DRAFT FOR DEVELOPMENT

DD CLC/TS
50509:2007

Use of LED signal heads in road traffic signal systems

ICS 93.080.30

BSI
British Standards

National foreword

This Draft for Development is the UK implementation of CLC/TS 50509:2007.

This publication is not to be regarded as a British Standard.

It is being issued in the Draft for Development series of publications and is of a provisional nature. It should be applied on this provisional basis, so that information and experience of its practical application can be obtained.

Comments arising from the use of this Draft for Development are requested so that UK experience can be reported to the European organization responsible for its conversion to a European standard. A review of this publication will be initiated not later than 3 years after its publication by the European organization so that a decision can be taken on its status. Notification of the start of the review period will be made in an announcement in the appropriate issue of *Update Standards*.

According to the replies received by the end of the review period, the responsible BSI Committee will decide whether to support the conversion into a European Standard, to extend the life of the Technical Specification or to withdraw it. Comments should be sent to the Secretary of the responsible BSI Technical Committee at British Standards House, 389 Chiswick High Road, London W4 4AL.

The UK participation in its preparation was entrusted to Technical Committee EPL/526, Road traffic control signals.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Use of LED signal heads in road traffic signal systems

This Technical Specification was approved by CENELEC on 2007-06-01.

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CENELEC

European Committee for Electrotechnical Standardization
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Foreword

This Technical Specification was prepared by Working Group 1 'Use of LED signal heads in road traffic signal systems' of CENELEC BTTF 69-3 'Road traffic signal system'.

The text of the draft was submitted to vote in accordance with the Internal Regulations, Part 2, Subclause 11.3.3.3 and was approved by CENELEC as CLC/TS 50509 on 2007-06-01.

The following date was fixed:

– latest date by which the existence of the CLC/TS has to be announced at national level (doa) 2007-12-01

This document contains specifications for the use of LED signal heads in road traffic signal systems in the form of information with regard to the interpretation of existing standards and additional specifications, dealing with specific technical properties of LED signal heads, not previously described in the existing standards.

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Contents

Introduction

This document gives a specification for the mutual behaviour of traffic signal controllers and *light-emitting diode* (LED) based signal heads in road traffic signal systems. The specification was written to contribute to safe and reliable operation, while at the same time allowing the compatible operation of various types and brands of signals and controllers.

Whilst the performance requirements for LED signals heads, as specified in the standards, remain unchanged, various properties of composite LED signals that were implicit for incandescent lamps now need to be described.

The market for LED signals has developed rapidly; products show considerable national or even regional technical differences. This document intends to give guidance to the market for future development and harmonisation.

It is the aim of this document to establish a minimum set of requirements that would allow both controllers and signal heads to be tested separately. Where a controller or signal has been verified as compatible with a class specified in this document, it would be deemed to function safely and securely in cooperation with a signal or controller verified as compatible with the same class.

1 Scope

This Technical Specification considers only newly manufactured and installed signal controllers and signal heads for road traffic applications, using appropriate cabling.

This Technical Specification considers only LED optical units with 200 mm and 300 mm roundels as standardised in EN 12368. It does not consider configurations such as an arrow or a pedestrian symbol, created by specifically positioned patterns of LEDs.

This Technical Specification does not consider railway signalling applications.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 12368, *Traffic control equipment – Signal heads*

EN 12675, *Traffic Signal Controllers – Functional safety requirements*

EN 50293, *Electromagnetic compatibility – Road traffic signal systems – Product standard*

EN 55015, *Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment (CISPR 15)*

EN 60825 series, Safety of laser products (IEC 60825 series)

EN 60950 series, *Information technology equipment – Safety (IEC 60950* series*)*

EN 61000-2-2, *Electromagnetic compatibility (EMC) – Part 2-2: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems (IEC 61000-2-2)*

EN 61000-3-2, *Electromagnetic compatibility (EMC) – Part 3-2: Limits for harmonic current emissions (equipment input current up to and including 16 A per phase) (IEC 61000-3-2)*

EN 61508 series, *Functional safety of electrical/electronic/programmable electronic safety-related systems (IEC 61508 series)*

HD 638 S1, *Road Traffic Signal Systems*

3 Definitions and abbreviations

3.1 General definitions

3.1.1
road traffic signal system
see HD 638 S1

3.1.2
traffic signal controller
see EN 12675

3.1.3
signal head
see EN 12368

3.1.4
optical unit
see EN 12368

3.1.5
LED signal head
signal head, containing one or more optical units with light-emitting diodes as light source

3.2 Optical definitions

3.2.1
luminous intensity
see EN 12368

3.2.2
luminance uniformity
see EN 12368

3.2.3
dimmed operation
operating mode of the road traffic signal system in which the luminous intensity of the signal heads is reduced, generally during the hours of darkness

