ASTRIN
Association of Traffic Industries in the Netherlands

Guideline for the application of new lamp types in road traffic signal systems

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Interface definitions

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Notice

This document is a translation of the Dutch document *Richtlijn voor de toepassing van nieuwe lamptypen in verkeersregelinstallaties – Grensvlakdefinities – Uitave 3 – December 2003*. This English translation is for information purposes only and is non-authoritative.

Preface

Traffic signal heads have entered the market during the last few years that have armatures without filament lamps, but with a light source that is composed of more light sources. This is the case with the so-called LED-lamps.
Until now, mainly optical requirements were formulated for traffic signal heads; the electrical performance of the traditional (gas filled) incandescent lamp was not explicitly prescribed. With the application of *light emitting diodes* (LED's) in traffic signalling it appeared to be necessary to expressly formulate such requirements, particularly in view of the difference in failure behaviour, power consumption and night-time dimming behaviour of the LED elements.

With this publication, the ASTRIN members would like to help the other parties with the unequivocal formulation of requirements, that must be prescribed for modern traffic signal heads and monitoring of these by the intersection controller. We assume full conformity to the existing, standardised safety level of road traffic signal systems (paragraph 2.1) in the Netherlands. This will result in a number of *general additional requirements,* independent of the applied technology (paragraph 2.2).

Other additional requirements are indeed dependent on the applied technology. Because lamps for traffic signal heads and traffic controllers are mostly purchased at different moments in time, we value the exchangeability of lamps without unexpected problems in operation and monitoring. This is the reason why we introduce the term *Interface definition*, an unequivocal description of the mutual operation of traffic controllers and traffic signal heads. Controllers and lamps of different types can be separately developed and approved and further be randomly combined, al long as this mutual interface definition is taken into consideration.

We are aware of the fact that the development of traffic controllers and optical technology continues and we will continue to contribute to that development. The formulated interface definitions will in due course become outdated through innovation and must be complemented or replaced. This publication is drafted in such way that this will be possible through addition of another interface definition to the *additional requirements for exchangeable traffic signal heads* (paragraph 2.3).

The ASTRIN members will adhere to the principles of this publication during product development and for the delivery of traffic signalling systems in the Netherlands.

Zoetermeer, March 2001
The ASTRIN board

Preface to the third edition

The first edition of the *interface definitions* gained a constructive interest from the market. During 2002 KEMA in Arnhem performed the first product approvals whereby the requirements proposed in this first edition were verified. This was the base for the compilation of this third edition. With regard to the first and the second (working) edition the following changes are worth mentioning -

- The requirements for electromagnetic compatibility for Class I and Class II are complemented with requirements for the power factor and the total harmonic distortion of the lamp current. Affiliation is sought to the Standard IEC 61000-3-2:2000 *Electromagnetic Compatibility – part 3-2 Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*. We do realise that this Standard is intended for the mains connection of a complete installation, but we intend to formulate a realistic definition that prevents lamps to be applied within these classes of which the current consumption strongly differs from the usual sinusoid.
- The minimum current consumption of Class II-lamps in faulty condition is now specified as a fixed value.
- The electrical transient periods for switching-on and -off have been limited.
- In view of prevention of misunderstandings at the time of lamp replacement, a requirement to specifically label voltage stabilised lamps has been added.
- The reaction intervals of Class I and II lamps at the occurrence of a fault have been changed.

When formulating the interface definitions we explicitly avoided creating requirements *deviating from the valid Standards*. This is particularly evident for the requirements with regard to the failure behaviour (paragraph 2.2), in which operation outside the prescribed limits of the standard values for luminous intensity and luminance uniformity is not allowed. This can lead to a defensive lamp design, with a certain surplus in luminous intensity and in the number applied light sources. We assume that it is the task of the Netherlands Standardisation Committee to formulate other requirements.

Since the publication of the first edition of the interface definitions there are announcements of LED lamps that have a lower rating than the current Class II (7-15 W non-dimmed). Although the systematics of the *interface definitions* allows classes with another power definition, we did not yet add a new class, in view of a reliable functioning of the lamp monitoring, also with larger cable lengths and oxidation of connectors.

