

Adaptive Front Lighting Systems (AFS)

Presentation to the 48th Session of GRE
(9-12 April 2002) Agenda items 1.2. and 4.2.

Contents

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| 1 Background | 5 Photometry |
| 2 Definitions | 6 Safety |
| 3 Functions / Modes | 7 Documentation & Approval |
| 4 The Appearance | |

Eureka Project EU 1403

Situations and Possible Modes

Adaptation modes				
	passing beam	main beam	DRL	Front fog
Country / normal / narrow road road shape surroundings speed / traffic density / traffic direction	x	x		
Motorway / wide road fast driving / motorized traffic only flat road without intersections special signs	x			
Town / lit road restricted speed high traffic density sidewalks / pedestrian	x			
Wet road glossy road surface precipitation	x			
Turns / bends of any road	x	x		
Daytime			x	
Fog				x

w203003

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The Program and the Milestones

1994 Phase I

Drivers /Traffic Needs - Improvement Potential
Possible Functions & Modes Definition - **Feasibility**
Initial Tests - Market Response

1997 Phase II

Field Studies
Scientific Support
Demonstration Lamps and Vehicles / Road Tests

1999 Phase III

Balocco and 44th GRE (Apr. 2000) **Presentation**
Requirements **Draft Specification**
Support to GTB's work for draft Regulation

w203002

AFS Acceptance and Market

Proposed Passing Beams, Customers Ranking

Yes, I need an improved Passing beam lighting for..	Study 1996 France, Italy, Sweden	Study 1995 Germany
Wet roads	rank 1	rank 1
Country roads	rank 2	rank 2
Bends	rank 3	} rank 3
Motorways	rank 4	
Town Situation	rank 5	(rank 4)

Comparison with other features/ values (1996)

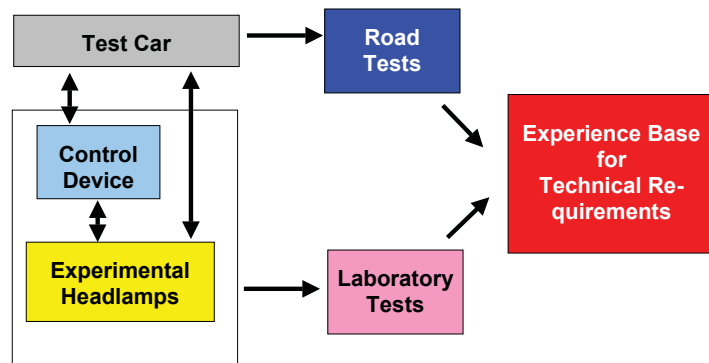
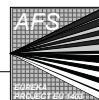
Adverse weather /wet road mode = as airbag (some 650 EUR option at that time)

Other AFS modes = as front fog lamps

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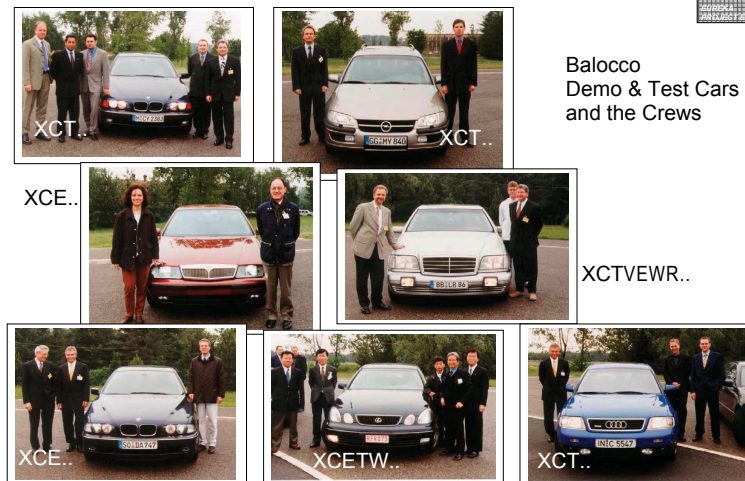
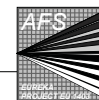
Phase II Test Activities



w203005

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Balocco Test Cars and Lamps



w203007

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AFS Presentation at Balocco (1999)



Project Presentation in the Premises of Fiat Lancia in Balocco (Italy)

Demo System Explanation at Daytime prior to the Tests



w203006

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44th GRE: AFS Presentation

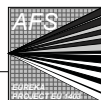


67. On 4 April, late in the evening after the session, a demonstration was given inside the premises of the Palais des Nations of a number of configurations of AFS installed on ten passenger cars (M1) of various types and makes. The GRE experts were provided the opportunity to drive these test vehicles. ...
68. Following the demonstration, all GRE experts acknowledged the experience with the new technology of front lighting, designed to improve the illumination and to adapt it to various driving situations, whilst reducing glare. ...

w203008

Eureka Project EU 1403

GTB - AFS Nov 2000 to Nov 2001



90th GTB

Paris 11/2000

Special Session Mandate

Special 1

First Check and Definition of Tasks

91st GTB

Rome 05/2001

Report, Additional Questions

Special 2

Main Discussion / Solutions

Light Source Module, R48 Amendment Structure, Photometry, Control, Language / Editorials

Special 3

Settlement of Open Points

92nd GTB

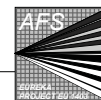
Kyoto 11/2001

GTB Release

w203009

AFS - Draft Regulation

System Definition



Adaptive front lighting system (AFS) means ..

- ▶ *..a lighting device, providing **two or more differing modes** for automatic adaptation of the beam characteristics to varying conditions of use*
- ▶ *of the **passing beam** and, if it applies, the **main beam** and/or the **day-time running light**;*
- ▶ *such systems consist of the **system control**, one or more **supply and operating device(s)**, if any, and the **installation units of the right and of the left side of the vehicle**.*

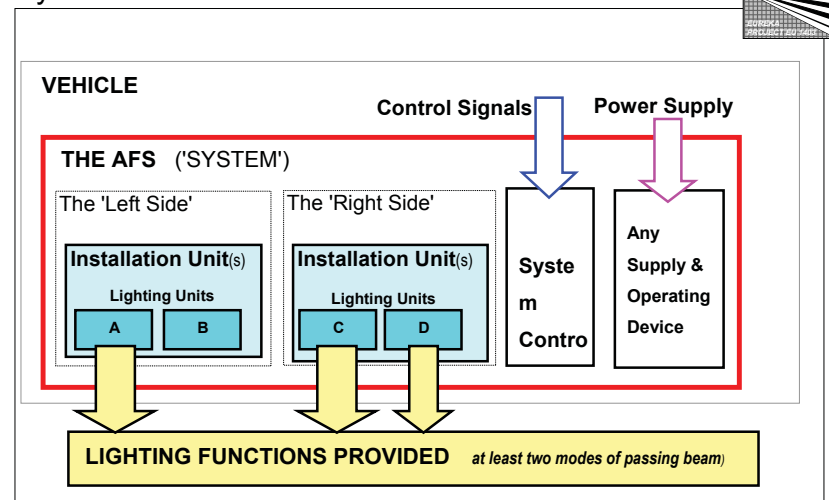
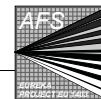
Para. 2.7.25 (AFS definition) of R.48 = scope of new Regulation on AFS

w203011

2 The Definitions

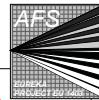
AFS - Draft Regulation

System Definition



w203012

AFS - Draft Regulation System Definition



Within the passing beam particular photometric provisions are defined..

..for the following classes

- (1) CLASS C (basic) passing beam
- (2) CLASS V (town) passing beam
- (3) CLASS E (motorway) passing beam
- (4) CLASS W (wet road) passing beam

and the 'BENDING MODES' of them.

