Updated for TFSR-10

Light Source
Requirements

- In general for UN approved light sources
- OEM situation and AFTM situation
- Requirements clustered in
  - Safety
  - Performance
  - Consumer / Customer

CONSUMER / CUSTOMER REQUIREMENTS
- E.g. higher lifetime specifications
- E.g. heavy duty performance
- E.g. limited color coordinates

PERFORMANCE REQUIREMENTS and TEST METHODS (IEC 60810)
- Technical
  - Minimum lifetime
  - Minimum vibration resistance
- Information / Communication
  - Restricted white
  - …

SAFETY REQUIREMENTS (UN ECE)
- Technical
  - Luminous flux incl. tolerances
  - Maximum power
  - “Geometry”
  - …
- Information / Communication
  - Rated voltage (and wattage)
  - Category name

LED Replacement Light Source (LEDr) acc. to R37

- Photometric parameters
  - Same as for LED Substitutes
- Electrical parameters
  - Voltage range
  - FailureDetectionSystem-compatibility
  - PWM operation
  - EMC
- Mechanical parameters
  - Size
  - Mass
- Thermal parameters
  - Behavior under high ambient T.

Task for TFSR

CONSUMER / CUSTOMER REQUIREMENTS
- …

PERFORMANCE REQUIREMENTS (IEC 60810)
- Technical
  - …
  - …
- Information / Communication
  - …
  - …

SAFETY REQUIREMENTS (UN ECE R37 / RE5)
- Technical
  - …
  - …
- Information / Communication
  - …
  - …

Collecting the topics / questions

Electrical

Status after TFSR-08:
Discussed and agreed

Nr	Topic	Question		
#1	Voltage range	Does the LEDr have the same voltage - flux behavior as the filament light source?		
#2	PWM operation	Does the LEDr flicker in case of pulse-width modulation (PWM) operation? Also covering PWM dimming for dual-function operation		
#3	Power / electr current	Does the LEDr cause a wrong failure message in the dashboard when it is working correctly? Does the LEDr cause a correct failure message in the dashboard when it has failed? Incl presence detection (Kaltüberwachung)		
		Possible interaction with other electronics		
#4	EMC / EMI	Does the LEDr cause EMC problems in the vehicle?		
#5	Electrical robustness	Is the LEDr as robust against electrical disturbance as the filament lamp?		

Mechanical

Status after TFSR-08:
Discussed and agreed

Nr	Topic	Question		
#1	Vibration / Mass	Does the LEDr have the same mass as the filament lamp and is it as robust against vibration as the filament lamp?		
#2	Maximum geometry	Does the LEDr have the same geometry / maximum outline as the filament lamp? Is the sealing affected by the geometry of the heat-sink		

Thermal

Status after TFSR-08:
Discussed and agreed

Nr	Topic	Question		
#1	1min / 30 min ratio	Could it happen that the LEDr has higher intensity in the beginning (when switched on) and will reduce its intensity significantly as it reaches steady-state temperature?		
#2	High ambient temperature	Could it happen that the LEDr has significantly reduced intensity when it is operated at high ambient temperature?		
#3	Low ambient temperature	Could the de-icing / de-fogging behaviour of a luminaire be different when an LEDr is used?		
#4	Cap temperature	Could the lamp cap get hotter with an LEDr compared with a filament lamp and could this lead to damage of the material of the luminaire?		

Colorimetric

Status after TFSR-08:
Discussed and agreed

Nr	Topic	Question		
#1	Spectral content	In signalling applications with coloured lenses, is the spectral content of the LEDr sufficiently like the spectral content of the incandescent lamp? e.g. • Red lens • Amber lens • Green+red = white • Green+red=amber		
#2	Minimum red content	Is the minimum red content fulfilled? (for RID applications).		

Electrical #1

- Voltage Range

Question:

Does the LEDr have the same voltage - flux behavior as the filament light source?