Zoetermeer, November 2003
The ASTRIN board

1. The application of LED's in traffic signal heads

1.1. Innovative lamps

The use of *light emitting diodes* (LED's) in traffic signal heads was until recently not possible in the Netherlands, because they did not meet the requirements on several points. This was the reason that the use of incandescent lamps was inevitable, with all implicit disadvantages, such as the limited lifetime, the necessity of preventive lamp replacement and relatively high power consumption. New developments in the production process of LED's have now made their application in traffic signal heads possible. Extension of the affordable production of the number of colours and the enhancement of the luminous intensity enable an economically responsible application at controlled intersections.

The different principles with which light in an incandescent lamp and in LED's is generated create a large number of advantages for the LED-technology over the incandescent lamp. In incandescent lamps light is generated through warming, which causes the lamp to gradually consume itself during the production of light, while a lot of energy is lost in the form of heat. Light is produced in an LED by a non-thermal quantum mechanic process in a semiconductor, which consequently allows a very long lifetime of the LED.

The (tungsten) filament of an incandescent lamp is gradually consumed during the operation of the lamp, so that it becomes more and more vulnerable for high transient currents and vibrations. The semiconductor material and the connections of an LED are completely fixed in an epoxy housing, so that it is not sensitive to vibrations and shocks.
The above mentioned properties make the very long lifetime of an LED-technology traffic lamp with a relatively low power consumption possible. In addition the redundancy that is inherent in the application of LED's replacing incandescent lamps, takes care for a gradual failure instead of the usual suddenly occurring fatal failure: an 'LED-lamp' consists of a number of independent light sources. Of course during the design the effects of such a gradual failure must be dealt with in a responsible way.
The power consumption of the present traffic signal heads in LED-construction will be lower than others, but the differences will usually be less than first expected. Most of the traffic signal heads in the Netherlands are already equipped with krypton- or halogen lamps that already have lower power consumption at the required luminous intensity than the normal incandescent lamp (35-40 W instead of 60-100 W).

1.2. Design consideration in view of functionality and safety

A traffic signal head must of course be developed in such a way that it meets the optical, electrical and mechanical requirements. The traffic signal head however, is part of a system: the traffic signal system. Within this system, the traffic controller is responsible for switching the connected lamps and for monitoring their operation. In the past, when designing the traffic controller, we implicitly assumed an *expected behaviour* of the connected lamps. We could for instance count on a clear failure behaviour ("a broken incandescent lamp is completely extinguished and does not take current") and on well measurable currents, generally representing 15 W or more per lamp. For dimming, the power supply of the incandescent lamps can easily be lowered, so that the luminous intensity of all types of incandescent lamps will be reduced to the same extent.

With the introduction of the LED-lamp for traffic signal applications these implicit assumptions no longer appear to be valid, so that extra attention should now be given to the "co-operation" between traffic controller and traffic signal head. Extra design criteria for both system parts can be established. There are *general criteria* that are independent of the lamp type and *specific criteria* that are dependent on the applied components and the lamp design. In the following text it is explained which additions and interpretations must be included in the requirements list, so that an LED-lamp – but also another innovative lamp type – can be easily applied.

a. Life expectancy
The *expected lifetime* of an LED-lamp is an important quality property. The life expectancy is naturally dependant on the properties of the LED's in the lamp, but also of the electrical circuit of the LED's, the temperature in the lamp, the reliability of the other electronic components in the lamp and especially of the answer to the question: "when is the lamp of an LED-signal head faulty?" The *design* of the LED-traffic lamp is at least as important for the life expectancy as the properties of the LED's used in the lamp.

For the application in traffic signal systems, the expected lifetime of the lamp is no *safety property*. A traffic controller detects the faulty (critical) lamps and reacts thereon, eventually by switching the signal system to flashing yellow. The expected lifetime does not lead to additional functional- or safety requirements.

b. Chance of failure
A component or system fails in an unsafe mode, when a serious fault regarding the operational safety is not discovered soon enough and/or if no timely reaction follows. Such a serious fault in a traffic controller is for example the showing of green light to conflicting traffic flows for an interval longer than 100 ms. In view of the public safety, severe requirements are in force for traffic controllers. The chance of failure in an unsafe mode must be smaller than once per 100,000 years of operation of the controller.
For the connected incandescent lamps in the traffic signal head, the chance of unsafe failure is taken to be negligible, so that the safety of the traffic signal system is equal to that of the traffic controller.
This is not self-evident for traffic lamps with electronic components such as LED's, control- and monitoring circuits. To prevent the safety of the traffic signal system as a whole from decreasing when applying such less safe signal heads or lamps, an additional requirement must be made with regard to the chance of (unsafe) failure of a traffic signal head and/or –lamp. This requirement is independent of the technology of the signal head and the lamp.