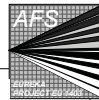
Within each class differing 'MODES' (including the one or more bending modes) can be provided.

w203013

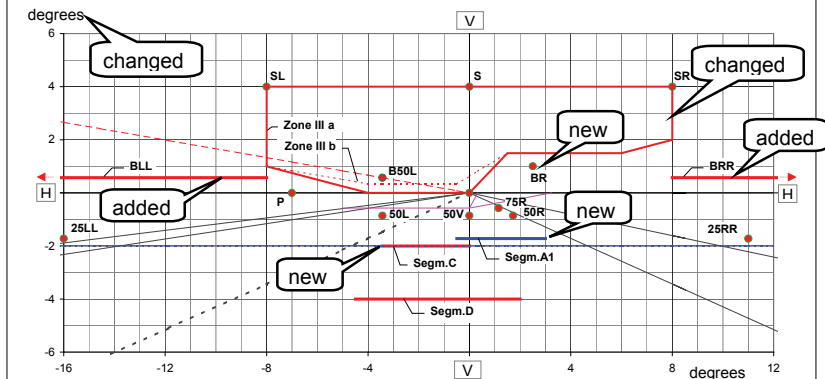
3 The Functions and Modes

3.1 General / The Class C (Basic) Passing Beam

Passing Beam Requirements Annex 3, Figure 1



New/changed elements, compared with R.112/R.98



w203015

Passing Beam Requirements Annex 3, Table 1



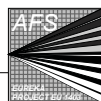
		Position /degrees		class C (basic) passing beam		class V (town) passing beam		class E (motorway) passing beam		class W (wet road) passing beam	
		horizontal	vertical	min	max	min	max	min	max	min	max
Part A	1	B50L	4/ L 3.43	U 0.57	0.4	0.7	0.4	0.7	0.7	0.7	0.7
	2	HV	4/ V								
	3	BR	4/ R 2.5	U 1	0.2	2	0.1	1	0.2	2	0.2
	4	Segment BRR	4/ R 8	R 20 U 0.57	4			4		4	6
	5	Segment BLL 4/ and above it	4/ L 8	L 20 U 0.57		0.7		1		1	1
	6	P	L 7	H	0.1					0.1	
	7	Zone III (as specified by Table 3 of			0.7		0.7		1		1
	8	S	V	U 4	0.1		0.1		0.1		0.1
	9	SL	L 8	U 4	0.05			0.05		0.05	
	10	SR	R 8	U 4	0.05			0.05		0.05	
	11	50 R	R 1.72	D 0.86		6					
	12	75 R	R 1.15	D 0.57	12		3	18		24	
	13	50 V	D 0.86		6			12		12	
	14	50L	L 3.43	D 0.86	4.2	25	2	25	8	8	35
	15	25LL	L 16	D 1.72	1.4		1	1.4		4	
	16	25RR	R 11	D 1.72	1.4		1	1.4		4	
	17	Segment C and below it	L 3.5 V	D 2			14	1	14	1	20
	18	Segment D (10m-Line) and below it	L 4.5 R 2.0	D 4			14	1	14	1	8
	19	E _{max} 3/			20	50	10	50	20	80	35
Part B	1	B50L	4/ L 3.43	U 0.57	0.6		0.6				
	2	HV	4/ V								
	7	Zone III (as specified by Table 3 of this annex)			1		1		1		1
	14	50L	L 3.43	D 0.86	2		1		4		4
	19	E _{max} 5/			12	50	6	50	12	90	24

(bend)

w203016

Passing Beam Requirements

Annex 3, Table 2



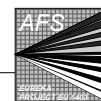
Emax and cut-off provisions

2	angular position / extend in degrees	Class C (basic) passing beam		Class V (town) passing beam		Class E (motorway) passing beam		Class W (wet road) passing beam	
		horiz.	vertical	horiz.	vertical	horiz.	vertical	horiz.	vertical
2-1	Emax shall not be positioned outside of the rectangle extending (above "Segment A1")	from H = 0,5L to 3R	from V = 0,3D to 1,72D		from V = 0,3D to 1,72D	from H = 0,5L to 3R	from V = 0,1D to 1,72D	from H = 0,5L to 3R	from V = 0,3D to 1,72D
2-2	the "cut-off" and part(s) of shall: - comply with the requirements of paragraph 1. of Annex 9 to this Regulation and be positioned with its "kink" at H = 0 and - be positioned with its "straight horizontal part"								
			at V = 0,57 D		not above 0,57D and not below 1,3D		not above 0,23D and not below 0,57D		not above 0,23D and not below 0,57D

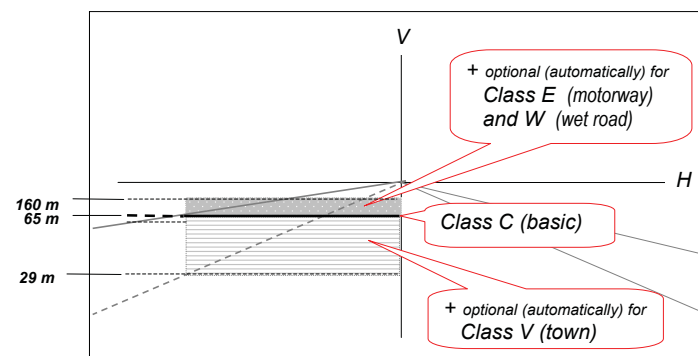
w203017

Passing Beam Requirements

Annex 3 Table 2.2.



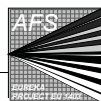
Optional left side cut-off position



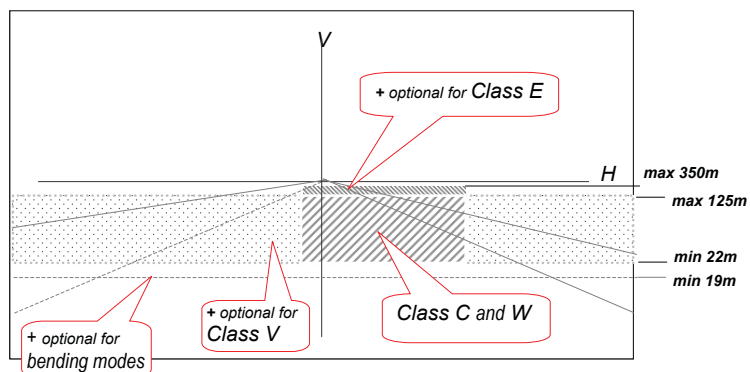
w203019

Passing Beam Requirements

Annex 3 Table 2.1.



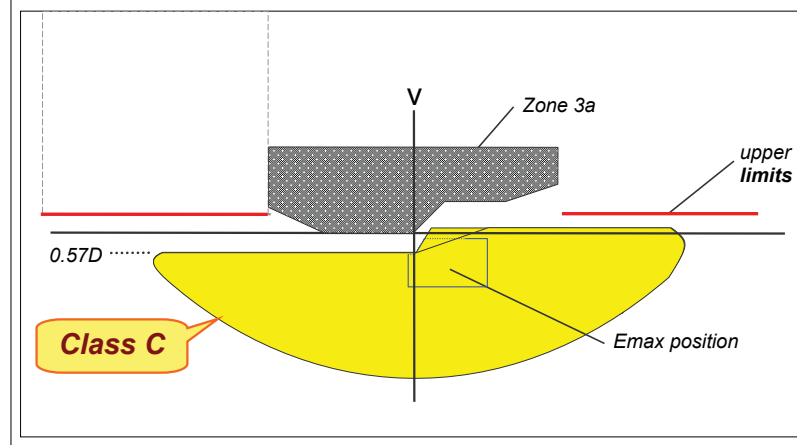
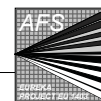
Optional beam Emax position



w203018

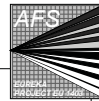
Class C (basic) Passing Beam

The Beam Pattern, Schematically on Screen



w203020

Class C (basic) Passing Beam The Automatic Activation



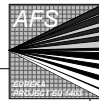
When the passing beam is switched on:

The class C (basic) passing beam:

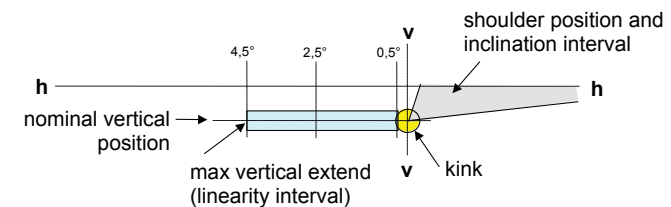
- ▶ **must be emitted**
 - when none of the signals (E-, V-, W-) is present
 - in case of adjustment of the system or parts of (means required)
- ▶ **may be emitted**
 - at any time,
 - in case of failure of any other passing beam mode
- ▶ **is allowed be modified** within the range of requirements and according to the system description, due to the presence of the T-signal and /or any additional specified signal (e.g. indicating that a certain speed threshold is exceeded)

w203021

Passing Beam Provisions Cut-Off Definitions (2)

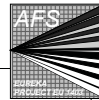


"Cut-Off" Adjustment

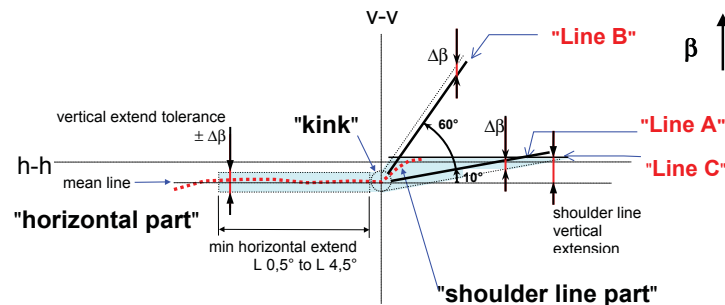


w203023

Passing Beam Provisions Cut-Off Definitions (1)



Shape of the "cut-off" line

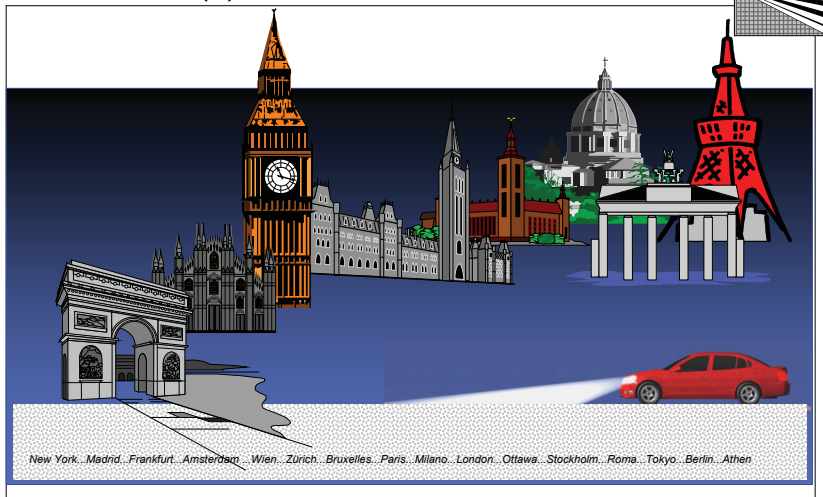


w203022

3.2 The Class V (Town) Passing Beam

Class V (town) Passing Beam

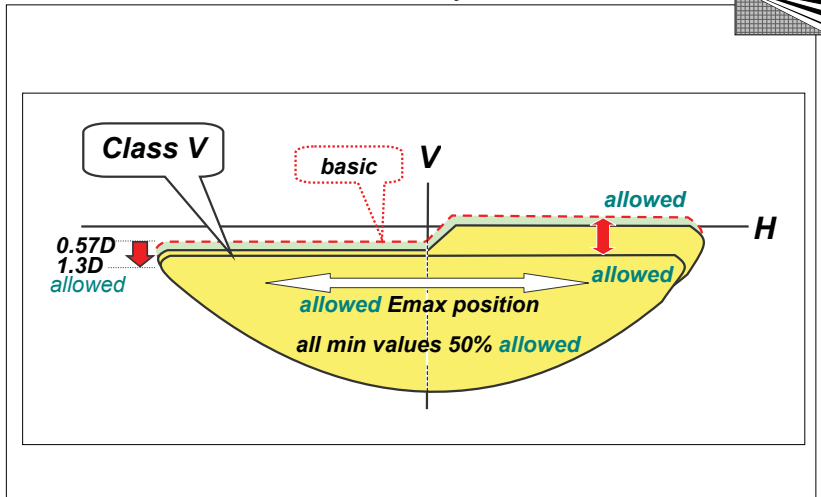
The Situation (1)



w203025

Class V (town) Passing Beam

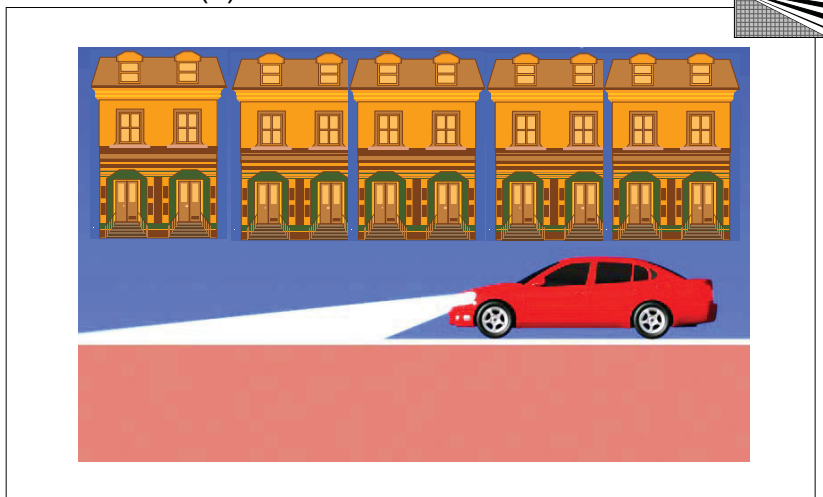
The Beam Pattern, Schematically on Screen



w203027

Class V (town) Passing Beam

The Situation (2)



w203026

Class V (town) Passing Beam

The Automatic Activation

When the passing beam is switched on:

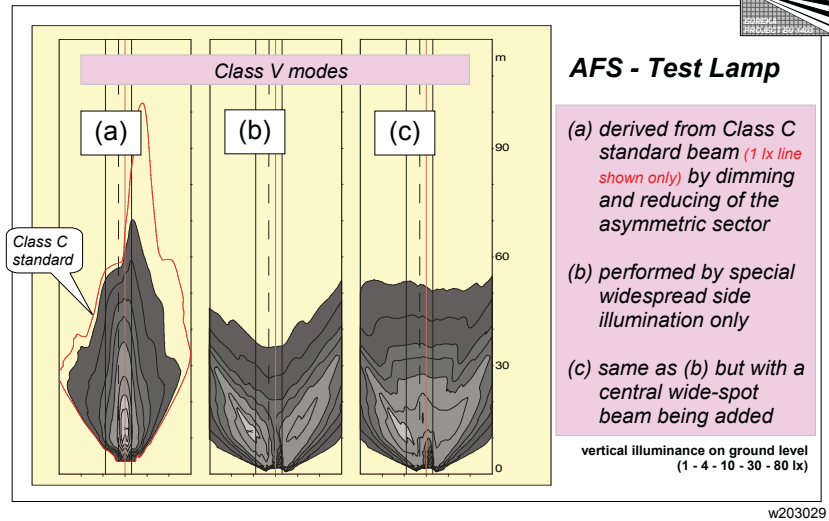
The class V (town) passing beam may be emitted if the vehicle generates the "V- signal".