3.3 Electrical definitions and abbreviations

3.3.1 Operating Conditions (Steady State) definitions and abbreviations

3.3.1.1
operating voltage U_{IN}
voltage value at the input terminals of the optical unit, whereby the luminous intensity corresponds to the Class indicated in accordance with EN 12368. The voltage is a *root-mean-square* (r.m.s) value

3.3.1.2
relationship between luminous intensity and operating voltage
permissible change of the luminous intensity of the optical unit over the operating voltage range U_{ON} – $U_{IN,max}$

3.3.1.3
operating current I_{IN}
effective (r.m.s) values of the operating current over the operating voltage range U_{ON} – $U_{IN,max}$ with the signal switched on and in the steady state

3.3.1.4
operating current window of measurement
period of time in each half-wave of the operating voltage in which the traffic signal controller can carry out the current measurement for reliable signal monitoring

3.3.1.5
operating current trace inside the window of measurement
allowed deviation for the current profile compared to that that would be taken by a purely resistive load, within the operating current window of measurement (see 3.3.1.4)

3.3.1.6
operating current trace outside the window of measurement
allowed deviation for the current profile compared to that that would be taken by a purely resistive load, outside the operating current window of measurement (see 3.3.1.4)

3.3.1.7
power consumption at nominal value of the operating voltage $P_{IN,nom}$
power consumption of the optical unit at the voltage value $U_{IN,nom}$

3.3.1.8
power factor
see EN 61000-3-2

3.3.2
switching-on (illumination) related definitions and abbreviations
NOTE Differences may exist in specifications depending on the meaning of a signal to road users. For the purpose of this Technical Specification:
- “stop” indicates any signal and/or colour blocking traffic (generally: red);

- “go” indicates any signal and/or colour, permissive to traffic (generally: green and yellow).

3.3.2.1
switch-on interval – current $T_{SET,current}$
interval following the application of the operating voltage until the input current is above the minimum operating current $I_{IN,min}$

3.3.2.2
switch-on interval – light $T_{ON,light}$
interval following the application of the operating voltage until the optical unit reaches the luminous intensity in accordance with EN 12368, 6.3

3.3.2.3
switch-on voltage U_{ON}

operating voltage at which the optical unit reaches a luminous intensity of 10 cd (signal considered “on”). The voltage is a root-mean-square (r.m.s) value

3.3.2.4
transient switch-on overcurrent interval $T_{ON,current}$
interval following the application of the operating voltage until the current is within specified limits of the operating current

3.3.2.5
switch-on overcurrent I_{ON} / $I_{IN,max}$
maximum permissible value (surge) over the operating current $I_{IN,max}$ during the interval $T_{ON,current}$

3.3.3 Switching-off (extinction) related definitions and abbreviations

3.3.3.1
switch-off interval - light $T_{OFF,light}$
interval following the removal of the operating voltage until the optical unit reaches a luminous intensity less than 0,05 cd in the reference axis (signal considered “off”)

3.3.3.2
switch-off voltage U_{OFF}
operating voltage below which the luminous intensity is less than 0,05 cd in the reference axis (signal considered “off”)

3.3.3.3
quiescent current – off I_{OFF}
input current for input voltages below the switch-on voltage U_{ON}

3.3.3.4
feedback voltage ratio U_{REV} / $U_{IN,nom}$
residual voltage ratio measured over the optical unit, a specified interval after the removal of the operating voltage, starting from the nominal value

3.3.3.5
optical unit resistance R_{OFF}
impedance of the unit measured on its terminals when no power is applied

NOTE R_{off} is one method of ensuring that any induced voltage pickup on long signal cable runs is eliminated / dissipate before it reaches any level that may cause controller conflict voltage monitoring where used to activate. However this may be an optional feature that can be dropped to reduce overall power consumption if an alternative method is available within the control equipment.

3.3.4 Fault response forced switch-off

3.3.4.1
residual current - FSO I_{FSO}
remaining residual current after a completed forced switch-off, for the entire operating voltage range

3.3.4.2
reaction interval - FSO $T_{OFF,FSO}$
interval from the triggering of the Forced switch-off procedure to the moment the input current reaches the permissible value for the residual current I_{FSO}

3.3.4.3
switch-off current ratio $I_{OFF,FSO}$ / $I_{IN,max}$
current during the interval $T_{OFF,FSO}$ in relation to the maximum operating current $I_{IN,max}$

3.3.4.4
load current during force off $I_{TRIGGER}$
maximum current drawn during activation of an operation termination circuit (“end of life fuse”) in the optical unit

3.3.4.5
interval to signal “off” – luminous intensity threshold T_{FAIL}
interval from the moment the luminous intensity drops below 80 % of the nominal value during operating conditions (steady state), to the moment the luminous intensity becomes less than 0,05 cd in the reference axis (signal considered “off”)

NOTE The luminous intensity of an optical unit may be measured directly, but may also be determined indirectly by measuring current and/or other electrical properties. The appropriate current values may be declared by the manufacturer of the optical unit.

