

DIRT DEPOSITS' INFLUENCE ON LUMINOUS FLUX DISTRIBUTION OF PASSING LIGHTS

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Abstract

In each discipline of lighting technology where light has influence on the users' health and safety, for the use of lighting devices, the so called, maintenance systems was established. Based on the accepted algorithms, among the others, intervals of light sources replacement and cleaning of luminaries are determined. The subject of the influence of headlamps dust deposits' on their photometric parameters is very rarely tackled in the vehicle lighting technology. Probably the reason for this is the assumption that a driver will control visually lighting condition of his vehicle. Unfortunately, in practice this assumption is not met usually. Only a few vehicle models are equipped with headlamp washers or wipers. During normal service life of the vehicle the lenses of headlamps are cleaned occasionally, mostly during the vehicle washing, or sometimes after noticing heavy dirt deposits. However, internal surfaces of headlamp are not cleaned at all. Paradoxically, in the winter, when it gets dark earlier and headlamps' light is used for a longer periods, the vehicle cleaning is more rare, because of very low temperatures. The article present examples of measurement results of dirt deposits' influence on illuminance distribution changes on the road surface (on measuring screen) of headlamp equipped with halogen bulb and discharge light source. The concept of solving headlamp lens maintenance problem by using lens soiling detector, is also illustrated.

Keywords: *passing lights, illuminance, soiling detector, dirt deposits, photometry*

1. Introduction

Passing lights in vehicle headlamps serve two opposite purposes: on one hand they should ensure the best road illumination, and on the other they should not dazzle oncoming drivers. To obtain proper luminous flux distribution, it is important to get the clear cut-off line and proper headlamp leveling. Dirt deposits' on headlamp reflector and lens cause the decrease of luminous flux emitted on the road surface, in which combined with the light diffusing effect (blurring of the cut-off line) significantly worsens the quality of road illumination and causes dazzling of the other traffic users.

2. Photometrical tests of passing lights

To analyze headlamp lens dirt deposits influence on its photometrical parameters a series of illuminance measurements on screen, placed at the distance of 25m, according to normative

documents, was made [4, 5]. Measurements were carried out with the aid of matrix luminance meter Illuminator 2.0 [3]. The Illuminator makes possible quasi-continuous measurement of tested surface luminance. Because of measuring screen's surface reflected the light in diffused and no selective way, it was possible to recalculate measured luminance values to illuminance. Tests were carried out for approved headlamp equipped with D2S 13.5V gas discharge light source and approved headlamp equipped with H4 13,5V filament lamp, for few chosen degree of dirt deposit's (10%, 25%, 50%, 75%, 90%) and for dry and wet dirt conditions. Dirt degree was determined by measurement of lens transmission factor (for instance 10% dirt degree is equivalent of 90% transmission factor). As a dirt factor, a standard European dirt was used, prepared according to recipe used during headlamps approval tests [4, 5]. Measurements of illumination values were made in points and zones analyzed during approval tests, including manufacturing deviations (values in brackets). Measurements results are presented in Tab. 1-4 (values not meeting the requirements are marked by bold type) and on Fig. 1-6.

Tab. 1. Measurements results of illuminance in function of dry dirt on the lens for headlamp with D2S light source

Point or zone on measuring screen	Illuminance [lx]						
	Reg. No 98 requirement	Lens dirt degree [%]					
		0	10	25	50	70	90
On and above lineH/H3/H4	≤ 1 (1.3)	1.33	2.40	2.65	2.73	2.15	0.84
HV	≤ 1 (1.2)	1.18	2.57	2.8	2.86	2.22	0.85
B50L	≤ 0,5 (0.7)	0.55	1.46	1.74	1.98	1.64	0.71
75R	≥ 20 (16)	34.91	24.45	20.53	10.49	5.39	1.17
50L	≤ 20 (24)	21.86	14.85	12.73	6.94	3.75	0.96
25L1	≤ 30 (36)	20.96	14.97	12.87	7.21	3.84	1.00
50V	≥ 12 (9.6)	28.74	19.77	16.83	8.82	4.68	1.10
50R	≥ 20 (16)	33.57	22.92	19.16	9.94	5.23	1.19
25L2	≥ 4 (3.2)	17.62	13.22	10.78	6.16	3.27	0.96
25R1	≥ 4 (3.2)	18.35	11.32	9.62	5.68	3.00	0.9
Segment I	≥ 6 (7.2)	21.53	14.7	12.57	6.8	3.72	0.94
Segment III	≤ 20 (24)	13.22	10.39	8.72	5.42	3.28	0.95

Tab. 2. Measurements results of illuminance in function of wet dirt on the lens for headlamp with D2S light source

