ms (pending the results of optical measurements).

8 Residual voltage when switched off

The requirement relates to a situation where a functional lamp is switched off by the control device.

Measurement method and test circuit are given in the test protocol.

Origin / Reasoning:

The residual voltage present across the LED lamp's terminals should fall to a level below the control device's detection threshold within a short space of time, so that it does not appear to the control device that the lamp is "on".

The voltage thresholds of the safety monitoring sensors in control devices have been measured and found to be: 5-9 V, 4 V and 8 V. The required threshold has therefore been set at 4 volts. Given the measured response times of safety monitors in control devices, the time of 20 ms should be acceptable.

Requirement contained in subsection 2.2 of the ASTRIN Interface Definitions: within 20 ms < 10% of nominal value (i.e. 4.2 volts)

9 Optical response time when switched off

Definition: the time interval between removal of the supply voltage and the light intensity dropping to 0.05 cd.

Origin / Reasoning:

The background to this requirement is as given for requirement 7, to which it is linked. The value of 0.05 cd is taken from the Introduction to NEN-EN 12368, which states that a green light may be considered operational when the light intensity in the reference direction $I > 0.05$ cd.

Requirement contained in subsection 2.2 of the ASTRIN Interface Definitions: 100 ms. Requirement contained the RWS Led2 document is 50 ms.

10 Change in current when a defective lamp is switched on

The requirement relates to a situation where an already defective lamp is energised by the control device. Under such circumstances, the current should within an acceptable space of time fall below a threshold value, so that the control device detects that the lamp is defective. Within 50 ms of the supply voltage being connected, the current should be less than 10 mA. The time interval has been chosen on the basis of the response time of the safety monitoring sensors. The current has been set at a value consistent with requirement 11.

With regard to the optical specifications for defective lamps, see Optical Requirement 6.

11 Current drawn by a defective lamp (stationary)

The requirement relates to the stationary current, i.e. excluding any switching-related phenomena.

Origin / Reasoning:

See Electrical Requirement 3.

With various types of Led2 lamp, the occurrence of a fault will cause a fuse to blow in the supply line. The current drawn will then fall to zero. Feedback from Led2 suppliers indicates that the current drawn when a lamp is switched off electronically can realistically be limited to 10 mA. This figure is sufficiently far below the minimum current drawn by a functional lamp (80 mA, see 3) to ensure that there should be no problem setting the control device to detect the final (red) lamp.

Requirement contained in the ASTRIN Interface Definitions: 33 mA.

12 Change in current when (defective) lamp switches off

The requirement relates to a situation where a lamp is no longer functioning according to the requirements (illuminated image is no longer acceptable), as a result of which the lamp's internal monitoring device turns the lamp off.

Origin / Reasoning:

Distinction is made between two situations.

If the light intensity is more than 80 per cent of the required minimum value, a response time of 300 ms is acceptable. This reduces the risk of an Led2 lamp responding too quickly and switching itself off unnecessarily (potentially leading to the entire traffic control system going down).

If the light intensity is less than 80 per cent of the required minimum value, the response time should be as specified in NEN 3384, for the assembly of the Led2 lamp and control device. The 200 ms therefore has to be divided between the Led2 lamp and control device. It has been decided to allocate 50 ms to the Led2 lamp and 150 ms to the control device.

Within 50 ms of a lamp ceasing to function correctly, the current should fall to below 10 mA.

Requirement contained in the ASTRIN Interface Definitions: a response time of 300 ms for all components collectively.

13 Relationship between current drawn and light intensity outside operating voltage range

The purpose of this requirement is to remove the risk of the control device failing to detect that a lamp producing insufficient light intensity is defective, if the lamp is operating on an abnormally low voltage.

14 EMC Requirements

Origin / Reasoning:

NEN-EN 50293 is the EMC product standard for traffic control systems.

Subsection 1.3 of NEN-EN 50293 states that cables leading to luminaires should be regarded as signal/control ports.