Answer:

The electronics of the LEDr is designed so that the voltage – flux behavior is equivalent, or more stable, than the filament light source

Status after TFSR-08:
Discussed and agreed

CONSUMER / CUSTOMER REQUIREMENTs

PERFORMANCE REQUIREMENTS (IEC 60810)

SAFETY REQUIREMENTS (UN ECE R37 /RE5)

- The luminous flux shall be tested between 9 V and 14 V

<u>INFO #1</u>: Filament technology, LED techn y

New for TFSR-10

- Filament light sources (usually voltage driven) have …
  - an inherent flux-voltage-dependency *(e.g. -30% for 12.0V compared to 13.2V)*
  - no significant flux-temperature dependency, hence no requirement in R37
- LED light sources (usually current driven) have …
  - electronics and hence flux-voltage requirement in R128 *(default ±30% for 12.0V compared to 13.2V)*
  - an inherent flux-temperature-dependency, hence requirements in R128/R.E.5 *(e.g. for L1/6)*

➢ For a real world comparison of both technologies the **combined effect** is relevant

➢ For example, a limited voltage dependency of ±10% flux *(@12V)* and a limited temperature dependency of ≥80% flux *(@T_{test})* leads to **same or better flux performance** in LED case *(→ see next slide)*

INFO #1: Filament technology, LED technology

New for TFSR-10

Comparison of minimum luminous flux under real world conditions

Filament light source *(e.g. H11 case)*

1. Objective luminous flux tolerance: ±10% *(see H11 category sheet)* → minimum: factor 0,9
2. ~ no dependency on ambient temperature: 0% *(typical halogen bulb property)* → minimum: factor 1,0
3. Voltage dependency: -30% *(typical halogen bulb property, 12V compared to 13,2V)* → minimum: factor 0,7
4. Lumen maintenance: - 20% *(@350h; see manuf. info, resp. IEC 60810 or SAE J2560)* → minimum: factor 0,8

- Worst case *(min. flux, high temp., 12.0V, 350h)*: 0,9 · 1,0 · 0,7 · 0,8 → 50% in total *(with lm-maintenance; i.e. old bulb)*
- Worst case *(min. flux, high temp., 12.0V)*: 0,9 · 1,0 · 0,7 → 63% in total *(without lm-maintenance; i.e. new bulb)*

H11 LED Replacement light source *(e.g. H11 case)*

1. Objective luminous flux tolerance: ±10% *(see H11/LED/6 category sheet)* → minimum: factor 0,9
2. Maximum drop at T_{test}: -20% *(intended H11 LEDr proposal @T_{test})* → minimum: factor 0,8
3. Voltage dependency: -10% *(intended H11 LEDr proposal @12.0V)* → minimum: factor 0,9
4. Lumen maintenance: - 2% *(typical white LED property)* → minimum: factor 0,98

- Worst case *(min. flux, T_{test}, 12.0V, 350h)*: 0,9 · 0,8 · 0,9 · 0,98 → 64% in total *(with lm-maintenance; i.e. old bulb)*
- Worst case *(min. flux, T_{test}, 12.0V)*: 0,9 · 0,8 · 0,9 → 65% in total *(without lm-maintenance; i.e. new bulb)*

Electrical #1

- Voltage Range

Question:

Does the LEDr have the same voltage - flux behavior as the filament light source?

Answer:

The electronics of the LEDr is designed so that the voltage – flux behavior is equivalent, or more stable, than the filament light source

CONSUMER / CUSTOMER REQUIREMENTs

PERFORMANCE REQUIREMENTS (IEC 60810)

SAFETY REQUIREMENTS (UN ECE R37 /RE5)

- The luminous flux shall be tested between 9 V and 14 V
- Introduce a dedicated flux-voltage-dependency limit per category (i.e. in category sheets of R.E.5), e.g. for H11 case: ±10% at 12.0V and 14.0V

New for TFSR-10

Electrical #2
- PWM operation

Question:

Does the LEDr flicker in case of pulse-width modulation (PWM) operation? Also covering PWM dimming for dual-function operation

Answer:

There are two application cases:

1. PWM for dual function dimming (tail / stop and FrontPos / DRL)

2. PWM for stabilisation (reduce voltage peaks))

→ 1) Dual function is only used for a limited number of categories: e.g., P21W, but not e.g. H7

→ 2) all LEDr are tested for “no visible flicker”

Status after TFSR-08: Discussed and agreed, technical details to be confirmed

e.g. P21W

e.g. H7

CONSUMER / CUSTOMER REQUIREMENTs

PERFORMANCE REQUIREMENTS (IEC 60810)

SAFETY REQUIREMENTS (UN ECE R37 /RE5)

- Technical requirements for PWM-dimming-curve equivalent to filament behavior; dimming range up-to [10:1]; PWM range [80 to 200] Hz; square wave

- Technical requirements for PWM operation at 80 Hz [80%] duty-cycle → no visible flicker, square wave

PWM for stabilisation

New for TFSR-10

Investigations on popular European vehicle models have shown:

- PWM is used in many vehicles to stabilize the voltage when the alternator is charging the battery
- The most typical operation mode is:
  - 100 Hz
  - 90% duty cycle

Proposal for an R37 requirements:

The LEDr should show “no visible flicker” when operated at 100Hz and 90% duty-cycle.