Point or zone on measuring screen	Illuminance [lx]						
	Reg. No 98 requirement	Lens dirt degree [%]					
		0	10	25	50	70	90
On and above lineH/H3/H4	≤ 1 (1.3)	1,33	7.27	4.92	4.33	3.75	1.47
HV	≤ 1 (1.2)	1.18	7.19	5.57	4.80	4.02	1.50
B50L	≤ 0,5 (0.7)	0.55	4.17	2.05	2.13	2.23	1.14
75R	≥ 20 (16)	34.91	15.52	21.07	14.59	8.83	1.96
50L	≤ 20 (24)	21.86	10.24	10.92	8.52	5.21	1.54
25L1	≤ 30 (36)	20.96	11.52	15.24	11.117	6.39	1.69
50V	≥ 12 (9.6)	28.74	13.51	16.66	12.05	7.33	1.83
50R	≥ 20 (16)	33.57	15.99	22.77	15.00	9.49	2.06
25L2	≥ 4 (3.2)	17.62	9.54	12.36	8.96	5.12	1.53
25R1	≥ 4 (3.2)	18.35	10.49	13.31	9.61	5.53	1.67
Segment I	≥ 6 (7.2)	21.53	9.97	10.38	8.06	4.9	1.52
Segment III	≤ 20 (24)	13.22	11.17	11.37	8.34	5.58	1.65

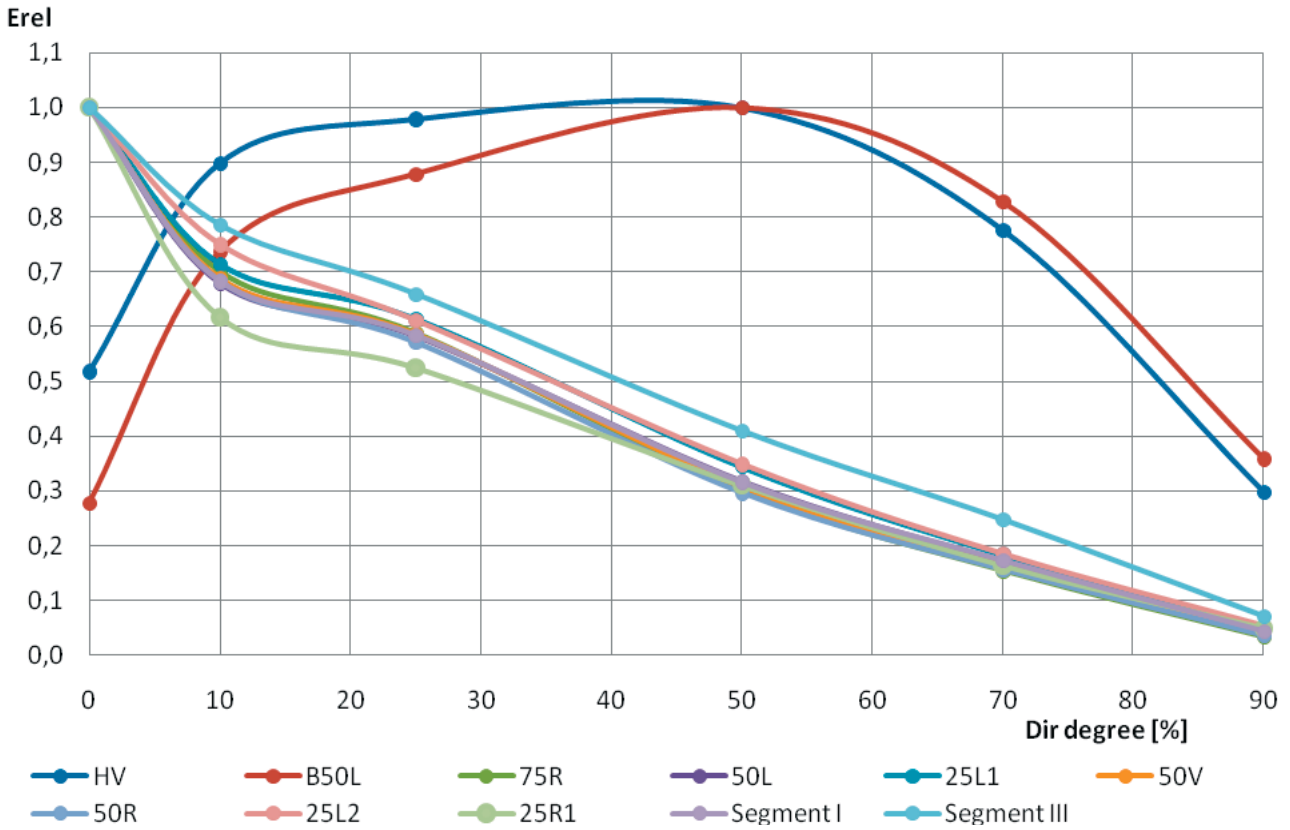


Fig. 1. Changes of illuminance relative values in function of dry dirt on the lens for headlamp with D2S light source