*This is allowed to be generated only:
if the vehicle's speed does not exceed 60 km/h;
notwithstanding the smart application of any light sensors,
camera devices, localization sensors, telemetry systems, or
others;*

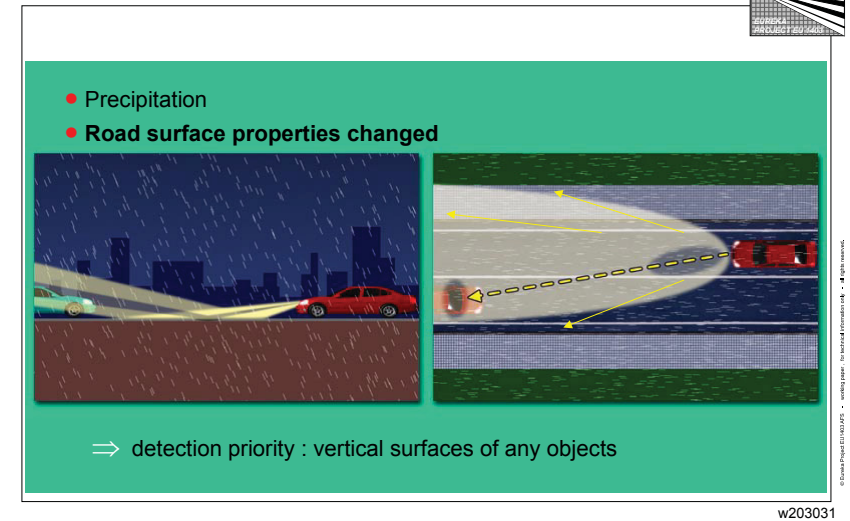
*it is not allowed to be generated at >60km/h
the car's lighting - even if not needed - has the priority
for redundancy reasons*

w203028

AFS Passing Beams (Examples) Bird's Eye View Comparison

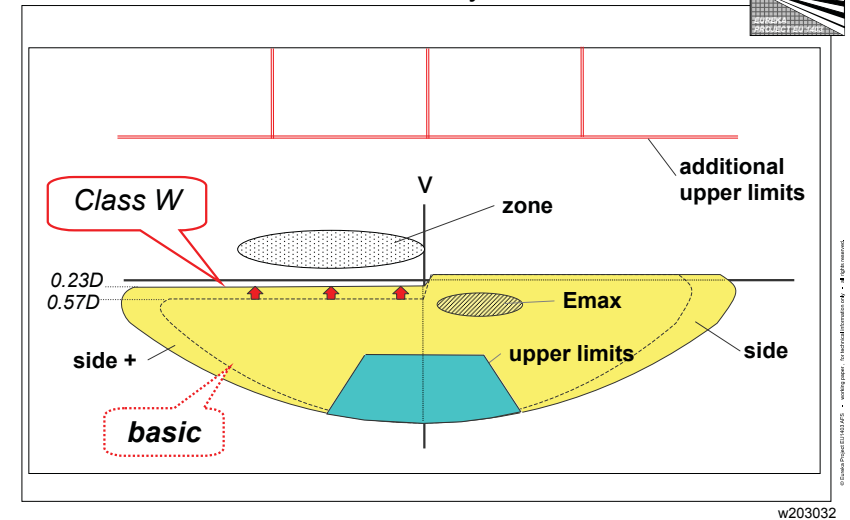


Class W (wet road) Passing Beam The Situation

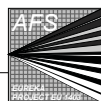


3.3 The Class W (Wet Road) Passing Beam

Class W (wet road) Passing Beam The Beam Pattern, Schematically on Screen



Class W (wet road) Passing Beam The Automatic Activation



When the passing beam is switched on:

The class W (wet-road) passing beam may be emitted, if the vehicle generates the "W-signal".

This is allowed to be generated only:

a) in general

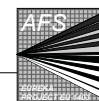
- if wet road and/or rain or snowfall is detected and
- the front fog lamp (if any) is not switched on

b) especially

- windshield wiper has operated for ≥ 2 min, and/or
- road wetness is automatically detected by any special means

w203033

Class W (wet road) Passing Beam Functionality – Requirements on the 25m Screen

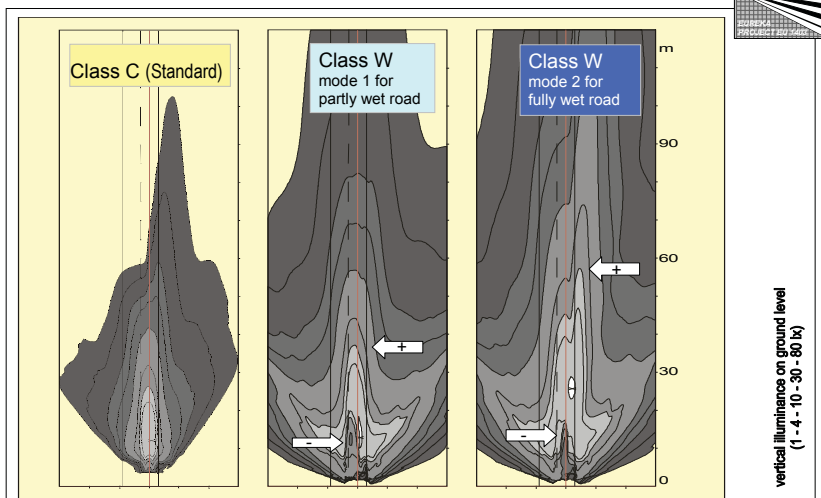
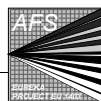


Passing beam requirements comparison

<u>lx @25m</u>	Class W grade 2 fully wet road	grade 1 partly wet road	Class C any type of road
E_{max} (fixed position area, including 50R and 75R)	≤ 100	≤ 80	≤ 50
foreground segment D (10m)	≤ 4	≤ 8 lx	≤ 18
segment C (20m)	≤ 10	≤ 20 lx	(no req.)
road curb minimum illumination 25RR/LL	≥ 4	≥ 4	$\geq 1,4$
direct illuminance values B50L, BR, BRR	$\leq 0,7..5$	$\leq 0,7..5$	$\leq 0,4..2$

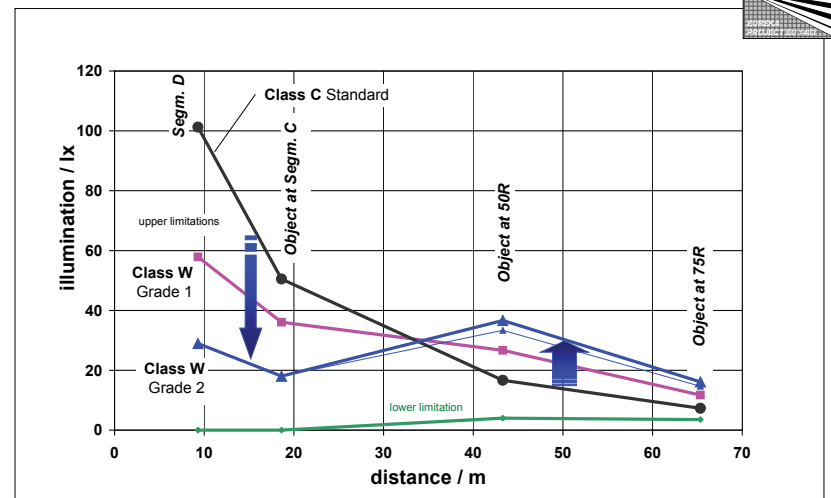
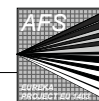
w203035