An objective criteria for “no visible flicker” is under investigation.

PWM for dual-level dimming

New for TFSR-10

In UNECE, there are two applications that can be addressed by the dimming of a single filament:

- DRL → Front position
- Stop → Rear position

Only certain filament lamp categories are suitable for such applications, e.g. P21W, W16W

The ratio between these two functions can be between 5:1 to 10:1

Due to filament physics:

  - Flux ratio 5:1 → voltage level: 65%, realised by PWM duty cycle of 65%
  - Flux ratio 10:1 → voltage level : 55%, realised by PWM duty cycle of 55%

Proposal for an RE5 requirements:

For categories, that are suitable for dual-function operation, the following shall be verified:

- Operated at 13.5V, 100Hz PWM, 65% duty-cycle → requirement: 20% (+/- x) flux compared to 13,5 V DC
- Operated at 13.5V, 100Hz PWM, 55% duty-cycle → requirement: 10% (+/- x) flux compared to 13,5 V DC

Electrical #3
- Failure detection system compatibility

Question:

Does the LEDr cause a wrong failure message in the dashboard when it is working correctly?

Does the LEDr cause a correct failure message in the dashboard when it has failed?

Incl presence detection (Kaltüberwachung)

Answer:

Failure detection is mandatory for direction indicators (DI)

→ 1) LEDr for DI – The electronics of the LEDr is designed to ensure compatibility.

→ 2) user information for non-DI application (optional failure detection)

Initial proposal to TFSR-08
Solution A

e.g. PY21W

e.g. H7

CONSUMER / CUSTOMER REQUIREMENTs

PERFORMANCE REQUIREMENTS (IEC 60810)

SAFETY REQUIREMENTS (UN ECE R37 /RE5)

- Technical requirements for minimum current / power : in case LEDr is working correctly. The limit should be >[50]% of the filament current; use of optional external electronics allowed
- Technical requirements for maximum current / power : in case LEDr is failed (no light emitting).; use of optional additional electronics needs to be discussed
- Information / Communication
  - The consumer is informed about the possible impact of the LEDr on the failure detection system and is given additional information / advice

Electrical #3
- Failure detection system compatibility

Question:

Does the LEDr cause a wrong failure message when it is working correctly?

Does the LEDr cause a correct failure message when it has failed?

Is the LEDr compatible with presence detection ("Kaltüberwachung") ?

Answer:

For all LEDr the electronics of the LEDr is designed to ensure compatibility.

There shall be no light in the first 2ms.

Discussion during TFSR-08:
Solution B
„high power option"

CONSUMER / CUSTOMER REQUIREMENTs

PERFORMANCE REQUIREMENTS (IEC 60810)

SAFETY REQUIREMENTS (UN ECE R37 /RE5)

- Technical requirements for minimum current / power : in case LEDr is working correctly. The limit should be >[50]% of the filament current; use of optional external electronics allowed
- Technical requirements for maximum current / power : in case LEDr is failed (no light emitting)
- Information / Communication
  - The consumer is informed about the possible impact of the LEDr on the failure detection system and is given additional information / advice

Failure detection system compatibility (non-DI) – two options

Solution A- “high power AND lower power” versions

- „High power“ version for vehicles with failure detection (~[20]% of vehicles for low beam)
- „Low power“ version for vehicles without failure detection and for vehicles with low threshold (~[80]% of vehicles for low beam)
- User information

Benefit:

- reduction of electronic waste by avoiding additional electronics
- optimized energy efficiency

-> reduced CO2 emission, reduced waste

Disadvantage:

- Increased complexity for the consumer

“mis-use”:

Wrong failure message in case of using a “low power” version where a “high power” version is needed “ (but the light source is working correctly)