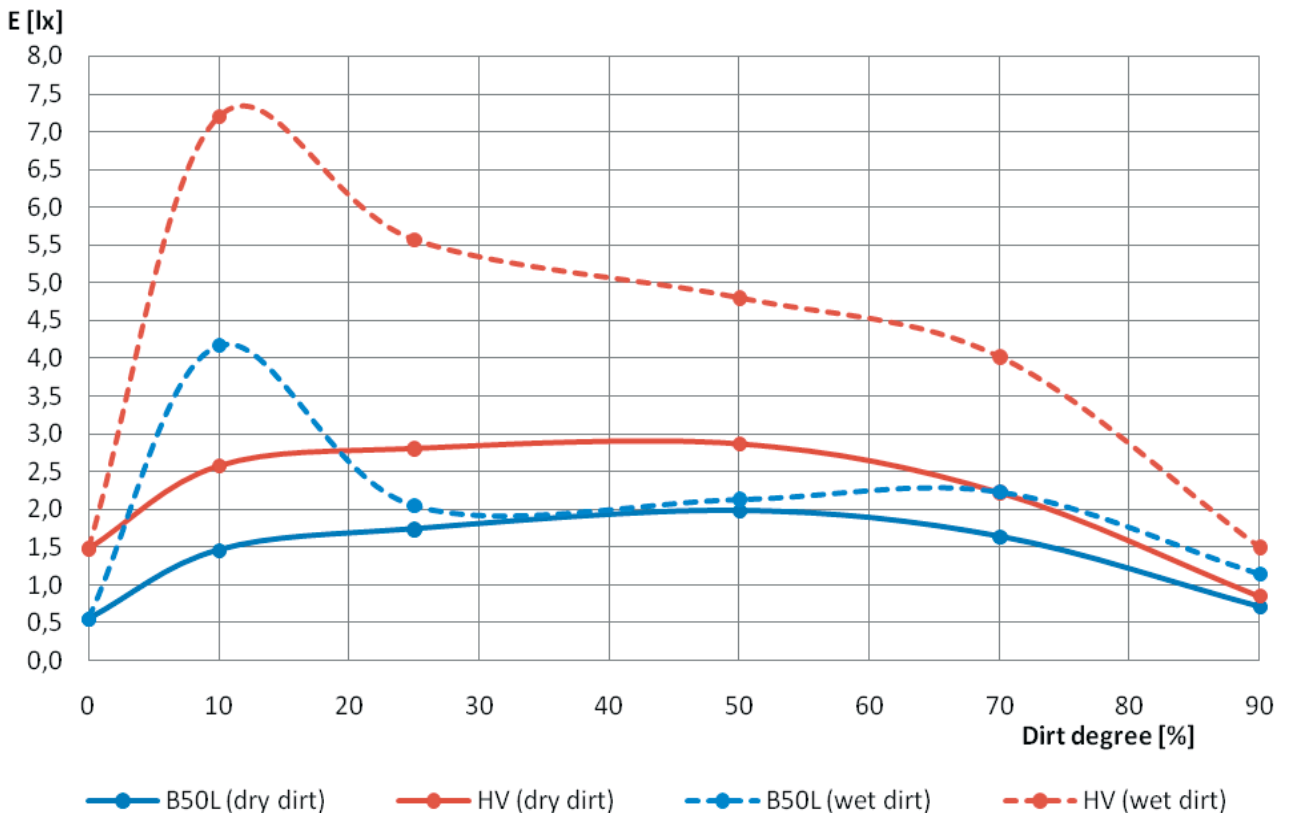


Fig. 2. Changes of illuminance values at points B50L, HV and in zone H/H3/H4 in function of dry and wet dirt on the lens for headlamp with D2S light source