3.3.4.6
optical unit resistance R_{OFF}
see 3.3.3.5

4 Specification

4.1 Existing standards

LED signal heads have to conform to EN 12368, HD 638 S1, EN 12675 and EN 50293 without restriction or limitation. When LV (Low Voltage) power supply is present, signal heads also have to comply with EN 60950.

Note that, within the scope of this Technical Specification, EN 12368 prescribes the luminous intensity values I_{OFF} and I_{ON}. The values for $I_{IN,min}$ and $I_{IN,max}$ are only tested for the voltage value $U_{IN,nom}$.

An informative, non exhaustive list of requirements that are not influenced by the technology of the light source, and consequently are outside the scope of this Technical Specification, are:

– constructional requirements (e.g. optical unit dimensions);

– environmental requirements (e.g. ambient temperature);

– optical requirements (e.g. luminous intensity, luminance uniformity, colour, phantom effect);

– constructional and environmental test methods.

4.2 Additional technical specifications

4.2.1 Introduction

The properties of traditional incandescent lamps in signal heads (such as a relatively high power consumption, the impossibility of a partial failure and the absence of complicated electronic components near the lamp), have produced standards that implicitly assume a certain behaviour of the light source.

The LED optical units for signal heads have different properties so that some of these assumptions are no longer valid, and explanatory or expanded technical specifications are necessary.

4.2.2 Explanatory specifications

This paragraph details the ***interpretation*** of some existing requirements with regard to specific properties of LED signal heads, such as the introduction of multiple light source LED optical units.

4.2.2.1 Partial failure

Failure of some of the light sources in an LED optical unit is permissible. However, an aspect of an LED signal head is considered to have failed when:

– the luminous intensity of the aspect is below the limit of the standard;

– the luminance uniformity of the aspect no longer satisfies the standard;

– a desired configuration/symbol becomes ambiguous.

The LED optical unit must either be designed in such a way that a failure cannot occur or be monitored in such a way that a failure is detected and dealt with according to the requirements of the standards, within the time interval required.

4.2.2.2 Failure mode analysis

When a failure mode analysis for road traffic signal systems, as defined in HD 638 S1, 5.2.4, is necessary, it must take into account the degree of reliability of any monitoring and control components in the LED signal head.

4.2.3 Expanded specifications

This paragraph details the ***expansion*** of some existing requirements with regard to specific properties of LED signal heads, such as the monitoring of optical units with (very) low power consumption. In addition, expansion of some existing requirements is necessary to allow interchangeability of (LED) optical units and controllers.

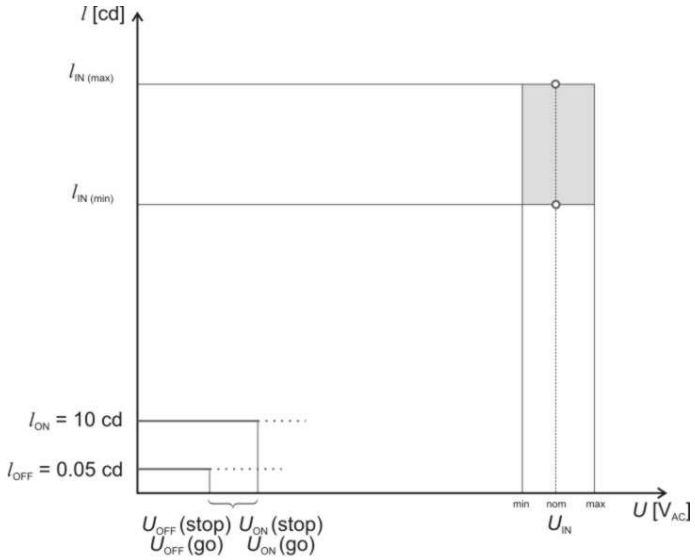

Figure 1 Luminous intensity and operating voltage

4.2.3.1 Functional monitoring in the optical unit

An integrated function monitor in the (LED) optical unit is mandatory for all colour variants. A Fault response Forced switch-off must be triggered in accordance with EN 12368. The manufacturer may select a higher practical value than 10 cd in the reference axis (signal considered “on” according to EN 12368) as a threshold for the function monitor. After a Forced switch-off, the optical unit must remain permanently switched off.