Solution B- only a “high power” version

- Only high power version

Benefit:

- Less complexity for the consumer

Disadvantage

- Increase of electronic waste by adding additional components where they are not necessary
- Artificially increased power consumption where low power consumption could be enabled

-> increased CO2 emissions, increased waste

Discussion during TFSR-08

New for TFSR-10

Failure detection compatibility

In order to find the correct minimum current/power level for the LEDr, that is necessary to be compatible with the failure detection systems of the vehicles (if present), measurements are planned on a selection of the top selling European cars:

Planned outcome: Summary of measured threshold currents and a proposed RE5 requirement

	Low beam						
	H11	H7	C5W	W5W	PY21W		
Vehicle #1	xxx mA						
Vehicle #2	yyy mA						
Vehicle #3	zzz mA						
…							
Minimum Current requiremeent in RE5	=highest value from the above list						

End of TFSR-08 meeting on 2019-12-10 in Bonn

Start of TFSR-09 meeting on 2020-01-17 by telephone

Electrical #4
- EMC

Status after TFSR-09:
Discussed and agreed

Question:

Does the LEDr cause EMC problems in the vehicle?

Answer:

No, the electronics design of the LEDr is made in such a way that no disturbance occurs; this is regulated in ECE R10 for all ESA in vehicles

CONSUMER / CUSTOMER REQUIREMENTs

PERFORMANCE REQUIREMENTS (IEC 60810)

SAFETY REQUIREMENTS (UN ECE R37 /RE5)

- LEDr shall comply with the technical requirements of an Electronic Sub Assembly (ESA) as specified in UNECE R10

Electrical #5
- Electrical robustness

Status after TFSR-09:
Discussed and agreed

Question:

Is the LEDr as robust against electrical disturbance as the filament lamp?

Answer:

Yes, the electronics of the LEDr should be designed so that it can withstand typical electrical overstress, e.g. reverse voltage

CONSUMER / CUSTOMER REQUIREMENTs

PERFORMANCE REQUIREMENTS (IEC 60810)

Electrical overstress tests are defined in IEC 60810 for all LED light sources

SAFETY REQUIREMENTS (UN ECE R37 /RE5)

Electrical #5A
- polarity

Question:

Does the LEDr need a specific polarity (+ / -)?

Answer:

The LEDr should either work with both polarities or should be designed to withstand a wrong polarity without damage

Status after TFSR-09: Newly introduced during the meeting. Discussed without conclusion

CONSUMER / CUSTOMER REQUIREMENTs

PERFORMANCE REQUIREMENTS (IEC 60810)

SAFETY REQUIREMENTS (UN ECE R37 /RE5)
- LEDr shall be tested with both polarities

Mechanical #1
- Vibration / Mass

Status after TFSR-09:
Discussed and agreed

Question:
Does the LEDr have the same mass as the filament lamp and is it as robust against vibration as the filament lamp?

Answer:
No, LEDr have typically a higher mass than a filament lamp,
but the mass of filament lamps is not regulated or standardised. A market survey can give guidance on the typical mass of the different categories.
For each cap-holder system a mass limit can be determined for which the system is designed.
The vibration resistance can be tested on the LEDr directly, using the same test method used to test the vibration resistance of filament lamps.

CONSUMER / CUSTOMER REQUIREMENTs

PERFORMANCE REQUIREMENTS (IEC 60810)

define for each LEDr category a maximum mass and test the vibration resistance

SAFETY REQUIREMENTS (UN ECE R37 /RE5)

Mechanical #2
- Maximum geometry

Status after TFSR-09:
Discussed and agreed

Question:
Does the LEDr have the same geometry / maximum outline as the filament lamp?

Answer:
Yes, the "burner-side" of the LEDr has the same maximum outline as the filament lamp to allow safe insertion into the luminaire.

For the "cap-side" of the LEDr there may be a somewhat larger specification
than the filament lamps (per category); this will be reflected in the installation instructions, which can be vehicle-specific.

CONSUMER / CUSTOMER REQUIREMENTs

PERFORMANCE REQUIREMENTS (IEC 60810)

SAFETY REQUIREMENTS (UN ECE R37 /RE5)

- Define maximum outline: cap-side
- Define maximum outline: burner-side

- In case the cap is bigger, provide to the consumer installation instructions (can be vehicle specific). These instructions shall be based on a real fitment-test on the vehicles.