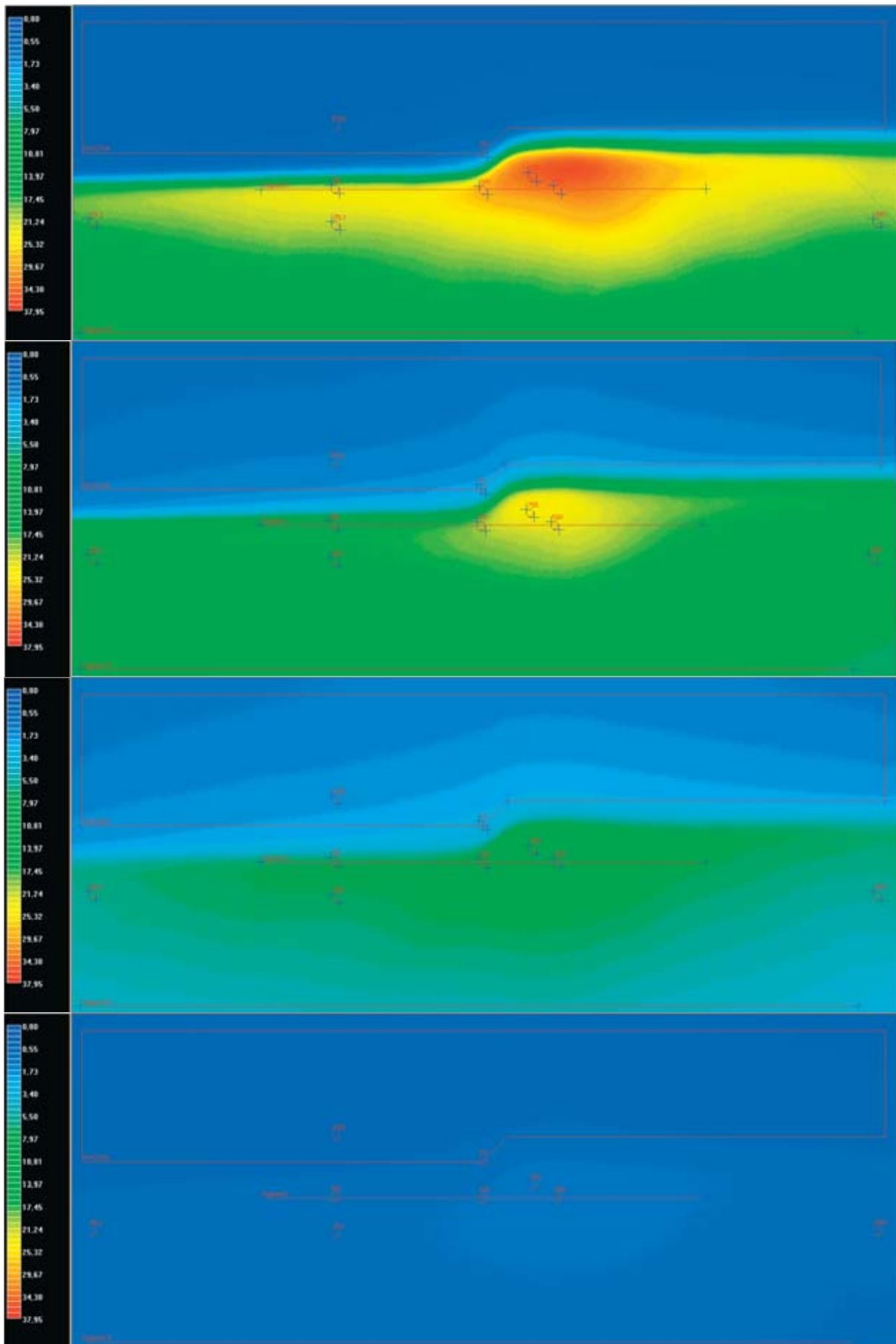


Fig. 3. Changes of illuminance distribution on measuring screen in function of dry dirt on the lens (0%, 10%, 50%, 90%) for headlamp with D2S light source

On the basis of measurements results it was concluded that dirt deposits on headlamp lens cause decreasing of a transmission factor and diffusing of lights and having influence on shape of luminous flux distribution. Those phenomena cause decreasing of illuminance values in zone under cut-off line and increasing illuminance values in zone above this line. Moreover, in given dirt degree, moistening the dirt causes increasing of transmission factor while keeping diffusing properties, what causes increasing of illumination.

In case of headlamp with D2S light source, it was concluded that for 50% dirt degree a minimum values of illumination at points 50V, 50R i 75R (points corresponding to the road illumination at distance of 50m before vehicle and right side of the road illumination at distance 50m and 75m before vehicle) was exceeded. Illumination values in these points decreased about 70%, comparing to values measured for clean headlamp, for dry and wet dirt as well. However, above cut-off line, at point B50L (point corresponding to statistical position of oncoming drivers eyes) and in zone above line H/H3/H4 exceeding of required values already for 10% dirt degree was observed. Maximum values were obtained for 25% and 50% dirt degree. At point B50L exceeding amounted about 140% for dry dirt and about 200% for wet dirt and in zone above H/H3/H4 about 170% and 390% respectively.

Tab. 3. Measurements results of illuminance in function of dry dirt on the lens for headlamp with H4 light source

Point or zone on measuring screen	Illuminance [lx]						
	Reg. nr 112 requirement	Lens dirt degree [%]					
		0	10	25	50	70	90
B50L	≤ 0.4 (0.6)	0.54	0.70	0.98	1.04	0.93	0.42
75L	≤ 12 (14.4)	3.02	2.81	2.79	2.17	1.71	0.51
75R	≥ 12 (9.6)	24.92	22.78	18.79	8.89	5.76	1.17
50L	≤ 15 (18)	4.50	4.34	3.93	2.80	2.05	0.54
50R	≥ 12 (9.6)	29.04	25.86	20.78	9.61	5.95	1.26
50V	≥ 6 (4.8)	27.20	24.58	20.38	9.92	6.18	1.17
25L	≥ 2 (1.6)	4.77	4.37	3.44	2.25	1.47	0.41
25R	≥ 2 (1.6)	8.41	7.55	5.97	3.92	2.45	0.77
zone III	≤ 0.7 (1)	1.07	1.31	1.70	1.78	1.59	0.66
zone IV	≥ 3 (2.4)	4.06	3.81	3.37	2.43	1.74	0.49
zone I	≤ 2×E _{50R}	18.53	16.44	12.75	6.76	4.38	1.07