AFS Passing Beams (Examples) Bird's Eye View Comparison



w203034

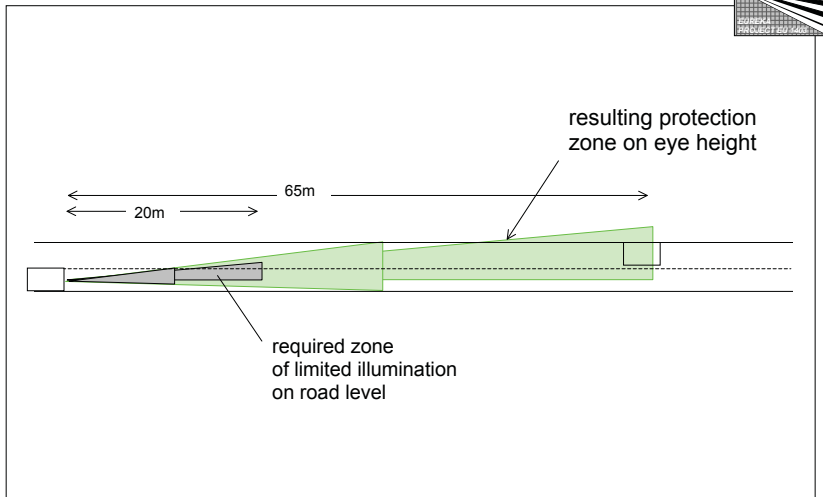
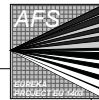
Class W (wet road) Passing Beam Functionality - Illumination of Objects on the Road



w203036

Class W (wet road) Passing Beam

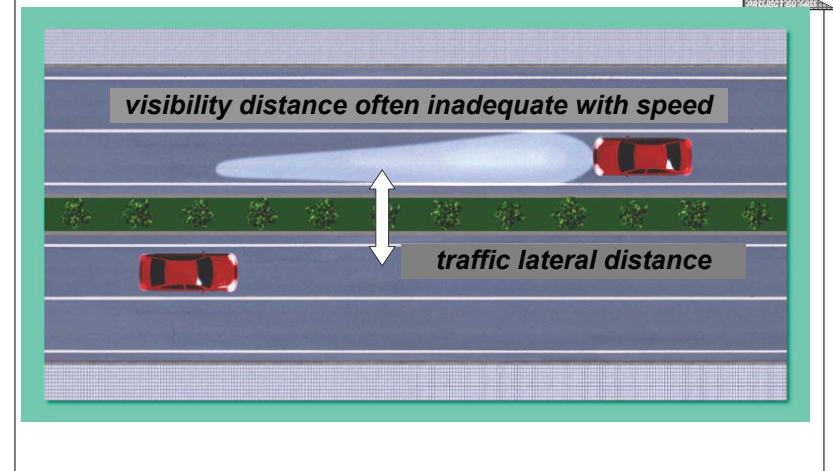
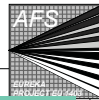
Functionality – Reflex Glare Reduction Zone



w203037

Class E (motorway) Passing Beam

The Situation



w203039

3.4 The Class E (Motorway) Passing Beam

Class E (motorway) Passing Beam

The Situation - Background



1968 Agreement

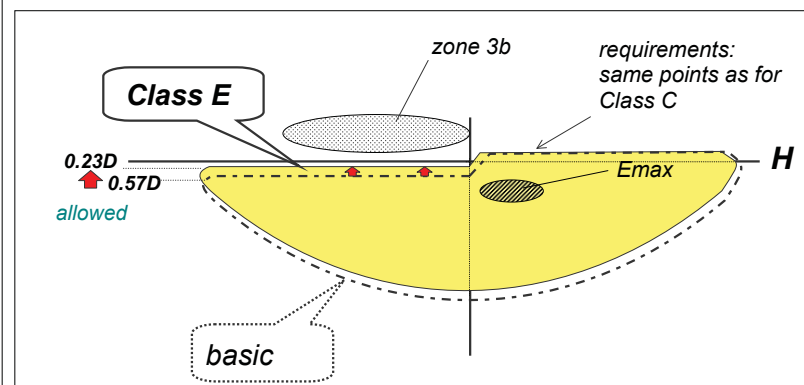
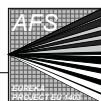
Definition of a Motorway:

- (j) "Motorway" means a road specially designed and built for motor traffic, which does not serve properties bordering on it, and which:
 - (i) Is provided, except at special points or temporarily, with separate carriageways for the two directions of traffic, separated from each other either by a dividing strip not intended for traffic or, exceptionally, by other means;
 - (ii) Does not cross at level with any road, railway or tramway track, or footpath; and
 - (iii) Is specially signposted as a motorway.

w203040

Class E (motorway) Passing Beam

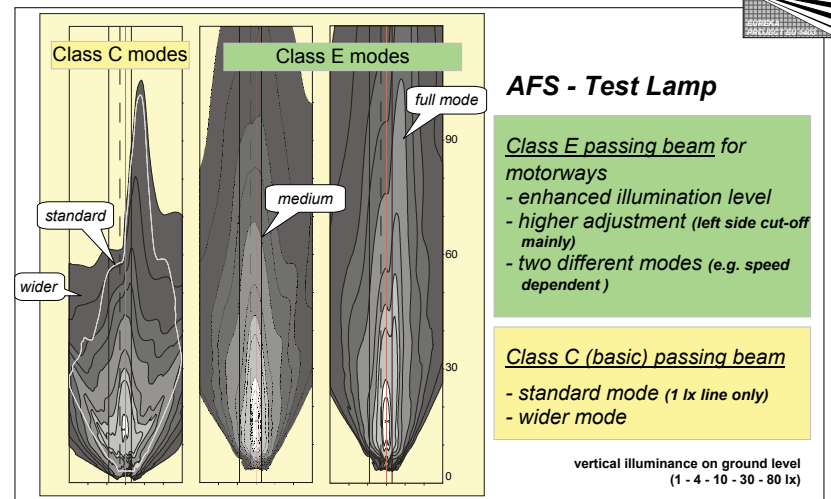
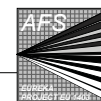
The Beam Pattern, Schematically on Screen



w203041

AFS Passing Beams (Examples)

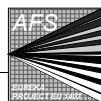
Bird's Eye View Comparison



w203043

Class E (motorway) Passing Beam

The Automatic Activation



When the passing beam is switched on:

The class E (motorway) passing beam may be emitted, if the vehicle generates the "E-signal".

This is allowed to be generated only:

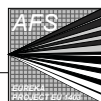
if the road characteristics correspond to motorway conditions;

it is not allowed to be generated if the vehicle speed is less than 60km/h

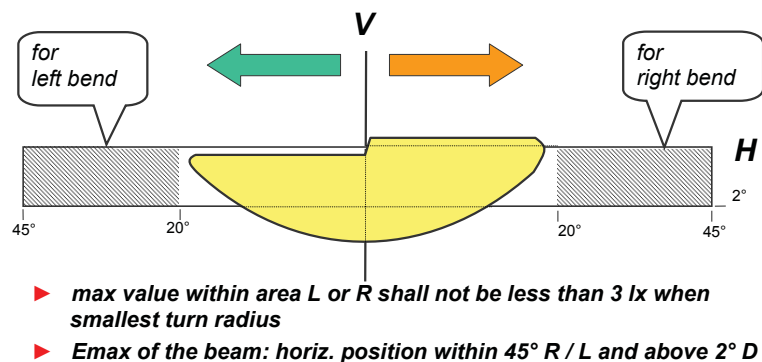
w203042

3.5 The Passing Beam Bending Modes

Passing Beam Bending Modes Additional Photometric Provisions

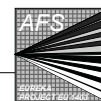


Bending Modes (on Screen, schematically)