c. Failure behaviour

Traffic lamps that use multiple light sources (such as LED lamps) do not fail *suddenly*, like traffic signal heads with incandescent lamps, but they degrade gradually. After a certain number of faulty light sources within a lamp, it must be concluded that the lamp has failed. This does not only refer to the *number* of LED's that are faulty, but sometimes also the position of faulty LED's. A traffic signal lamp may not have large dark areas and may not be degraded in such a way that a figuration (directional arrow-, bicycle- or pedestrian symbol) is not recognisable anymore.

For traffic lamps that use multiple light sources, a general additional requirement must be formulated, which will indicate under which circumstances a lamp is considered to have failed. We respect under all circumstances the minimum luminous intensity, as required in the Standard. It is not justified to go below this limit during normal operation of the traffic signal system.

d. Lamp monitoring

A traffic controller will generally react to failure of a (red) lamp by either reporting the fault, or switching the traffic signal system to flashing yellow. Such a provision will remain necessary when applying lamps with a long lifetime, because incidental (production) faults may still occur and not only the lamp, but also the cables between the controller and the lamp can become defective.

The previous and the current generation of traffic controllers are generally based on current measurement at the usual power range for incandescent lamps. Moreover, when an incandescent lamp fails, a decrease in current is easy to detect. In a certain number of cases, the current limit must be adapted in the controller when a lamp is replaced by a lamp with a different power rating.

Because the LED-lamps operate at a lower current than the incandescent lamps and because the LED-lamp mostly fails gradually, whereby the current decrease will be limited, the monitoring circuit in the controller will have to be tuned to the (electrical) properties of the (LED-) lamps to be monitored. These requirements cannot be formulated in general terms, but are dependent on the state of the art of the lamp technology.

e. Monitoring response time

The lamp monitoring in the controllers is designed in such a way that the monitoring response interval requirements in the Standard are satisfied. At the required values for monitoring response intervals in the Netherlands, this is technically only just possible, without the controller reacting too critically to every disturbance.

During the development of an LED-lamp, a solution is often selected whereby a part of the monitoring function is accommodated in the lamp. The failure of individual LED's or LED-groups can be monitored in the lamp itself, whereby the lamp can be completely switched off upon reaching a specified condition. The monitoring circuit of the controller then "sees" this switching off and reacts. The sum of the response interval of the monitoring circuits in the lamp and in the controller will have to remain within the required total response time given in the Standard. For a sound and defensive design of an LED-lamp this should not be a problem when the lamp gradually fails and will be switched off before reaching the minimum level for luminous intensity. Nevertheless it is desirable to formulate requirements for the response time of a possible monitoring circuit in the lamp to a gradual failure of that lamp. This prevents a situation whereby a lamp would remain in operation with a reduced light output during an extended period.
Note. The Standard NEN-EN 12368:2000 requires a minimum value for an operative lamp of 10 cd in the reference axis. This formally means that a temporarily (very) weakly illuminated lamp would still satisfy the requirements of the Standard.

f. Power consumption

The *power consumption* of an LED-lamp is an important quality property, but no *safety factor*. From the point of view of energy saving, minimum power consumption is desired, of course within the standardised optical requirements. However, in combination with existing controllers, the power consumption cannot be decreased to the lowest reachable value. Traffic controllers will have to distinguish miniature repeater signals from primary lamps during the monitoring of the functioning of the installation. The traffic controller cannot monitor an LED-lamp by remote power measurement that does not seem to consume energy while operating properly.

The energy that a traffic lamp with LED's consumes will be the result of the balance between minimum consumption, the intended areas of application and economical series. Additional requirements with regard to the power consumption may result from the characteristics of the monitoring circuit (see *lamp monitoring)*, or be specified independently, leading to requirements to the interface with the controller.

g. Dimming

Many traffic controllers have one fixed nighttime dimming mode that is effected by lowering the voltage of the lamps, by switching a central transformer into the supply circuit. The luminous intensity of LED-lamps as a function of the supply voltage is different than the intensity of incandescent lamps, so that often another value for the (fixed) dimming voltage will have to be selected. Since LED-lamps will also be applied in existing traffic signal systems, the dimming equipment in the controller may have to be replaced. Another complication is that also a mixed use of lamps and LED's is desirable, within the signal system, an approach, a signal group, or even in different aspects of the same signal head.