Tab. 4. Measurements results of illuminance in function of wet dirt on the lens for headlamp with H4 light source

Point or zone on measuring screen	Illuminance [lx]						
	Reg. nr 112 requirement	Lens dirt degree [%]					
		0	10	25	50	70	90
B50L	≤ 0.4 (0.6)	0.54	0.99	1.32	1.36	1.21	0.71
75L	≤ 12 (14.4)	3.02	3.18	3.58	2.86	2.36	1.02
75R	≥ 12 (9.6)	24.92	16.84	14.32	10.25	6.83	2.11
50L	≤ 15 (18)	4.50	4.71	4.70	3.58	3.16	1.13
50R	≥ 12 (9.6)	29.04	18.84	18.41	12.60	8.27	2.42
50V	≥ 6 (4.8)	27.20	18.29	14.96	10.17	6.87	2.09
25L	≥ 2 (1.6)	4.77	4.59	4.01	3.14	2.55	0.89
25R	≥ 2 (1.6)	8.41	7.78	7.67	5.71	4.48	1.61
zone III	≤ 0.7 (1)	1.07	2.94	3.86	3.00	2.55	1.22
zone IV	≥ 3 (2.4)	4.08	4.16	4.45	3.27	2.85	1.03
zone I	≤ 2×E _{50R}	18.53	14.13	16.12	10.65	7.57	2.38

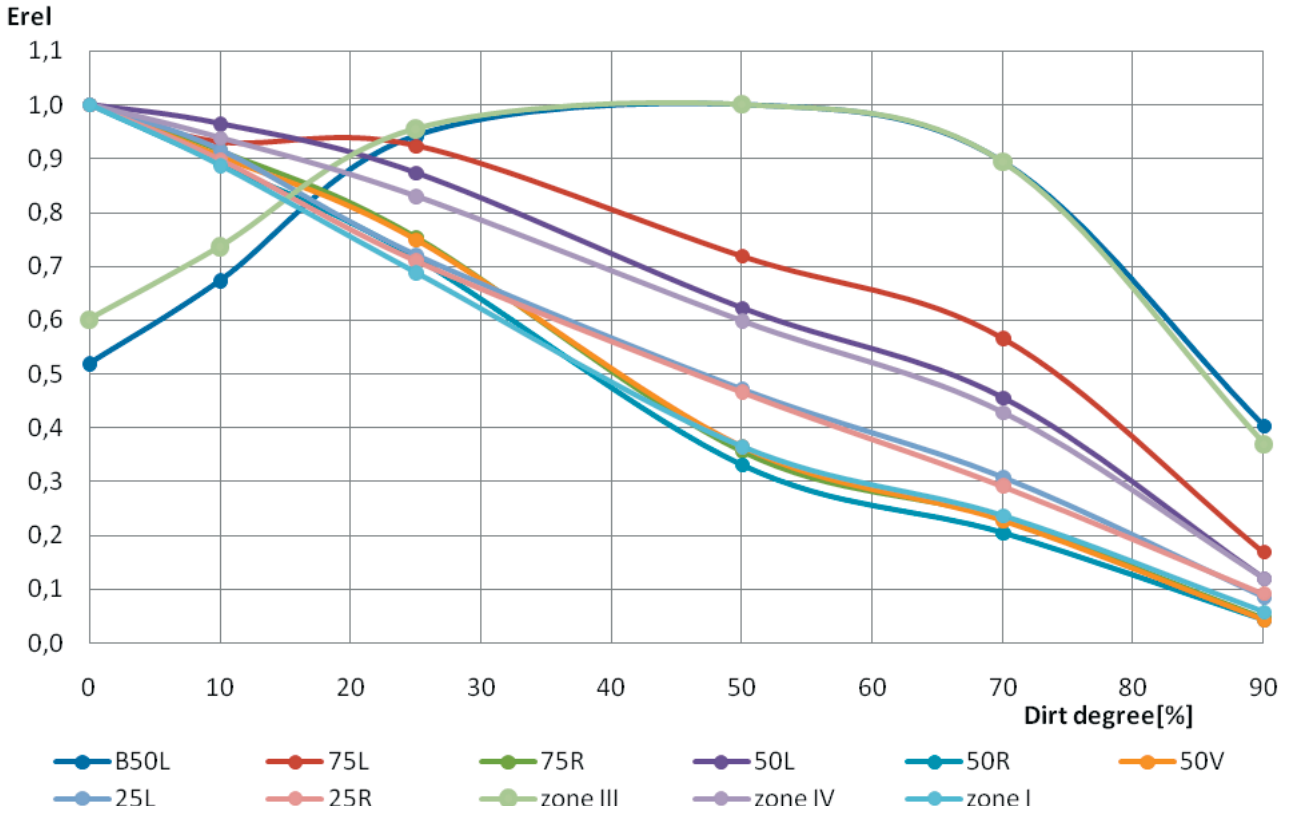


Fig. 4. Changes of illuminance relative values in function of dry dirt on the lens for headlamp with H4 light source