4.2.3.2 Relationship between luminous intensity and operating voltage

According to the current standards, the values for $I_{IN,min}$ and $I_{IN,max}$ are only tested for the voltage value $U_{IN,nom}$. For traditional incandescent lamps this gives enough confidence for the operating range $U_{IN,min}$ – $U_{IN,max}$, for LED optical units the behaviour is not self-evident.

For this reason, the following expanded requirements apply to the luminous intensity emitted by LED signal heads *for the entire operating range* $U_{IN,min}$ – $U_{IN,max}$:

The luminous intensity must be:

– within the limits $I_{IN,min}$ – $I_{IN,max}$;

– continuous (smooth), except when switching to or from dimmed operation, where this may be a step change.

4.2.3.3 Interface properties for optical units

NOTE This Technical Specification is restricted to new road traffic signal systems and connected LED signal heads, containing optical units with characteristics, as described in Tables 1 to 4.

Table 1 - Operating conditions (steady state)

Property	Unit	Dimension	Threshold	Type A	Type B	Type C	Type D	Type E	Remarks
Operating voltage (*for optical unit*) [a]	**$U_{IN,nom}$**	**V_{ac}**	**Nominal**	**40**	**42**	**42**	**48**	**230**	
	$U_{IN,min}$		Minimum	34 (-15 %)	36 (-14,3 %)	31 (-26,2 %)	38 (-21 %)	195 (-15 %)	
	$U_{IN,max}$		Maximum	50 (+25 %)	50 (+19,1 %)	50 (+19,1 %)	58 (+21 %)	254 (+10 %)	
Operating current	I_{IN}	mA	Minimum	100	80	140		50	
			Maximum	360		485		90	
Operating current window of measurement	-	ms	Minimum	3,5		3,5	3,5	3,5	after zero crossing point
			Maximum	6,5		6,5	6,5	6,5	
Operating current trace inside the window of measurement	Deviation from I_{IN}	%	Maximum	10 % [b]	Total harmonic distortion (THD) ≤ 33 %	Total harmonic distortion (THD) ≤ 33 %	Total harmonic distortion (THD) ≤ 20 %	Total harmonic distortion (THD) ≤ 20 %	applies *after* the transient over current interval $T_{ON,current}$
Operating current trace outside the window of measurement	Deviation from I_{IN}	%	Maximum	20 %					
Power consumption at nominal value of the operating voltage	$P_{IN,nom}$	W	Minimum	5	7	7	8	5	
			Maximum	9	15	15	12	20	
Power factor	λ	[a]	Minimum	0,9	0,9	0,9	0,9	0,9	In accordance with EN 61000-3-2, Class C (luminous media), both in operating and in failure state

[a] The voltage drop in cables between the traffic signal controller and the signal heads must be incorporated in these values. A voltage drop of maximum 5 % is considered an acceptable value.

[b] This indicates that during the measurement window the current profile is required to follow that of a purely resistive load more closely than outside of the window.

NOTE This relationship between power consumption, voltage and current is a design characteristic of the optical unit. With in-phase voltage control the current consumption changes only slightly with an increase in voltage but the power consumption rises. With switched mode regulation the current decreases with an increase in voltage, while the power consumption remains practically constant.

Table 2 - Switching-on (illumination) procedure

Property	Unit	Dimension	Threshold	Type A	Type B	Type C	Type D	Type E	Remarks
Switch-on interval – current	$T_{SET,current}$	ms	Maximum	20		20	20	30	
Switch-on interval – light	$T_{ON,light}$	ms	Maximum	50	50	50	50	50	
Switch-on voltage	$U_{ON,stop}$	V_{ac}	Minimum	11		15	15	80	
			Maximum	20 [b]		18	22	120	
	$U_{ON,go}$	V_{ac}	Minimum	16		15	15	80	
			Maximum	25		18	22	120	
Transient time – switch-on overcurrent	$T_{ON,current}$	ms	Maximum	100 (90 % < I_{IN} < 110 %)	100 (80 % < I_{IN} < 120 %)	100 (80 % < I_{IN} < 120 %)	200 (I = $I_{IN,nom}$ +/- 1 %)	100	With a faulty start the specifications under "*Fault response Forced switch-off*" apply
Switch-on overcurrent	I_{ON} / $I_{IN,max}$	[a]	Maximum	2,5				2,5	
	I_{ON}	mA	Maximum			1 000	1 000		Limit over full voltage range

[a] The voltage drop in cables between the traffic signal controller and the signal heads must be incorporated in these values. A voltage drop of maximum 5 % is considered an acceptable value.

[b] Upper safety limit.