Depending on the application, corresponding dimming characteristics between lamps will have to be achieved by either matching lamp performance at the traditional reduced voltage level for incandescent lamps, or by supplying the entire system with similar new lamps. As an alternative, an LED-lamp can be equipped with current control in the lamp, also supporting a dimming mode.

In the Netherlands there is presently no quantitative Standard that prescribes a *level* of luminous intensity reduction when dimming. The introduction of innovative lamp types in itself is no ground to introduce such additional requirements.

h. Photometric measurements

Every lamp of whatever type must satisfy the standardised optical requirements. For the LED-lamp, no additional requirements have to be formulated.

The way the luminous intensity of traffic signal heads has to be measured has become widespread during many years of experience. This time honoured method is not necessarily applicable to LED-lamps. Signal heads with incandescent lamps are generally supplied with a sinusoid alternating voltage with a frequency of 50 Hz, but because of the inertness of the physical process in the lamp, the produced luminous flux is rather constant. Equipment that makes a snapshot of the luminous flux will thus render a reliable indication. LED-lamps that are supplied with a non-smoothened block current of 100 Hz (rectified sinusoid) show another picture however. Because of the character of the process in which electrical energy is transformed into light, the luminous flux follows the supply shape much closer. This makes it necessary to use equipment for measurements of the luminous intensity that does not make snapshots, but determines an average over a number of periods of the power supply to the lamp.

i. Electromagnetic compatibility (EMC)

Traffic signal systems must satisfy the EMC-product Standard NEN-EN 50293, which can be achieved in principle by ensuring that every part of the signal system satisfies this Standard individually. The Standard specifies the disturbances against which a system component must be resistant (*immunity*). It also specifies what level of disturbance a system is allowed to cause, including the influence on the supplying electricity network (*emission*). Technology development may be a motive for the use of other electrical standards *within* the traffic signal system, for example between the controller and the lamps. For the purpose of energy conservation for instance, it could be appropriate to supply an LED lamp with another voltage form than the usual 50 Hz pure sinusoid. This can obviously only be realised if the relevant interface definition co-exists between the controller and the lamps. The controller may have to apply filtering so that the disturbance of the supplying electricity network will not exceed the limits of the Standard NEN-EN 50293. In most cases the *accumulated* influence of all connected lamps must be considered.
In view of the different voltage-current characteristic of LED-lamps, not all controllers with mechanical relays as a final lamp switch will be suitable for controlling new lamp types. Safety is not an issue in this case however.

j. Deviation of optical performance during operation (short term)

The optical features of an incandescent lamp during operation are practically constant. The colour and the intensity of the light, as emitted by an LED is however dependant on the temperature of the LED and thus of the duration of illumination. For the optical test of a signal head with LED lamps we should not only observe the performance directly after switching on, but also the possible deviation of the performance after some time (stability). Realistic operational conditions should be taken into consideration, so that a different duty cycle may apply to the red, yellow and green aspects.

k. Deviation of optical performance during operation (long term)

As is the case in all types of lamps, the luminous intensity diminishes through ageing during the lifetime of the lamp. In addition, the traffic signal heads degrade because of air pollution and emissions by traffic. These effects can be considerable, but until now they have not been considered in the standardisation of traffic signal heads. The introduction of innovative lamp types as such is no reason to introduce additional requirements.

l. Phantom effect

The application of LED's in traffic signal heads is so different from the application of other lamps that a considerable influence exists on the phantom phenomena in the traffic signal heads. Although at first sight it could be assumed that the sensitivity to the phantom effect in the case of LED's is absent, in reality this is not the case.