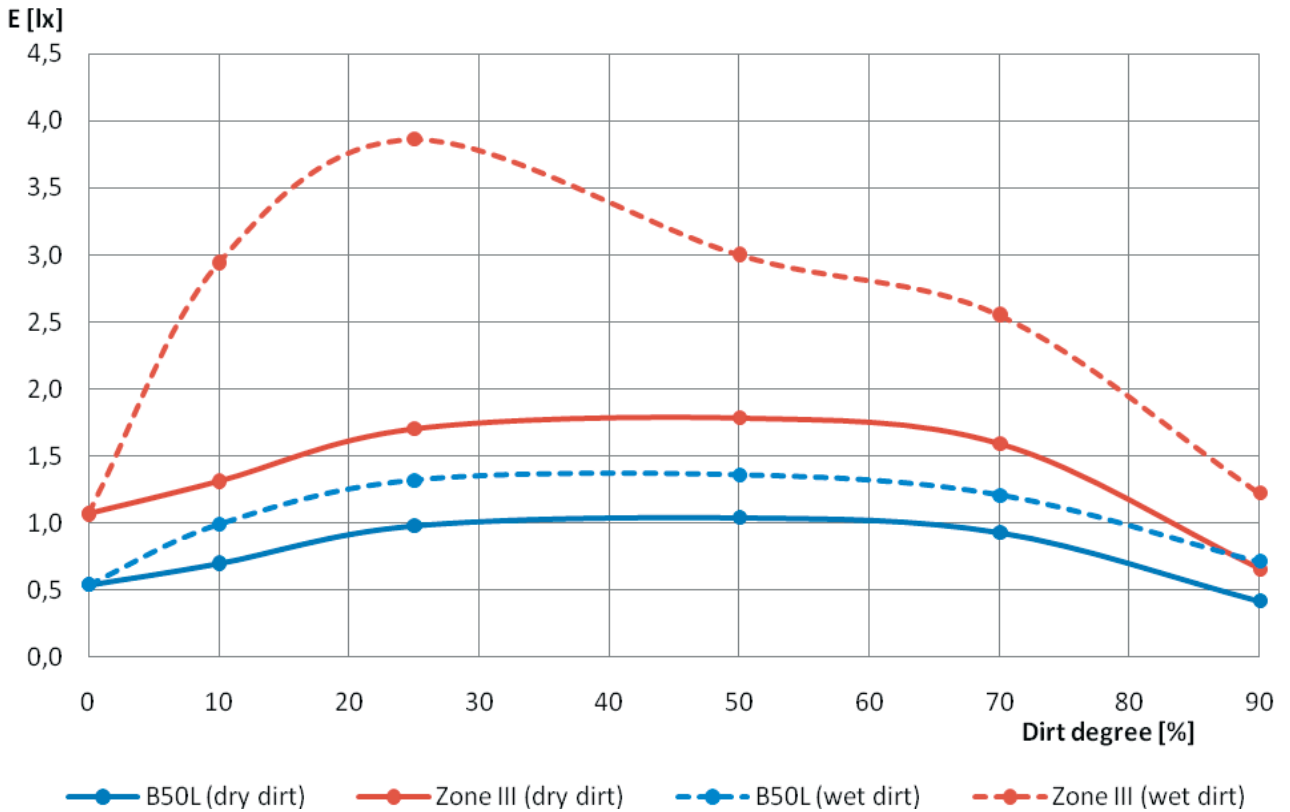


Fig. 5. Changes of illuminance values at points B50L and in zone III in function of dry and wet dirt on the lens for headlamp with H4 light source