Thermal #1
- 1min / 30 min ratio (hot-cold-ratio)

Question:

Could it happen that the LEDr has significantly higher intensity in the beginning (when switched on)?

Answer:

No, due to the proposed requirement, there is no significant effect, as the design of the LEDr is such that such excessive lumen-drop from 1 min to 30 min is be prevented.

Status after TFSR-09:
Discussed and agreed

CONSUMER / CUSTOMER REQUIREMENTs

PERFORMANCE REQUIREMENTS (IEC 60810)

SAFETY REQUIREMENTS (UN ECE R37 /RE5)

- Limit the deviation of the luminous flux values between 1 min and 30 min

Thermal #2
- High ambient temperature

Status after TFSR-09: Discussed without final conclusion

Question:

Could it happen that the LEDr has significantly reduced intensity when it is operated at high ambient temperature?

Answer:

LED-technology has a temperature-dependent behaviour. Additional tests are defined to ensure that there is no significant reduction of luminous flux.

The “real-world” temperatures show a function-, vehicle- and climate-specific statistical distribution. This statistical distribution is influenced by:

- Driving or stand-still
- Vehicle ambient air temperature and sun load
- Engine heating
- Light-source self-heating
- Heating by near-by light sources e.g. high wattage filament

CONSUMER / CUSTOMER REQUIREMENTs

PERFORMANCE REQUIREMENTS (IEC 60810)

SAFETY REQUIREMENTS (UN ECE R37 /RE5)

- define minimum luminous flux performance at a high ambient temperature

Statistical Distribution

Status after TFSR-09: Discussed without final conclusion

Amb Temp	Probability	Flux limit	
Temp1	Prob 1	Flux limit 1	
Temp2	Prob 2	Flux limit 2	
Temp3	Prob 3	Flux limit 3	

New for TFSR-10

- The topic „Thermal #2 high ambient temperature“ is discussed together with topic „Electrical #1 Voltage range“ , see slides above

INFO #2: Thermal situation of headlamps

New for TFSR-10

- Application conditions with respect to ambient temperature are subject to statistics
- Typical OEM temperature spectrum "Installation in engine compartment, but not on the engine" →

Temperature (°C)	Distribution (%)
-40°C	6%
23°C	20%
65°C	65%
115°C	8%
120°C	1%

- Headlamps have one side in the engine compartment, but the other side in the car environment *("outside air")*

- Low- and high-beam functions are safety-critical when driving at night, e.g. no sun-load *("T_{amb} ~15°C")*

<u>INFO #2</u>: Thermal situation of headlamp

New for TFSR-10

Translation of temperature spectrum to light source test

- Assumption: 1/3 of housing is exposed to the "outside air" T_{out} and 2/3 to the engine compartment T_{sp} *(i.e. impact of the engine side weighted by factor 2)*

$$T_{test} \approx 2/3 \cdot T_{sp} + 1/3 \cdot T_{out}$$

T_{sp}	Distribution	T_{test}	Proposed testing	Proposed criteria (e.g. H11)
-40°C	6%			
23°C	20%	~20°C *	Regular test (@23°C) after 30min	1350 lm ± 10%
65°C	65%	~48°C *	Additional test **@50°C** after 30min	**≥80%** of value @23°C
115°C	8%	~82°C *	Additional test **@80°C** after 30min	**≥60%** of value @23°C
120°C	1%	~85°C *		

* Based on T_{out}=15°C

intended H11 LEDr proposal

Thermal #2
- High ambient temperature

Question:

Could it happen that the LEDr has significantly reduced intensity when it is operated at high ambient temperature?

Answer:

LED-technology has a temperature-dependent behaviour. Additional tests are defined to ensure that there is no significant reduction of luminous flux.

The “real-world” temperatures show a function-, vehicle- and climate-specific statistical distribution.

CONSUMER / CUSTOMER REQUIREMENTs

PERFORMANCE REQUIREMENTS (IEC 60810)

SAFETY REQUIREMENTS (UN ECE R37 /RE5)

- define minimum luminous flux performance at a high ambient temperature
- Introduce a dedicated flux-temperature-dependency limit per category (i.e. in category sheets of R.E.5)
  - … to ensure same/better overall performance level in very most cases (e.g. H11: ≥80% @50°C)
  - … to ensure minimum functional safety in rare extreme cases (e.g. H11: ≥60% @80°C)

New for TFSR-10

Thermal #3A
- de-fogging

Status after TFSR-09: Discussed without final conclusion

Question:

Could the de-fogging behaviour of a luminaire be different when an LEDr is used?