The effect of sunlight striking traffic signal heads can be divided into two components: light that reflects on the lens of the traffic signal head, and light that enters through the lens, is reflected inside the aspect and thereafter leaves through the lens.
The first effect, reflection on the lens, is not dependent on what is inside the aspect and is only determined by the characteristics of the applied lens. The second effect, reflection in the inside of the aspect is different for an LED signal head and a signal head with incandescent lamps. If a colourless lens is applied, as opposed to a necessarily coloured lens for an incandescent lamp, outgoing phantom light will definitely not have the colour of the aspect concerned. Moreover, the outgoing phantom light will be less concentrated because of the absence of a large reflector in an LED lamp.
While LED's do not reflect any coloured light and application of a colourless ensures that no entering light will leave an LED lamp in a coloured form, sufficient suppression of reflective phantom light remains necessary to satisfy the requirements. For this purpose however, no additional requirements have to be formulated.

m. Switching behaviour; duty cycle

Optical performance

Where the reaction of road-users to lamp switching is the basis for public regulations, generally the performance is specified in tenths of a second. The "reaction time" of a lamp during ignition (warm-up) or extinction (persistence) is of great importance. For the current types of incandescent traffic signal lamps these phenomena are negligible, but with the introduction of lamps with electronic, time dependent components, it is necessary to formulate (once more) minimum requirements for switching behaviour. These are technology independent and have the form of general, additional requirements.

Duty cycle

Following the Standard, yellow flashing in a traffic signal head has a frequency of 0,66 to 1 Hz, with a light-dark distribution of 1:1; this is the so-called duty cycle. To achieve this duty cycle an intermittent power supply must be generated in the controller, with a distribution that may take into account a specific switching behaviour of the applied lamps. For this reason, it is not straightforwardly possible to connect new lamp types with a substantially different switching characteristic. In situations whereby a mixed usage of lamp types is to be expected, certain uniformity should be specified for the flashing behaviour.

Electrical performance
At the *ignition* of a lamp a short current surge generally occurs, for which reason the monitoring circuit in the controller is temporarily confronted with non-realistic values. In incandescent lamps this surge decreases sufficiently quick to avoid compromising the prescribed response time for lamp failure; in addition any lamp failure is a complete failure, so that there will be no significant residual current. For new lamp types with electronic components, the surge current does not decrease *a priori* to within a sufficiently short period, while at the same time a residual current may remain in case of a partial failure. To guarantee that despite the switching current a (partial) failure will be discovered in time, the time interval wherein a (strong) current surge occurs must be limited. On the other hand, the power consumption must increase quickly enough for the controller to confirm the proper operation of the lamp.

At the *extinction* of a lamp, the voltage over that lamp must decrease quickly enough. Because energy can be stored in lamps with electrical components, some voltage level may remain in the controller after switching off the power to the lamp, causing the monitoring circuit in the controller to be deceived.

n. Power stabilisation
In some traffic controllers a so-called voltage stabilisation is applied, in which power supply to the signal heads is stabilised around the nominal values for daytime and dimmed operation. With this facility, the luminous intensity is independent of the momentary supply voltage level and/or the lifetime of the applied lamps will not be harmfully influenced by long-term operation under a high voltage level, which may occur locally.

Power stabilisation can be arranged in the controller, or locally in every lamp. Under conditions central stabilisation is indispensable, especially when configurations of more lamps per signal group must be monitored within a relatively broad class of mutual exchangeable lamps. To be able to measure sufficiently exact from the controller, a limitation in the variation of the operating voltage level of the connected lamps is inevitable.

In those cases that central power stabilisation does not have to be applied, but a (local) power stabilisation is valued, one stabilised lamp must be replaced by another stabilised lamp. Local power and power stabilisation in the lamp is therefore an important product property, which must be clearly recognisable.

2. Requirements for traffic signal heads

2.1.Existing Standards

New traffic signal heads that are used in the Netherlands must satisfy the Standard NEN-EN 12368:2000 *Verkeersregelinstallaties – Verkeerslantaarns*[1], - independent from the applied light technology. Additional requirements for the Netherlands, for areas not covered by this (European) Standard, are contained in a so-called residual Standard NEN 3322:2000 *Verkeersregelinstallaties – Verkeerslantaarns – Aanvullende eisen.* The text of the European Standard was written in such a way as to leave the technology for application in the signal head open. Requirements for electrical safety and the electromagnetic compatibility for signal heads are based upon the European harmonisation document HD 638 S1:2001 *Road Traffic Signal Systems* and the Standard NEN-EN 20293:2001 *Elektromagnetische compatibiliteit – Verkeersregelinstallaties – Productnorm*[2]. Requirements for the traffic safety of control equipment are, as a matter of course, also important for the requirements for signal heads. Signal heads, especially the red aspects, need to be monitored for proper operation. The applicable requirements are formulated in the Standard NEN-EN 12675:2000 *Verkeersregeltoestellen*[3], and the Dutch residual Standard NEN 3384:2001 *Elektrische Verkeersregeltoestellen*. The Standard NEN-EN 12368 defines performance classes for various functional requirements. Classes are selected on a country by country basis. The Standard indicates the following choice for the Netherlands –