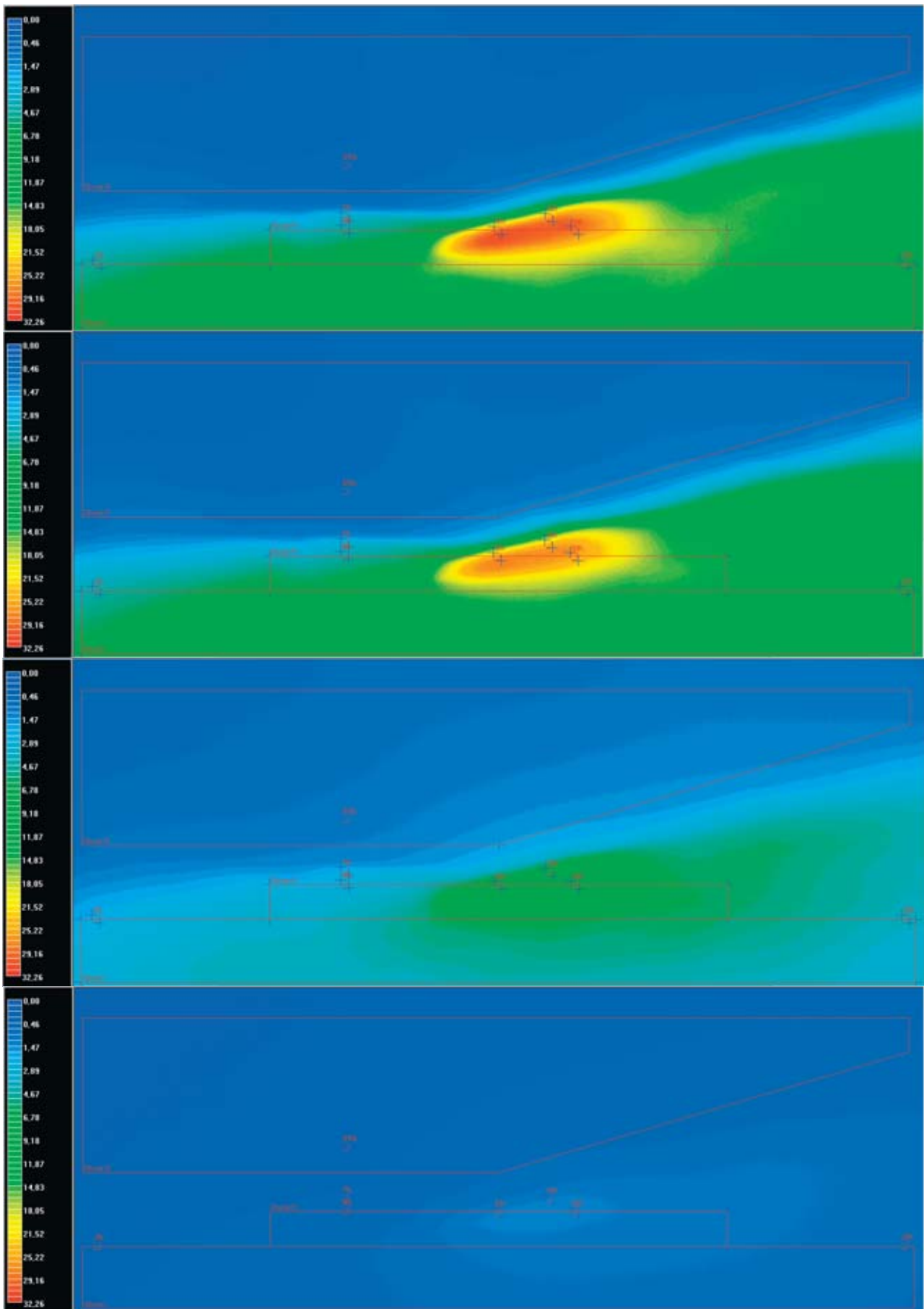


Fig. 6. Changes of illuminance distribution on measuring screen in function of dry dirt on the lens (0%. 10%. 50%. 90%) for headlamp with H4 light source

In the case of headlamp with H4 light source a similar dependence was observed. For about 70% dirt degree minimum values of required illumination at point 50R and 75R were exceeded. Illumination values decreased about 70% for dry and wet dirt as well. Above cut-off line at point B50L and in zone III exceeding of required values for about 10% dirt degree was observed. Maximum values were obtained for 50% dirt degree. At point B50L exceeding amounted about 100% for dry dirt and about 150% for wet dirt and in zone III about 80% and 200% respectively.

Summarizing the above analysis it can be stated that in both headlamps already at dirt degree 50% the light diffusing causes significant decrease of illuminance values on the road surface and exceeds required values in zone above cut-off line. Observations made by authors revealed that dirt degrees of exploited vehicles exceed this amount very often. In practice, it causes insufficient road illumination and glare of oncoming drivers.

3. Device for detecting and signaling of dirt deposits

The simplest solution of analyzed problem would be an introduction of obligatory headlamp cleaning for instance before every trip on public roads. Unfortunately, in practice it would be hard to execute this requirement. Moreover, it would contribute to faster tarnish of lens surface because of frequent wiping. An attempt to counteract the dirt depositing is equipping headlamps with cleaning devices such as wipers and washers. Normative documents obligate to use such devices only in headlamps equipped with gas discharge light source. Meanwhile, as conducted tests has showed, influence of dirt deposits is quite strong also in headlamps equipped with halogen filament lamps, which as a rule are not equipped with cleaning devices. Furthermore, normative documents [6] don't describe when a cleaning device should be turn on. The only requirement is that turning on should be possible from drivers seat and it is allowed to be turned on with other cleaning device. In practice such a device is turned on with windscreen washers. In authors opinion the most rational solution of headlamp dirt depositing problem is using a lens soiling detector [1, 2]. The device consists of infrared light emitting diode, aimed at proper angle in direction of lens external surface, infrared photodiode and control unit. The device use the phenomena of changing light direction and reflection ratio on lens external surface (Fig. 7.). For clean surface light is transmitted thru the lens. Increase of dirt deposits on the lens surface causes reflection of more light to photodiode. In the case of dry dirt it causes increasing of signal measured by photodiode (Fig. 8). Moistening of the dirt causes improvement of its transmission factor and decreasing of measured signal (the biggest thickness of dirt deposits causes the biggest improvement of transmission factor, comparing to the same thickness of dry dirt).