Table 3 - Switching-off (extinction) procedure

Property	Unit	Dimension	Threshold	Type A	Type B	Type C	Type D	Type E	Remarks
Switch-off interval – light	$T_{OFF,light}$	ms	Maximum	50	50	50	50	50	
Switch-off voltage	$U_{OFF,stop}$	V_{ac}	Minimum	11		15	15 [a]	80	
			Maximum	20		18	22	120	
	$U_{OFF,go}$	V_{ac}	Minimum	16 [b]		15	15 [a]	80	
			Maximum	25		18	22 [c]	120	
Quiescent current – off	$I_{OFF,stop}$	mA	Minimum	0				0	measured at U_{IN} = U_{ON} – 5 $V_{r.m.s}$
			Maximum	30				30	
	$I_{OFF,go}$	mA	Minimum	8				-	
			Maximum	30				30	
Feedback voltage ratio	U_{REV} / $U_{IN,nom}$	%	Maximum	15 (within 20 ms)	10 (within 20 ms)	10 (within 50 ms)	10 (within 50 ms)	12 (within 20 ms)	
Optical unit resistance	R_{OFF}	Ω	Minimum					-	
			Maximum				3 000	-	

[a] Guaranteed switch off point.

[b] Upper safety limit.

[c] At least 2 V hysteresis required to prevent flickering.

Table 4 - Fault response procedure

Property	Unit	Dimension	Threshold	Type A	Type B	Type C	Type D	Type E	Remarks
Residual current – FSO	I_{FSO}	mA	Maximum	5		10		15	FSO - Forced switch-off
Reaction interval – FSO	$T_{OFF,FSO}$	ms	Maximum	100	50	50		100	The maximum reaction time must be guaranteed: – over the entire operating voltage range – when switching on – from operation mode
Switch-off current ratio	$I_{OFF,FSO}$ / $I_{IN,max}$	[a]	Maximum	5		10		5	Current used to trigger the “end-of-life fuse”
Load current during force off	$I_{TRIGGER}$	mA	Maximum				3 000		
Interval to signal “off” – luminous intensity threshold	$T_{FAIL,stop}$	ms	Maximum				100		
	$T_{FAIL,go}$	s	Maximum				2		
Optical unit resistance [b]	R_{OFF}	Ω	Minimum						
			Maximum				3 000		

[a] The voltage drop in cables between the traffic signal controller and the signal heads must be incorporated in these values. A voltage drop of maximum 5 % is considered an acceptable value.

[b] The optical unit resistance is expected to be present both when not powered and when the unit has effectively switched itself off due to a fault.

4.3 Other issues

4.3.1 EMC emission requirements for other applications

NOTE For the use of signal heads in other than road traffic signal systems, which is outside the scope of this document, it may be appropriate to consider additional emission requirements in the range specified by EN 55015.

4.3.2 Dimmed operation

In some countries, dimmed operation of signals is commonplace or a mandatory requirement. To allow interchangeability of (LED) optical units and controllers, at least a second set of operating voltage parameters needs to be defined. However, dimmed operation has not been defined in the standards and therefore remains a national requirement. In this document, the existing national requirements are included as appendices.

4.3.3 Eye safety

In order to avoid the use of special personal protection during optical unit production or maintenance, the applied LEDs must be safe to handle. A way to assess this is to judge the product against laser safety class I according to EN 60825.

5 Testing

5.1 General

Testing must be done in accordance with EN 12368 Annex ZA. The conformity of an LED signal head or a traffic signal controller with the requirements of the appropriate standards has to be demonstrated, taking into account the Explanatory specifications.

The conformity of an LED signal head or a traffic signal controller with the expanded specifications has to be demonstrated.

5.2 Testing of the yellow optical unit

In road traffic control, the yellow optical unit is not illuminated continuously during long intervals. Therefore, it is not realistic to require the same general test procedure for yellow as for red and green optical units.

NOTE The following test procedure has been agreed for Germany and the Netherlands, as well as for the UK (flashing is not tested in the UK).

Table 5 - Yellow optical unit test intervals

Step	Procedure	Interval (minutes)
1	Optical unit switched on (permanent)	1
2	Measurement of luminous intensities according to EN 12368	max. 2
3	Optical unit switched on (permanent)	1
4	Measurement of uniformity according to EN 12368	max. 2
5	Optical unit switched off (cool down)	15
6	Optical unit switched on (flashing [a])	15
7	Measurement of luminous intensities according to EN 12368 (after flashing)	max. 2
[a] Duty cycle (60 ± 1) flashes per min (1 Hz), light-dark ratio 1:1		

6 Marking, labelling and product information

The marking, labelling and product information with regard to an LED signal head is in accordance with Annex ZA of EN 12368. In addition, every LED optical unit shall be marked, stating its:

– signal colour;

– power consumption at the nominal voltage;

– eye safety attributes; if necessary;

– type according to Table 1 of this Technical Specification.