Temperature range	class B (-25 ºC to +55 ºC)
Luminous intensity	class A3/1 (400 cd to 1000 cd)
Distribution of luminous intensity	class W (all beam types except the extra wide beam)
Phantom signal	class 2
Signal heads with symbols	class S1 (as full roundel)

There is no difference in requirements for signal heads with 20 and 30 cm roundel diameter.
Please note: the above table is informative *only* and represents the status as per April 2001.

2.2. General additional requirements for traffic signal heads

In this paragraph, requirements are formulated that have a general validity for the application of signal heads and signal lamps in traffic signal installations, in addition to the Standards.

The requirements are not dependent on the location or the applied technology. The additional requirements remain valid when a technical innovation enables other optical elements to be used or another form of interfacing between signal head and controller.

The conformity of a traffic signal head with the general additional requirements has to be demonstrated.

Degree of reliability

The total assembly of components in, and belonging to, the lamp has a chance of unsafe failure of less than once per 1.000.000 equipment years.

The purpose of this requirement is to prevent an increase in the chance of unsafe failure of the traffic signal system as a whole, to a level, considerably above the prescribed level of once per 100.000 equipment years, by the addition of electronic components outside the traffic controller cabinet.

Failure behaviour

All clauses from applicable requirements and Standards are maintained for lamps with multiple light sources, also when one or more of the light sources (“dots”) has ceased to function.

There is no reason for the modification of optical, mechanical, electrical and safety requirements for the benefit of new types of signal heads. With regard to traffic signal heads with multiple light sources, attention is particularly drawn to the relevant clauses from the Standard NEN-EN 12368:2000:

- the luminous intensity must satisfy the limits of the Standard, also in the case of a partial failure;
- luminance uniformity: the aspect image must remain within the limits of the Standard, also in the case of a partial failure.

A lamp with a multiple light source that no longer satisfies the requirements is deemed to function incorrectly. A lamp that may fail partially, must be designed or monitored in such a way that an operation outside the prescribed limits as a consequence of a partial failure cannot occur, or is detected.

[1] Identical to EN 12368:2000 *Traffic control equipment – Signal heads*
[2] Identical to EN 20293:2001 *Electromagnetic compatibility – Road Traffic Signal Systems – Product Standard*
[3] Identical to EN 12675:2000 *Traffic signal controllers – Functional safety requirements*.

Deviation of optical performance during operation (short term)

The red and the green aspects of a signal head must satisfy the requirements for luminous intensity, luminance uniformity and colour in an interval between the maximum ignition time to fifteen minutes afterwards. The yellow (amber) aspect of a signal head must satisfy these requirements during an interval between the maximum ignition time to one minute afterwards. In addition, the yellow aspect must satisfy these requirements during flashing with a duty cycle of 1 Hz and an effective voltage period of 50 %, in an interval shortly after the first ignition to fifteen minutes afterwards.

The measurement for the deviation of optical performance (stability) is limited in time to keep the duration of the test within reasonable limits. It is presumed that lamps will certainly have reached optical stability after fifteen minutes of operation.

Switching behaviour

The interval between the moment of switching on of a lamp by the controller and reaching of the specified luminous intensity is maximum 50 ms. The interval between the moment of switching off of a lamp by the controller and extinguishing of the lamp is maximum 50 ms.

This requirement aims to prevent a negative influence to the optical performance of signal heads as expected by traffic, caused by electronic components in the lamp.

The current of a lamp must have a value between 80 and 120% of the nominal value within 100 ms after being switched on.

This requirement aims to have the lamp monitoring in the signal system react correctly in case of a partly failing lamp.