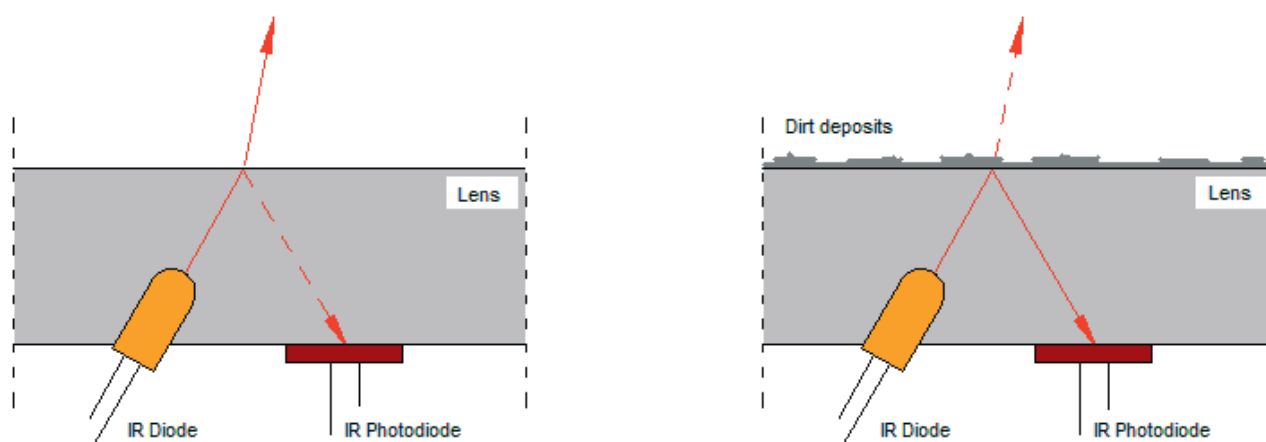


Fig. 7. Working scheme of dirt deposits' detector

The use of such a device on vehicle headlamps will make possible detection of excessive dirt deposits and in case headlamps equipped with halogen filament lamp it will signalize a need of

lens cleaning and in case of headlamps equipped with gas discharge light source it will automatically turn on the washers. It will contribute to the effective use of passing light during vehicle exploitation. ensuring proper road illumination and limiting the glare of oncoming drivers. So, it will improve traffic safety.

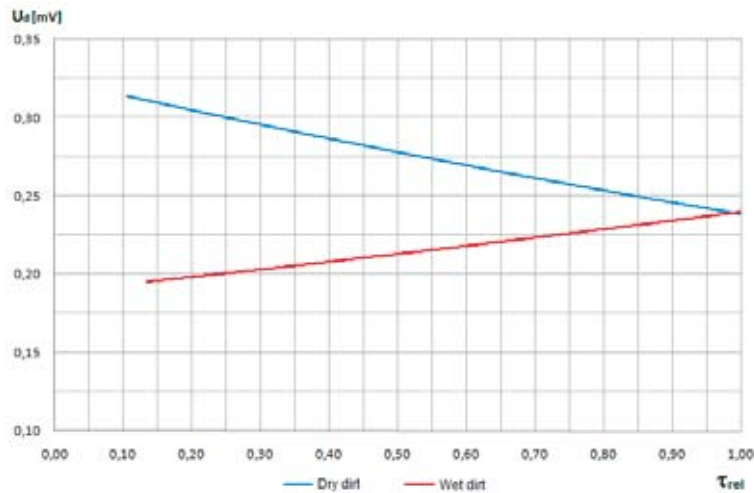


Fig. 8. Characteristic of dirt deposits' detector

4. Summary

In vehicle lighting technology we can observe a trend of constant improvement of road illumination. Producers are manufacturing special designs of light sources, which in expense of light source durability makes possible achieving (according to producers' information) even a few dozen percent „more light on the road surface”. Some vehicle owners decided to change halogen for gas discharge headlamp. Unfortunately, all kind of these actions are thwart by lack of systematical care of headlamps' technical condition during its exploitation. Dirt deposits on the lens cause changes in luminous flux distribution. Conducted tests revealed that for gas discharge headlamp and halogen headlamp as well, already 10% dirt degree cause exceeding required illuminance values (including manufactured deviations) in zone above cut-off line, what can cause a glare of oncoming drivers. Next 50% dirt deposits cause insufficient road illumination. Observations made by the authors revealed that this amount of dirt degrees are often achieved and even exceed during vehicles exploitation. Effective solution of this problem is using headlamps with a lens soiling detector elaborated in MTI.

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