Annex A
(informative)

Additional requirements under operating conditions - United Kingdom

NOTE This is a representation of existing UK requirements.

A.1 Operation over voltage range

The signal shall operate within the ranges defined in Figure A.1 below. There shall be no discontinuity of light output at the dim/bright threshold or the low voltage switch off threshold.

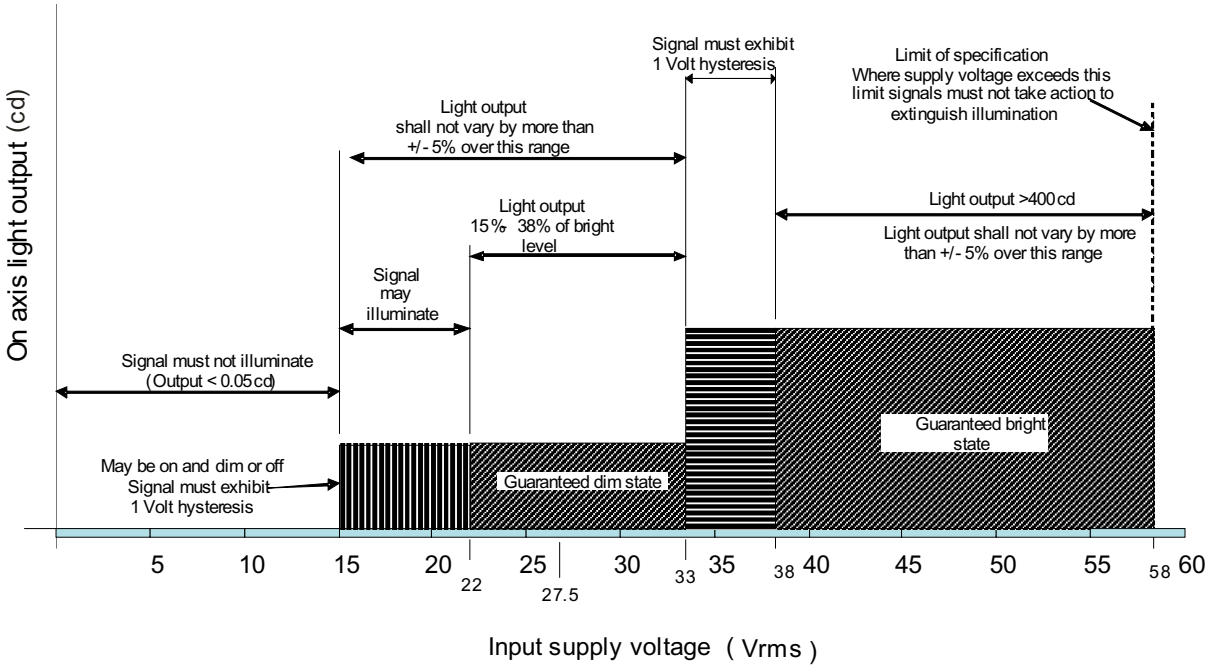

Figure A.1 - Operation over voltage range

A.2 Linearity of light output

In order to prevent flickering lights or large fluctuations in light output for changes in input voltage, the following is stated as a requirement. The light output may vary within the tolerance shown in the diagram below, however it should be a linear change over the range, i.e. it should not fluctuate between less than the nominal and more than the nominal.