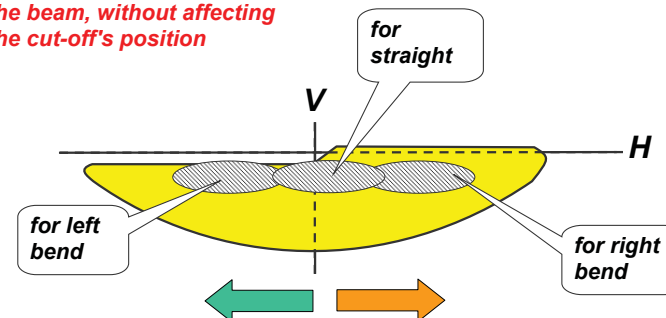
w203045

Passing Beam Bending Modes Categories Definition



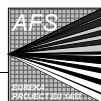
Bending Modes <Category 2> (on Screen, schematically)

moved or added parts of the beam, without affecting the cut-off's position

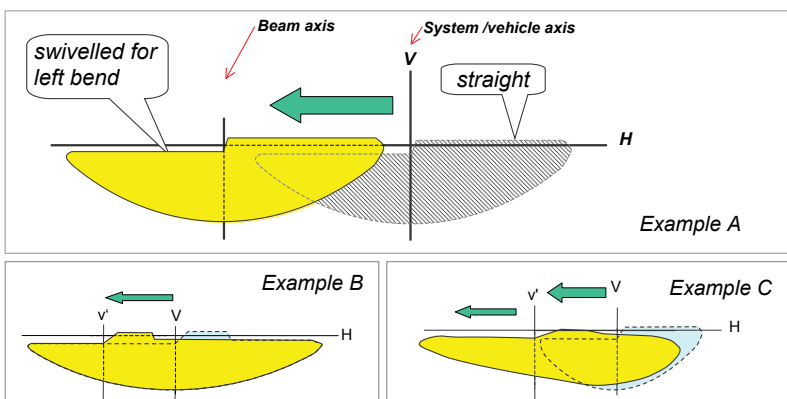


w203047

Passing Beam Bending Modes Categories Definition

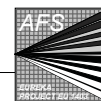


Bending Modes <Category 1> (on Screen, schematically)



w203046

Passing Beam Bending Modes The Automatic Activation



When the passing beam is switched on:

The bending mode of a passing beam may be emitted if the vehicle generates the "T- signal".

This is allowed to be generated only:

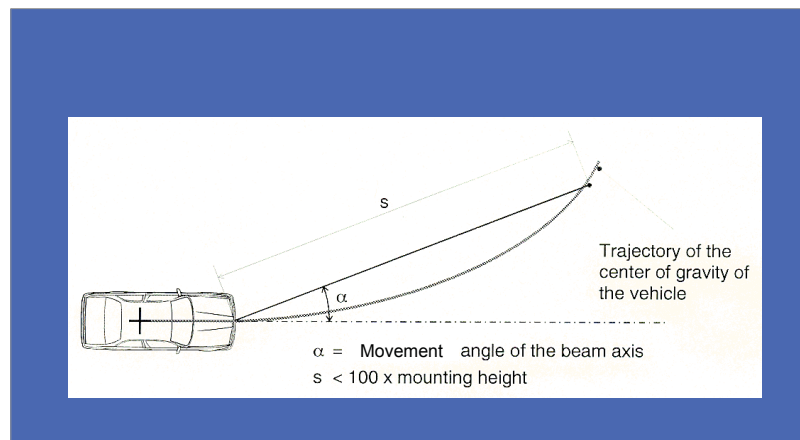
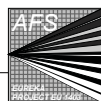
in / for curves or during / for cornering at intersections.

In Addition:

- the activation of additional unit(s) is only permitted if the turn radius is 500 m or less
- the activation of a category 1 bending mode is only permitted during forward motion of the vehicle except for turn to the side of traffic direction and S shall not exceed 100 x h (for the definitions see the following figure)

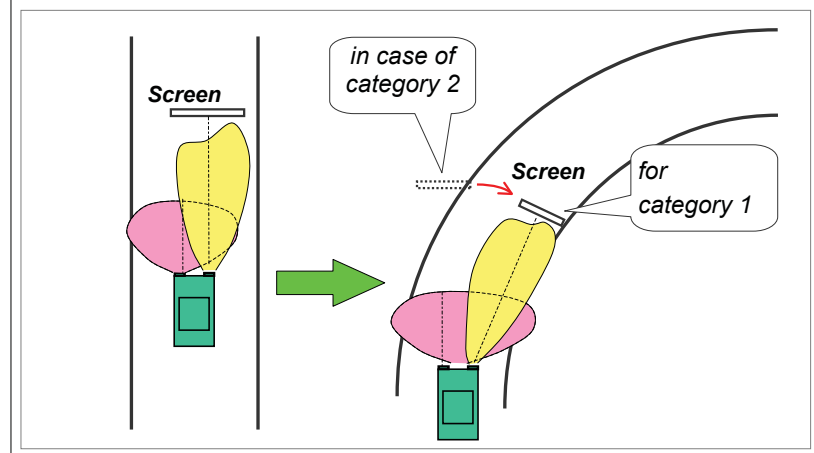
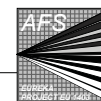
w203048

Passing Beam Bending Modes The Automatic Activation



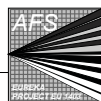
w203049

Passing Beam Bending Modes Category Dependent Photometry

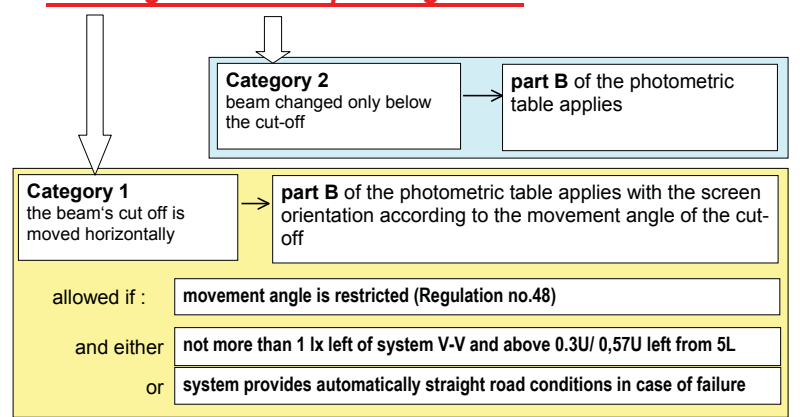


w203051

Passing Beam Bending Modes Categories, Survey



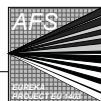
Bending modes of a passing beam



w203050

3.6 The Main Beam and DRL Provisions

Main Beam New / Changed Items



New

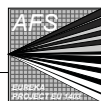
- ▶ *number of lighting units per side not restricted*
- ▶ *swivelling of any lighting unit allowed* (test provisions corresponding to those for passing beam categories)
- ▶ *automatic beam modifications allowed* (to specified/ tested)

unchanged (compared with R.112 / R.98)

- *photometry provisions* (however system based instead for individual lamps)
- *reference figures system and relevant limitations*
- *time conditions* (as R.98)
- *activation of the main beam* (switching on /off)

w203053

Daytime Running Light (DRL) New / Changed Items



New

- ▶ *more than one lighting unit per side allowed* (each of them must comply)
- ▶ *photometry maximum requirements combined with that of a basic passing beam*
- ▶ *automatic beam modifications allowed, including swivelling*

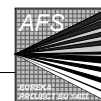
unchanged (compared with R.87)

- *photometry minimum requirements*
- *the activation of the DRL* (switching on/off)

w203054

4 The Appearance

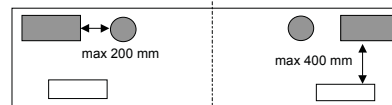
The Appearance Installation Provisions (1)



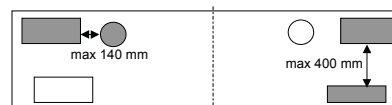
Vehicle's front view, illuminating surfaces, schematically



two symmetrically placed lighting units



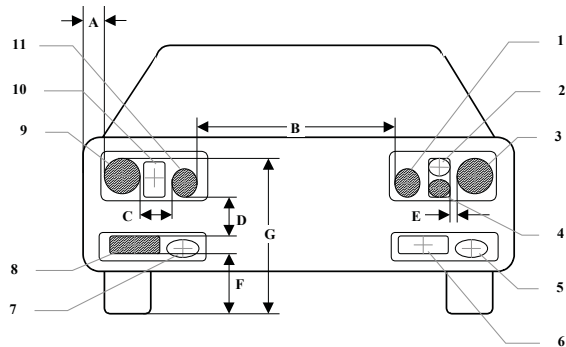
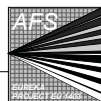
more than two symmetrically placed lighting units, if intended to be used symmetrically



more than two symmetrically placed lighting units, if intended to be lit in an asymmetrical configuration

w203056

The Appearance Installation Provisions (2)