After removing the power supply, the voltage over the lamp must have decreased to a maximum of 10% of the nominal value within 20 ms.

This requirement prevents that possible accumulated energy in the lamp might mislead the lamp monitoring circuit in the signal system after switching off.

Voltage stabilisation

The presence of a circuit for voltage stabilisation within a lamp must clearly be marked on the outside of the lamp housing.

This requirement aims to prevent misunderstandings during the exchange of lamps.

2.3 Additional requirements for exchangeable traffic signal heads

In this paragraph, additional requirements are formulated that are only valid for a specific combination of controller and lamp technologies. Since safety of the traffic signal system is, among other things, dependent on the monitoring of the electrical circuits between signal head and traffic controller, the electrical performance of signal head and controller must be matched.
Since traffic controllers and signal heads are often procured independently, and in addition the exchangeability of signal heads of different manufacture and type is desirable, there is a need for an *interface definition* of the electrical properties of signal heads.

The conformity of a traffic signal head and a traffic controller with the general additional requirements has to be demonstrated for the class(es) of the interface definition for which use is admitted.

These additional requirements will change when technical innovation allows other optical elements or another form of co-operation between signal head and controller.

Interface definition exchangeable traffic signal heads

Class I: First generation LED signal heads with a lamp rating up to 50 W and a nominal operating voltage of 42 or 230 V AC

Traffic signal heads of which the electrical performance complies with this *Interface definition exchangeable traffic signal heads*, Class I, may be used in combination with the new and most of the existing traffic controllers.

Power consumption

The nominal operating voltage of the lamp is 42 V or 230 V AC. The power consumption per lamp is below 50 W in non-dimmed state. The power consumption per signal group is below 300 W.

This requirement is formulated in view of the precision and the adjustment range of the measuring circuit for lamp monitoring of the controller and the possible combined effect of the switching behaviour of a (very) large number of LED lamps.

Lamp monitoring

The perceived power rating of the connected lamp is at least 20 W in non-dimmed state, and 12 W in dimmed state respectively.

This requirement is formulated in view of the electrical properties of the power switches, applied in traffic controllers.

The failure of a connected lamp is measurable at the controller terminal rail by the decrease of the lamp's continuous power rating of minimum 10 W non-dimmed, and 6 W dimmed.

This requirement is formulated in view of the adjustment range of the measuring circuit of the controller. It must be emphasised that the monitoring thresholds in the controller may have to be adjusted when the lamp(s) are replaced by lamp(s) with another nominal power rating, even when belonging to the same Class of this Interface definition.

Monitoring response time

The response time of the total assembly of components in the aspect, intended to monitor it's operation, is lower than 30 ms, when an event occurs after which the aspect no longer meets the optical requirements. In the case of stepwise degradation of the luminous flux there must be no response time of all the components in the aspect, if the aspect no longer satisfies the requirements.

This purpose of this requirement is to prevent an extension beyond the requirements of the response time of existing and new traffic signal system as a whole, caused by the addition of monitoring elements outside the controller. Given a present requirement for the total system of 200 ms, the controller must react within 170 ms, because the aspect has a reaction time below 30 ms.

Dimming

The luminous intensity of the aspect diminishes in the usual way at a terminal voltage in the controller with a value between 65% and 75% of the nominal terminal voltage in non-dimmed state.

This qualitative requirement is formulated in view of the present dim supply in existing and new traffic controllers and of maintaining the usual dimmed image on street, also for mixed use of LED's 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.

Electromagnetic compatibility

The aspect satisfies the requirements of product Standard NEN-EN 50293:2001.

This requirement is formulated in view of the sensitivity of components within the traffic controller for the disturbance of the electrical circuit between controller and signal heads. In addition, this requirement presumes the absence of special provisions in the traffic controller for the protection of the external power supply for disturbances, induced by (electronic) components in the signal heads or the lamps.

The aspect has a power factor (PF, cos φ) $\geq$ 0,9 (inductive) and a total harmonic distortion (THD) $\leq$ 33 %, at the nominal operating voltage.

A consequence of this requirement is that the power consumption must be globally sinusoid. A further consequence is that the monitoring circuit of the existing traffic controllers does not have to be adapted to different characteristics of specific electronic components (current control) in the lamp.