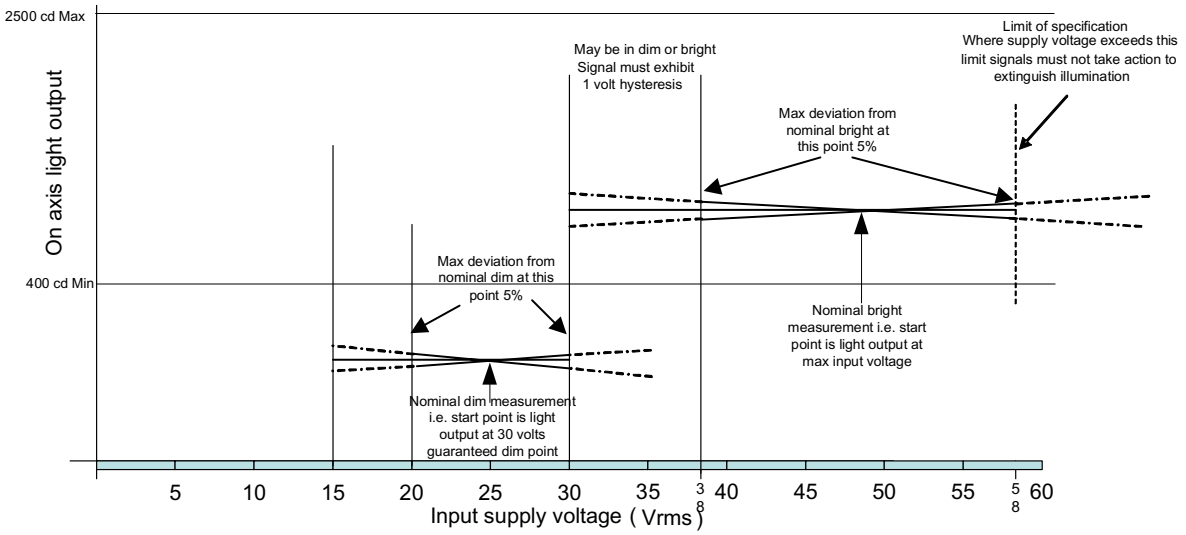

Figure A.2 - Light output over voltage range

A.3 Additional electrical requirements

Table A.1 - Additional electrical requirements

Property	Unit	Dimension	Threshold	Type D	Remarks
Operating Conditions (Steady State)					
Power consumption at nominal value of the dimmed operating voltage	$P_{IN,nom\ dim}$	W	Minimum	3	
			Maximum	4,5	
Operating voltage frequency	f_{IN}	Hz	Minimum	47,5 (-5 %)	Signals should also be able to operate on fully rectified supplies based on this same frequency
			Nominal	50	
			Maximum	52,5 (+5 %)	

Annex B
(informative)

Dimmed operation - the Netherlands

Source: *Guideline for the application of new lamp types in road traffic signal systems – Interface definitions*, Edition 3-2, January 2004, ASTRIN, Zoetermeer

Dimming
Class II: Second generation LED signal heads with a lamp rating up to 15 W and a nominal operating voltage of 42 V_{ac}

The luminous intensity of the aspect diminishes in the usual way when the nominal terminal voltage is decreased from 42 V_{ac} to 31 V_{ac}.

This qualitative requirement is formulated in view of maintaining the usual dimmed image on street, also for mixed use of LEDs and incandescent lamps. There are no further quantitative requirements since there is currently no starting point for this, neither in the standards NEN-EN 12368:2000 and NEN 3322:2000, nor in other public regulations.

A non-continuous dimming (current controlled) lamp must function normally with a supply voltage between 36 V and 50 V and must operate in dimming mode at a supply voltage between 26 V and 34 V.

NOTE The Netherlands currently use signal heads of different manufacture, each certified for the above mentioned Class II; this equals type B of this Technical Specification. A change in requirements would force recertification for signal heads already on the market. However, harmonisation to conform to type C of this Technical Specification will be considered.

Annex C
(informative)

Dimmed operation - Spain

NOTE This is a representation of a proposed requirement in Spain.

The signal shall operate within the ranges defined in Figure C.1.