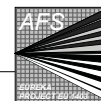
Dimensions in mm:

A = 400
B = 600 (400)
C = 200
E = 140
D = 400
F = 250
G = 1500

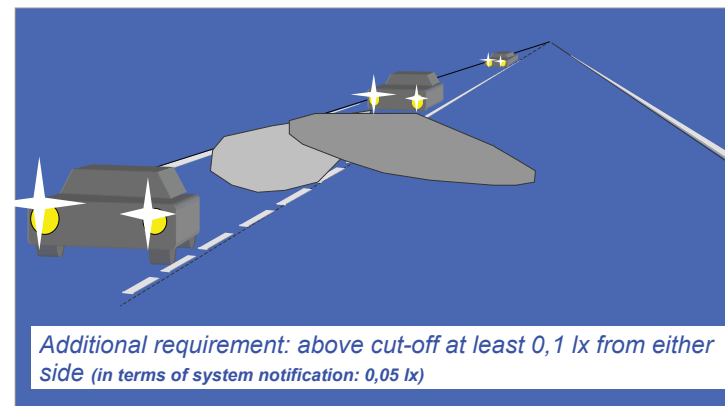
Simultaneously energized for a given lighting function:
two symmetrically placed lighting units No. 3 and 9
two additional lighting units No. 4 and 8
two additional symmetrically placed units No. 1 and 11

w203057

The Appearance The Right-Left Symmetry

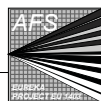


Oncoming vehicle, drivers view (schematically)

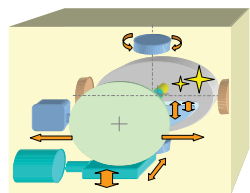


w203059

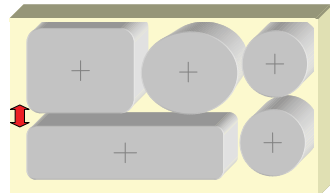
The Appearance Adaptability – Necessary Means



A *Variable Lighting Unit*



B *Multiple Lighting Units*



C

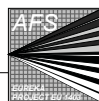
→ *any combination
of A and B* ←

w203058

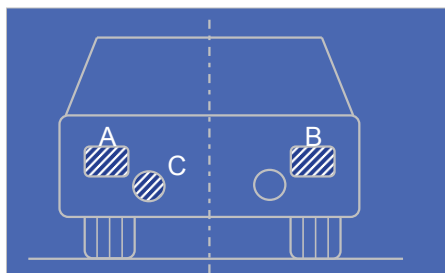
5 The Photometry

Photometry

Individual Contributions by the Lighting Units



Photometric requirements per vehicle



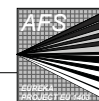
Lighting units may be differently "specialized" each to perform an individual lighting task producing in total one common illumination of the road

$\frac{1}{2}$ [Measured illumination values A + B + C]

w203061

Photometry

Different Light Sources



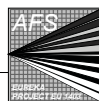
Measurements and conversion of results

Light source	Operation of the lighting unit	Factor
replaceable, accord. R37	with étalon light source at standard luminous flux	1
Any other	with its own light source and supply / operating device (if any) at vehicle voltage (13,5 V for 12 V system, e.g.)	0,7

w203063

Photometry

Light Sources Provisions



Light source	A Mechanical status		B Power control status		
	being exchangeable	being part of a 'light source module'	voltage from the vehicle's electrical system		specified separately -by a 'supply and operating device'-
R.37	Standard	☒	-directly-	☒ *	☒ *
R.99		☒	--	--	☒ *
not being type approved**	not allowed	☒	☒ *	☒ *	☒ *

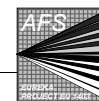
** requirements corresponding to R.99 and relevant information, identification, marking, etc.

* to be measured @13,5V (e.g., in the case of a 12 V system)

w203062

Photometry

Non-Approved Light Sources

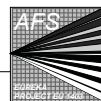


Supplementary Provisions

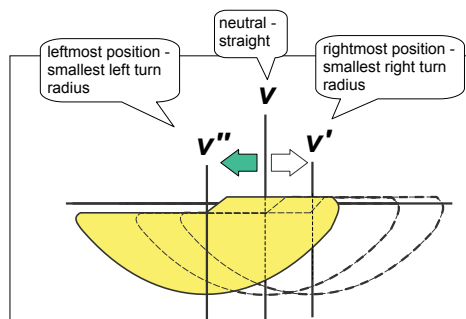
- ▶ Non-replaceable / as part of a light source module, only
- ▶ Annex 8: additional requirements and test specifications
 - ⇒ bulb and fixation performance
 - ⇒ dimensions and positioning compliance / data sheet
 - ⇒ starting, run-up and hot-restrike (from R.99)
 - ⇒ minimum red content (from R.99)
 - ⇒ UV-radiation Test etc. (from R.99)

w203064

Photometry Bending Modes Testing



Test positions

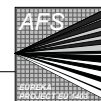


- ▶ extreme positions
- ▶ visual check and decision about tests in intermediate positions

- ▶ in case of category 1 or main beam: horizontal re-aim by means of the goniometer before testing

w203065

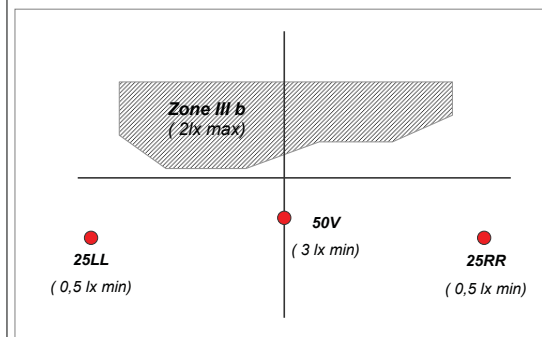
Safety Provisions Fail Safe Requirements



In case of failure:

(1) General provisions

- ▶ tell tale operation
- ▶ illumination values ..



..to be obtained automatically

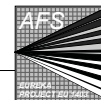
(a) by means within the AFS and/or

(b) by means of a substitute lighting function

w203067

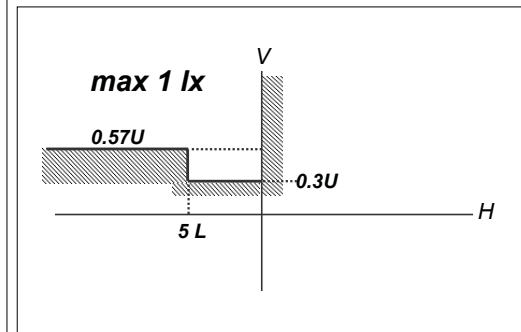
6 The Safety Provisions

Safety Provisions Fail Safe Requirements



In case of failure:

(2) Additional provisions for category 1 bending modes



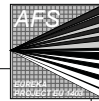
either
(a) being so designed that in no case 1 lx is exceeded above the line $0,3^\circ / 0,57^\circ$ (see graph)

or/ and
(b) to obtain automatically a non-bending mode

w203068

Safety Provisions

Cleaning and Levelling (1)



Automatic levelling and cleaning requirements

The use of lighting units providing a cut-off which projects into the area of 8 L to 8 R and above 0,9 D is confined to vehicles that provide headlamp cleaner and automatic headlamp levelling devices, if:

from all such lighting units on a side of the vehicle

(a) the combined objective luminous flux exceeds 2000 lm and

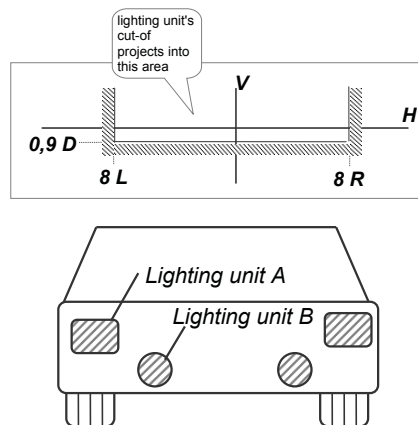
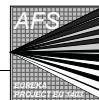
(b) the combined light output in terms of luminous flux within its isolux of 0,5 lx exceeds 650 lm