In practical terms, this gives rise to the following EMC requirements:

Table 1 Emissions – Enclosure port

Table 3 Immunity – Enclosure port

Table 4 Immunity – Ports for signal and control lines

Since the Led2 lamps in a traffic control system will account for a large part of the system's network load, the requirements contained in Table 2 Emissions – Input AC mains port are also relevant.

The ASTRIN Interface Definitions also refer to NEN-EN 50293.

Subsection 5.2 of NEN-EN 12368 refers to the EMC requirements of prEN 50278, 1997. Subsection 6.8 of prEN 50278 contains various references that have yet to be detailed.

6 NOTES REGARDING OPTICAL REQUIREMENTS

1 Light intensity undimmed

The required intensity has been selected from the levels given in subsections 6.3 and 6.4 of NEN-EN 12368.

At no point in an Led2 lamp's service life should the light intensity fall below 320 cd (80 per cent of 400 cd), excluding the influence of dirt accumulation.

2 Light intensity dimmed

This requirement supplements the requirements of NEN-EN 12368. (Values given by IVER.)

The values were set after consultation within IVER and on the basis of information contained in NEN 3322 (1972) and the now withdrawn NPR 3323.

3 Light intensity distribution

The specified values have been selected from the options given in subsection 6.4 of NEN-EN 12368.

4 Maximum phantom signal

The specified value has been selected from the options given in subsection 6.6 of NEN-EN 12368.

Requirements 1 to 4 correspond to the table in subsection 2.1 of the ASTRIN Interface Definitions. The ASTRIN Interface Definitions make no requirements regarding a lamp's light intensity when dimmed.

6 Light intensity when defective lamp switched on

The purpose of this requirement is to remove the risk of a lamp that has previously switched itself off as "defective" (briefly) re-illuminating when subsequently a voltage is applied. The value of 0.05 cd is derived from the Introduction to NEN-EN 12368.

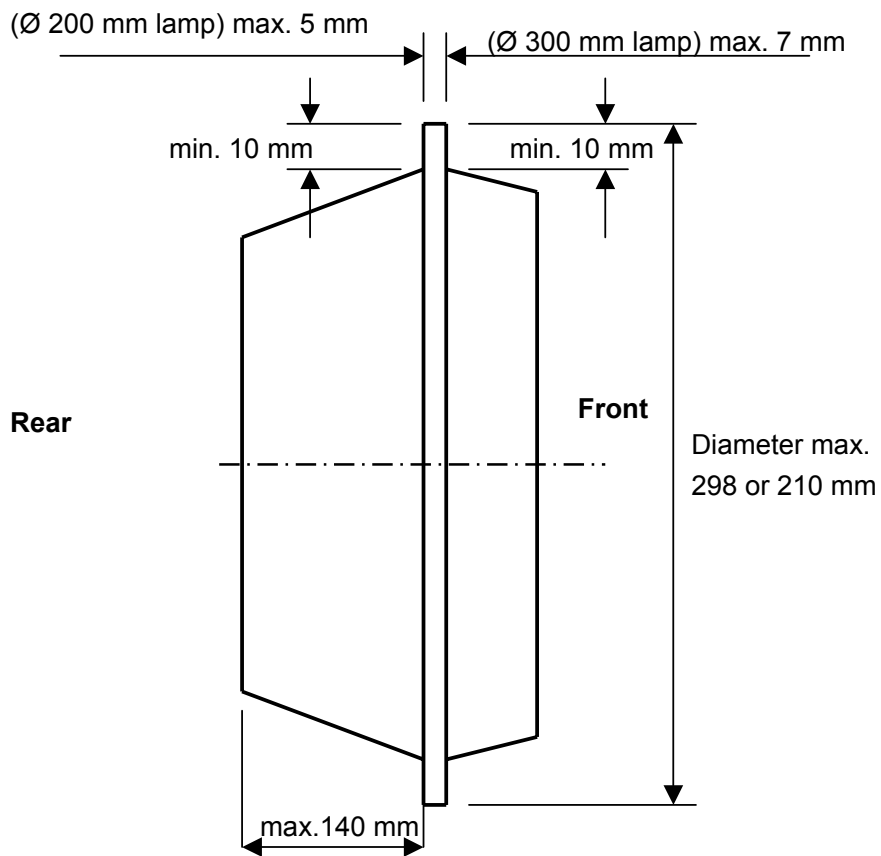
7 NOTES REGARDING MECHANICAL REQUIREMENTS

1 Preferred lamp dimensions

If LED lamps are to be mounted successfully in existing signal blocks, it is important that the lamps are dimensioned so as to allow sufficient space for the mounting rubber.