Duty cycle flashing yellow

The effective powered interval of the flashing voltage generator in the traffic controller is 40 to 50 % of the duration of the flashing cycle. The effective light-emitting interval of the lamp during flashing operation is 40 to 60 % of the duration of the flashing cycle.

This requirement is formulated in view of the flashing voltage generator, present in existing and new traffic controllers, and the preservation of an acceptable flashing image on street, also for mixed use of LED's and incandescent lamps.

Interface definition exchangeable traffic signal heads

Class II: Second generation LED signal heads with a lamp rating up to 15 W and a nominal operating voltage of 42 V AC

Traffic signal heads of which the electrical performance complies with this *Interface definition exchangeable traffic signal heads*, Class II, may be used in combination with traffic controllers with a lamp monitoring circuit, adapted accordingly.

Power consumption

The nominal operating voltage of the lamp is 42 V AC. The lamp must satisfy this interface definition at a power supply between 26 and 50 V.

This requirement is formulated for reasons of to uniformity.

The power consumption of the lamp is below 15 W at the nominal operating voltage.

This requirement is formulated in view of the precision and the adjustment range of the measuring circuit for lamp monitoring of the controller.

Lamp monitoring

The maximum number of connected and monitored lamps is five per signal group.

This requirement is formulated to obtain sufficient distinction for the detection of faulty lamps in configurations with several lamps per signal group.

The current through an illuminated lamp must be at least 80 mA.

This conforms with a 3.5 W at 42 V and 2.5 W at 31 V. This requirement is formulated in view of the electrical properties of applied types of power switches in traffic controllers.

The failure of a connected lamp is measurable on the terminal rail of the controller by a decrease of the current through that lamp to a value of maximum 33 mA.

This requirement is formulated in view of the precision and the adjustment range of the measuring circuit of the controller. At the indicated values it is possible in practice to set an unequivocal limit for the monitoring the last illuminated (red) lamp of a signal group, which does not have to be adjusted when lamps are replaced by other lamps of Class II. It must be emphasised that specific monitoring thresholds set for other situations than the failure of the last (red) lamp may have to be adjusted if lamp(s) are replaced by lamp(s) with another nominal power rating, even when belonging to the same Class of this Interface definition.

Monitoring response time

The response time of the total assembly of components in the lamp, intended to monitor it's operation, is lower than 50 ms, when an event occurs after which the lamp no longer meets the requirements.

This purpose of this requirement is to prevent an extension beyond the requirements of the response time of the traffic signal system as a whole, caused by the addition of monitoring elements outside the controller. Given a present requirement for the total system of 200 ms, the controller must react within 150 ms, because the lamp has a reaction time below 50 ms.

Dimming

The luminous intensity of the aspect diminishes in the usual way when the nominal terminal voltage is decreased from 42 V to 31 V AC.

This qualitative requirement is formulated in view of maintaining the usual dimmed image on street, also for mixed use of LED's 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 and 50 V and must operate in dimming mode at a supply voltage between 26 and 34 V.

Power stabilisation

Equipment for central stabilisation of the power supply to the lamps can be installed in the traffic controller; this provision however is not mandatory.

Electromagnetic compatibility

The aspect satisfies the requirements of the product Standard NEN-EN 50293:2001.

This requirement is formulated in view of the sensitivity of components within the traffic controller for the disturbance of the electrical circuit between controller and signal heads. In addition, this requirement presumes the absence of special provisions in the traffic controller for the protection of the external power supply for disturbances, induced by (electronic) components in the signal heads or the lamps.

The aspect has a power factor (PF, cos φ) $\geq$ 0,9 (inductive) and a total harmonic distortion (THD) $\leq$ 33 %, at the nominal operating voltage.

A consequence of this requirement is that the power consumption must be globally sinusoid. A further consequence is that the monitoring circuit of the existing traffic controllers does not have to be adapted to different characteristics of specific electronic components (current control) in the lamp.

Duty cycle flashing yellow

The effective powered interval of the flashing voltage generator in the traffic controller is 40 to 50 % of the duration of the flashing cycle. The effective light-emitting interval of the lamp during flashing operation is 40 to 60 % of the duration of the flashing cycle.

This requirement is formulated in view of the flashing voltage generator, present in existing and new traffic controllers, and the preservation of an acceptable flashing image on street, also for mixed use of LED's and incandescent lamps.