To be indicated in the type approval documents

w203069

Safety Provisions

Cleaning and Levelling (2)



Example

► Design values [lighting units A + B]

**if the sum exceeds
2000 lm light sources
objective luminous flux
and 650 lm units output**

**then devices for
cleaning and automatic
levelling for these
lighting units required**

w203070

7 Documentation & Approval

Application for Approval Documentation



Additional documentation

- **Description of the system**
 - lighting functions provided
 - modes of these lighting functions
 - the lighting units providing each of them
 - control signals relevant to each mode
 - the passing beam classes being provided
 - cut-off characteristics
 - adjustment means and specific procedures, if any
- **Safety concept**

w203072

AFS
TEOREKA
PRODUKSI NO 4402

***..lamps providing separate functions
being grouped, combined or
reciprocally incorporated to an AFS***

R.07 Front Position Lamp
R.19 Front Fog Lamp***
R.87 Daytime Running Lamp
R.98 Driving Beam
R.112 Driving Beam

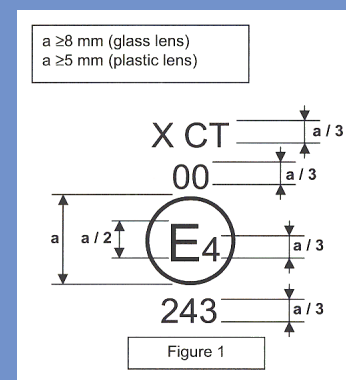
- ▶ **To be indicated in the Application, including details of intended use as functional substitution, if any**
- ▶ **AFS designed operation must not impair the lamp's compliance**
- ▶ **Contribution to AFS (to be specified) only if not used in its separate 'original' function**

*** Front fog lamp subjected to adjustment prescriptions in that case

w203073

AFS
EUREKA
PROJECT 50

<i>Passing beam (class, mode)</i>	<i>Marking</i>
<i>AFS</i>	X
<i>Class C (basic)</i>	C
<i>Class V (town)</i>	V
<i>Class E (motorway)</i>	E
<i>Class W (wet road)</i>	W
<i>Bend modes</i>	...«T



w203075

AFS
PROJECT 20-500

BUZUNGA
PROJEKTOWA I WYKONAWCZA

AFS Specification (Lighting hardware, classes of passing beams / modes and the lighting units designed to provide R

Fast lighting hardware	CONE / MODE	provided in accordance with the lighting unit No.									
		5, 7, 9									
1) passing beam	2) DIAL	3) Beam	4) Beam	5) Beam	6) Beam	7) Beam	8) Beam	9) Beam	10) Beam	11) Beam	12) Beam
	13) Beam	14) Beam	15) Beam	16) Beam	17) Beam	18) Beam	19) Beam	20) Beam	21) Beam	22) Beam	23) Beam
	24) Beam	25) Beam	26) Beam	27) Beam	28) Beam	29) Beam	30) Beam	31) Beam	32) Beam	33) Beam	34) Beam
	35) Beam	36) Beam	37) Beam	38) Beam	39) Beam	40) Beam	41) Beam	42) Beam	43) Beam	44) Beam	45) Beam
	46) Beam	47) Beam	48) Beam	49) Beam	50) Beam	51) Beam	52) Beam	53) Beam	54) Beam	55) Beam	56) Beam
	57) Beam	58) Beam	59) Beam	60) Beam	61) Beam	62) Beam	63) Beam	64) Beam	65) Beam	66) Beam	67) Beam
	68) Beam	69) Beam	70) Beam	71) Beam	72) Beam	73) Beam	74) Beam	75) Beam	76) Beam	77) Beam	78) Beam
	79) Beam	80) Beam	81) Beam	82) Beam	83) Beam	84) Beam	85) Beam	86) Beam	87) Beam	88) Beam	89) Beam
	90) Beam	91) Beam	92) Beam	93) Beam	94) Beam	95) Beam	96) Beam	97) Beam	98) Beam	99) Beam	100) Beam
	101) Beam	102) Beam	103) Beam	104) Beam	105) Beam	106) Beam	107) Beam	108) Beam	109) Beam	110) Beam	111) Beam
12) main beam	13) Beam	14) Beam	15) Beam	16) Beam	17) Beam	18) Beam	19) Beam	20) Beam	21) Beam	22) Beam	23) Beam
14) main beam	15) Beam	16) Beam	17) Beam	18) Beam	19) Beam	20) Beam	21) Beam	22) Beam	23) Beam	24) Beam	25) Beam
15) main beam	16) Beam	17) Beam	18) Beam	19) Beam	20) Beam	21) Beam	22) Beam	23) Beam	24) Beam	25) Beam	26) Beam
16) main beam	17) Beam	18) Beam	19) Beam	20) Beam	21) Beam	22) Beam	23) Beam	24) Beam	25) Beam	26) Beam	27) Beam
17) main beam	18) Beam	19) Beam	20) Beam	21) Beam	22) Beam	23) Beam	24) Beam	25) Beam	26) Beam	27) Beam	28) Beam
18) main beam	19) Beam	20) Beam	21) Beam	22) Beam	23) Beam	24) Beam	25) Beam	26) Beam	27) Beam	28) Beam	29) Beam
19) main beam	20) Beam	21) Beam	22) Beam	23) Beam	24) Beam	25) Beam	26) Beam	27) Beam	28) Beam	29) Beam	30) Beam
20) main beam	21) Beam	22) Beam	23) Beam	24) Beam	25) Beam	26) Beam	27) Beam	28) Beam	29) Beam	30) Beam	31) Beam
21) main beam	22) Beam	23) Beam	24) Beam	25) Beam	26) Beam	27) Beam	28) Beam	29) Beam	30) Beam	31) Beam	32) Beam
22) main beam	23) Beam	24) Beam	25) Beam	26) Beam	27) Beam	28) Beam	29) Beam	30) Beam	31) Beam	32) Beam	33) Beam
23) main beam	24) Beam	25) Beam	26) Beam	27) Beam	28) Beam	29) Beam	30) Beam	31) Beam	32) Beam	33) Beam	34) Beam
24) main beam	25) Beam	26) Beam	27) Beam	28) Beam	29) Beam	30) Beam	31) Beam	32) Beam	33) Beam	34) Beam	35) Beam
25) main beam	26) Beam	27) Beam	28) Beam	29) Beam	30) Beam	31) Beam	32) Beam	33) Beam	34) Beam	35) Beam	36) Beam
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27) main beam	28) Beam	29) Beam	30) Beam	31) Beam	32) Beam	33) Beam	34) Beam	35) Beam	36) Beam	37) Beam	38) Beam
28) main beam	29) Beam	30) Beam	31) Beam	32) Beam	33) Beam	34) Beam	35) Beam	36) Beam	37) Beam	38) Beam	39) Beam
29) main beam	30) Beam	31) Beam	32) Beam	33) Beam	34) Beam	35) Beam	36) Beam	37) Beam	38) Beam	39) Beam	40) Beam
30) main beam	31) Beam	32) Beam	33) Beam	34) Beam	35) Beam	36) Beam	37) Beam	38) Beam	39) Beam	40) Beam	41) Beam
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33) main beam	34) Beam	35) Beam	36) Beam	37) Beam	38) Beam	39) Beam	40) Beam	41) Beam	42) Beam	43) Beam	44) Beam
34) main beam	35) Beam	36) Beam	37) Beam	38) Beam	39) Beam	40) Beam	41) Beam	42) Beam	43) Beam	44) Beam	45) Beam
35) main beam											

w203074