When a lamp is fitted, the rubber has to be folded double around the rim of the lamp, but the dimensions of many LED lamps leave insufficient room for this at either the front or the back. The maximum or minimum values for the critical measurements are accordingly given in the dimensional drawing below.

Dimensional Requirements for Led2 Lamps



2 Sealing

The highest category of seal defined in subsection 4.2 of NEN-EN 12368, category IV, is IP 55 (the initial '5' meaning "dust protected"). However, NEN-EN 12368 applies to **complete lamp units** and (for the time being, at least) assumes that the light source is an incandescent bulb. Because of the electronics used in Led2 lamps, the exclusion of moisture is important for reasons of reliability and service life maximisation. Led2 lamps should therefore be sealed to IP 65 standard (the initial 6 meaning "dust-tight").

This requirement is linked to requirement 4:

Alternatively, the lamp and lens may be sealed to IP 55 standard only, provided that the more demanding damp heat test described in requirement 4 is also passed.

The lamp (i.e. the light source and lens assembly) has to form a structurally integrated unit. In other words, the lamp should not be made up of readily separated parts. This requirement is made to ensure that there is no temptation to try to repair defective lamps on site.

3 Impact resistance (lens)

The specified level of impact resistance has been selected from the options given in table 9 of NEN-EN 12368.

N.B.: Resistance to vibration is covered by Section 7, table 10, of NEN-EN 12368.

4 Damp heat test

Table 12 in NEN-EN 12368 describes a damp heat test consistent with IEC 60068-2-30, referred to as the Dd test. The maximum temperature is 40°C and the number of cycles is two. In other words, the test is not particularly exacting. In order to properly test an LED lamp's resistance to condensation formation, a more demanding test is required. The test can be made more demanding by specifying a higher maximum temperature and/or a higher number of cycles. IEC 60068-2-30 states that, at 40°C, a maximum of 56 cycles are permitted, and at 55°C a maximum of six cycles. (A cycle lasts 24 hours.)

This requirement is linked to requirement 2:

If the LED lamp is sealed to IP 65 standard, it is assumed to be sufficiently resistant to moisture penetration and does not therefore need to pass the more exacting damp heat test.

1 **NOTES REGARDING OTHER REQUIREMENTS**

1 Diminution in light intensity due to ageing

LEDs age in use, leading to a gradual diminution of the light intensity (at a given current and voltage) over the course of a lamp's service life. This requirement is concerned with loss of brightness due to ageing and *not* due to the accumulation of dirt. The purpose of this requirement is to ensure that, in the course of its service life, an Led2 lamp's light intensity does not fall to less than 80 per cent of the minimum required value.

2 Failure criterion

This criterion relates to the acceptability of the lamp's illuminated image; when this image ceases to be acceptable, the lamp should switch itself off.

For LED lamps, the ASTRIN Interface Definitions adopt in full the requirements on light intensity and luminance uniformity contained in NEN-EN 12368. The requirement regarding luminance uniformity is particularly exacting. Indeed, some types of Led2 lamp will cease to meet this requirement if a small number of LEDs, or even a single LED, fails. This can be problematical in practice, since the failure of just a few LEDs will cause the traffic control system to switch to flashing amber mode. Consequently, it was decided to require that the light intensity should always remain in excess of 80 per cent of the minimum required value.

3 Risk of unsafe failure

This maximum permissible risk has been set at a level ten times lower than that specified for control devices in NEN-EN 12675 (one event per 100,000 years). Hence, the risk of unsafe traffic control system failure will barely increase, if at all, as a result of the application of Led2 lamps.

The ASTRIN Interface Definition makes a similar requirement in subsection 2.2.