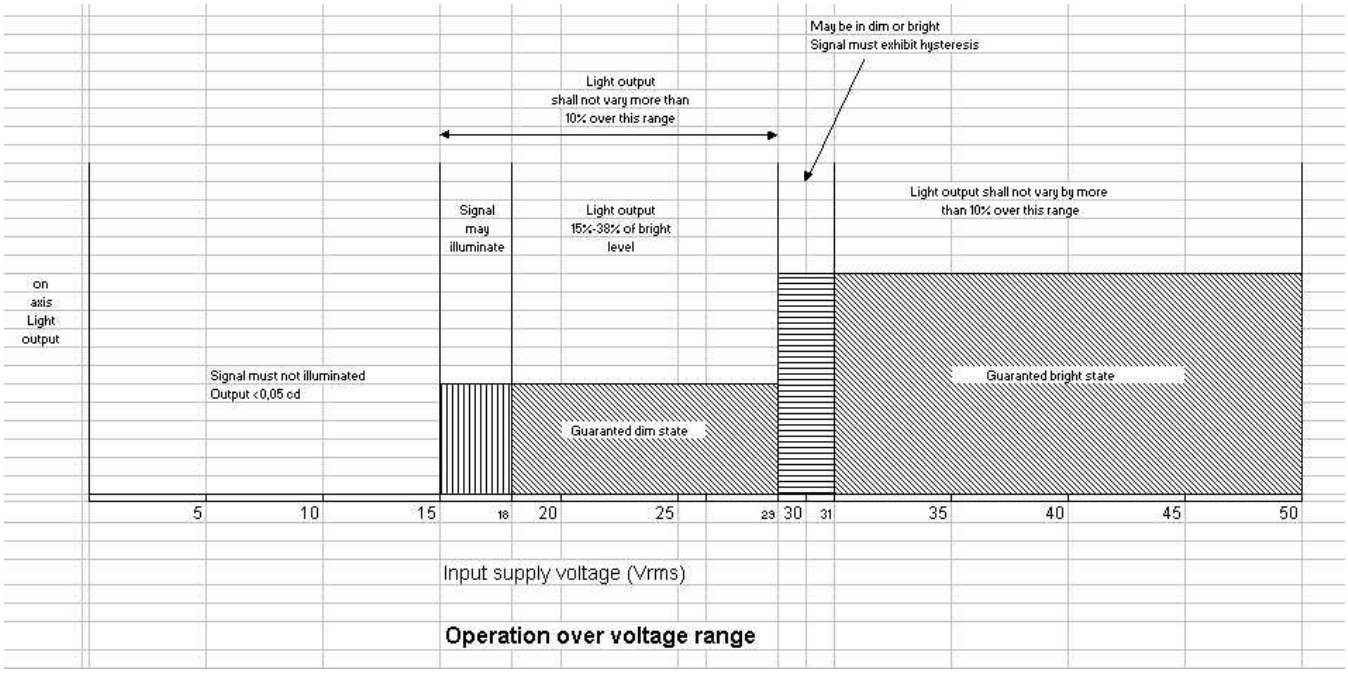

Figure C.1 - Operation over voltage range

The signal shall operate within the ranges defined in Figure C.2.

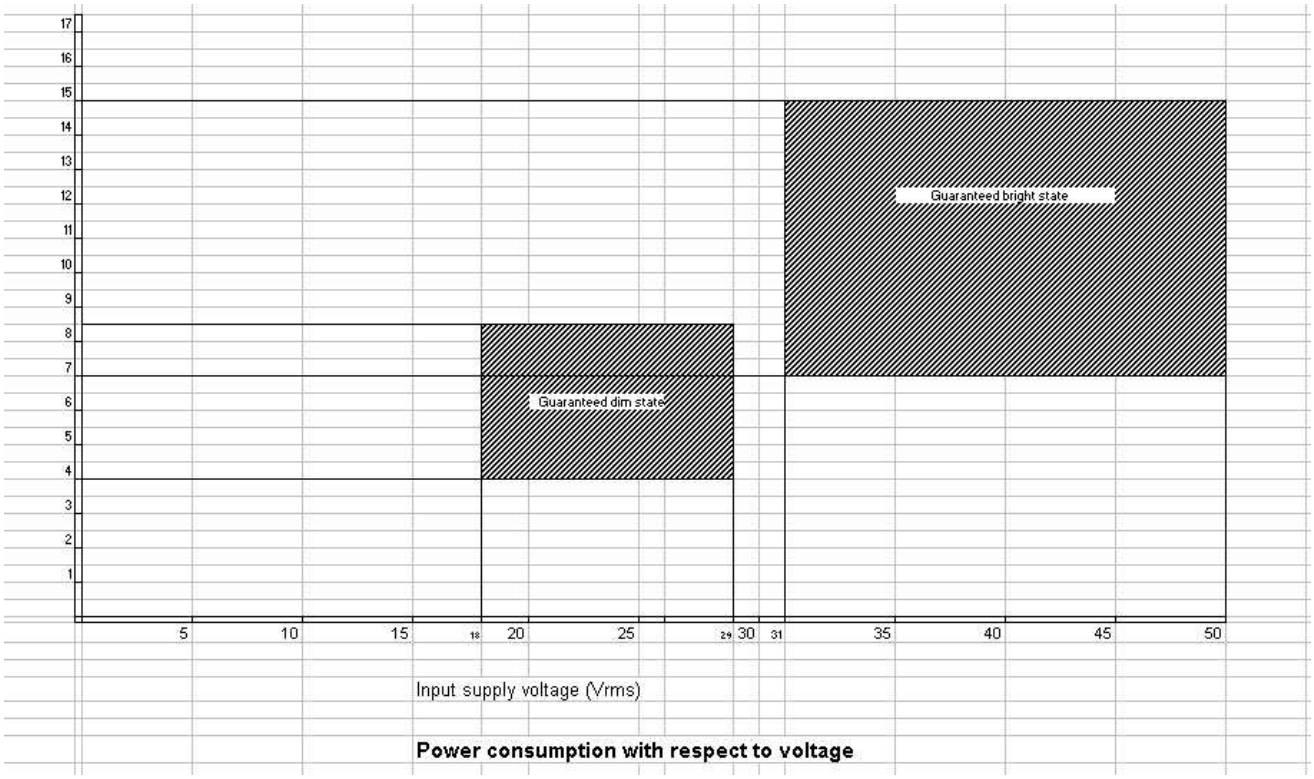

Figure C.2 - Power consumption over voltage range

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BSI — British Standards Institution

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