Answer:

Yes, the de-fogging behaviour may be different (can become better or worse). It could change due to the different power consumption and energy balance of the LEDr; the consumer is informed about this.

CONSUMER / CUSTOMER REQUIREMENTs

PERFORMANCE REQUIREMENTS (IEC 60810)

SAFETY REQUIREMENTS (UN ECE R37 /RE5)

- require specific user information to be included on de-fogging, where the experience from tests is taken into account

Discussion during TFSR-09:

- „De-fogging“ is referring to avoiding or removing humidity accumulation inside the luminaire
- Temperature cycles with higher „Delta-T“ lead to higher „humidity pumping-effect“ and vice-versa
- There is no test method / requirement defined in UNECE today.
- No test method known in ISO or IEC
- Reference was made to FMVSS 108 and SAE test requirements

De-Fogging

New for TFSR-10

Comparison tests are planned based on SAE J575

Test 1: headlamp A* with halogen light source
Test 2: headlamp A* with LEDr

<u>SAE Test</u>
4.11 Humidity Test
This test determines the ability of the lamp to resist the accumulation of moisture within the lamp that could cause either physical defects to the lamp materials that might affect lamp beam performance or that could persist to affect the photometric performance of the lamp.
[….]

<u>Requirement</u>
5.11 Humidity
There shall be no visual evidence of moisture or condensation on active portions of reflectors and lens(es) on the interior of the device.

* target: a typical headlamp representative for European market

Thermal #3B
- de-icing

Question:

Could the de-icing behaviour of a luminaire be different when an LEDr is used?

Answer:

Yes, the de-icing / de-fogging behaviour may be different (can become better or worse). It could change due to the different power consumption and energy balance of the LEDr; the consumer is informed about this.

Status after TFSR-09:
Discussed without final conclusion

CONSUMER / CUSTOMER REQUIREMENTs

PERFORMANCE REQUIREMENTS (IEC 60810)

SAFETY REQUIREMENTS (UN ECE R37 /RE5)
- require specific user information to be included on de-icing

Discussion during TFSR-09:

- Term „de-icing“ not clearly defined; Is it removal of „frozen fog“ in the morning? Or is it removal of snow / ice during driving? Or …
- No test method defined in UNECE or IEC or ISO
- No test method defined in FMVSS or SAE
- Consequently no test conditions defined (ambient temperature, amount of „ice“, de-icing-time, criteria for being “ice-free”)
- Does this refer to all functions or only low beam?
- Noted that the driver is always responsible to keep vehicle and lighting functions in „clean“ state

Thermal #4

- cap-temperature

Question:

Could the lamp cap get hotter with an LEDr compared with a filament lamp and could this lead to damage of the material of the luminaire?

Answer:

No, a maximum power or temperature limit for the LEDr avoids this situation. So even though LEDr has less power consumption than the filament lamp, cap temperature is considered relevant.

Status after TFSR-09:
Discussed and agreed

CONSUMER / CUSTOMER REQUIREMENTs

PERFORMANCE REQUIREMENTS (IEC 60810)

SAFETY REQUIREMENTS (UN ECE R37 /RE5)

- either a maximum power limit shall be given for the LEDr or the maximum cap temperature shall be specified for each cap-holder system.

Summary of the proposal

Status after TFSR-09:
Discussed and agreed

LED replacement light source

CONSUMER / CUSTOMER REQUIREMENTs

PERFORMANCE REQUIREMENTS (IEC 60810)
Electrical
#5: Electrical robustness
Mechanical
#1: Vibration

SAFETY REQUIREMENTS (UN ECE)
Electrical
#1: voltage range
#2: PWM operation
#3: failure detection compatibility
#4: EMC
#5A: Polarity
Mechanical
#2: Geometry
Thermal
#1: hot-cold-ratio
#2: high ambient temperature
#3A: de-icing
#3B: de-fogging
#4: cap temperature
Colorimetric
#1,2: Spectral aspects