

**CRASH AND SAFETY TESTING
STANDARD
FOR PARATRANSIT BUSES
ACQUIRED BY THE STATE OF FLORIDA**



**Technical Report 1-2013
Florida Department of Transportation
Transit Office**

**Paratransit Bus Bike Rack
Headlight Obstruction Evaluation**

Revision History:

v1.0 – Initial Testing Summary - 1/30/13

v2.0 – 40 ft. Gillig 3 bike tests added – 3/18/13

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Scope:

Evaluate FDOT TRIPS acquired paratransit buses, in particular cutaway models, for headlight output degradation due to front-mounted bike racks.

Equipment:

Extech Heavy Duty Meter Model 407026 – Specifications (of mode used during testing) = measurement range 0-1999 lux, resolution 1 lux, accuracy +/- 2 lux + +/- 4% of reading

Relevant Literature:

- Altair Test Procedure ALTPD-TP-137 Method of Evaluating Obstruction of Motor Vehicle Headlamp Output (Appendix A)
- Measuring Light Intensity (Appendix B)
- ECE R112 – Approval of Motor Vehicle Equipped with Filament Headlamps (portion related to headlamp measurement - Appendix D)
- FMVSS 108 – Lamps, reflective devices, and associated equipment - reviewed but deemed not applicable due to equipment and procedures beyond the current scope of this project

Conducted Tests:**1. Altair Test Procedure Evaluation 1/15/2013**

The Altair Test Procedure ALTPD-TP-137 Method of Evaluating Obstruction of Motor Vehicle Headlamp Output (appendix A) was provided to FDOT by transit bus bicycle rack manufacturer BykRak. It is intended to “identify the level of light output degradation due to obstructions ... due to front mounted equipment or accessories.” The test procedure consists of measuring the lux (for more information, see appendix B) levels of the vehicle headlights using a photometer at specified locations in a 12’x4’x4’ test apparatus (Figure 1- but the blue tape does not indicate Altair measurement locations) during low ambient light conditions. The initial reading is the ambient light lux level, followed by the unobstructed headlight lux level, and the obstructed headlight lux level. Finally, as a check, the ambient level is



Figure 1: Altair Test Procedure Apparatus

measured a second time. The percent light output degradation is then calculated using the two measured lux levels. The low beam and high beam evaluation procedures are identical except for the measurement distances - 150ft for low beam and 450ft for high beam.

Results:

Recorded lux levels too low to report.

Commentary:

The Altair test procedure was evaluated at the FDOT Springhill Test Facility on 1/15/2013. Two paratransit buses were used, a 21 ft. Chevrolet and 29 ft. International, and several different areas within Springhill were investigated for suitability. It became quickly evident that the Altair test procedure, as written, would not work well for FDOT buses. The primary reason was that at the specified measurement distances the light had become so diffuse that the low beam measurements were averaging less than 10 lux and the high beam readings were approximately 3 lux. At these levels, the relative uncertainty of the meter is approximately 25% and 66% (respectively), making valid comparisons between obstructed and unobstructed impossible.



Figure 2: Unobstructed Test reverse angle

A related issue was that at the Altair test distances, in particular 450 ft., the downward angle of the headlights resulted in nearly all of the primary headlight beam spot shining on the very bottom edge of the measurement box or completely onto the road surface and only reflecting into the box. The headlights on all vehicles are intentionally aimed slightly down to prevent blinding oncoming motorists and at these test distances this was most likely normal. However, the headlight aim of the tested buses was not checked prior to testing, so incorrectly aimed headlights could be exacerbating this issue on the tested buses. It is also unclear what exactly correct means in regards to paratransit bus headlight aim, due to a lack of a clear procedure for the correct aiming of paratransit bus headlights -- the angle of which will change dramatically with increasing passenger load due to compression of the rear suspension.

2. Modified Procedure Development Testing 1/24/2013

The priority for this round of testing was to determine whether bikes placed in a front bike rack measurably degrade headlight output. The problems discovered in the previous round of testing were addressed in the following manner:

- Test distance was decreased to 35 feet so that unobstructed LUX levels averaged 200 and the main spot of the headlight beam shined directly on the test apparatus (Figure 2.).
- Only low beams were tested.
- The number of measurement points was increased to 33. Three rows of test points were located at 6 in., 18 in., and 30 in. from the bottom edge of the test apparatus. Each row consisted of 11 points spaced at 12 in. intervals across the width of the rear plane of the box (Figure 1).

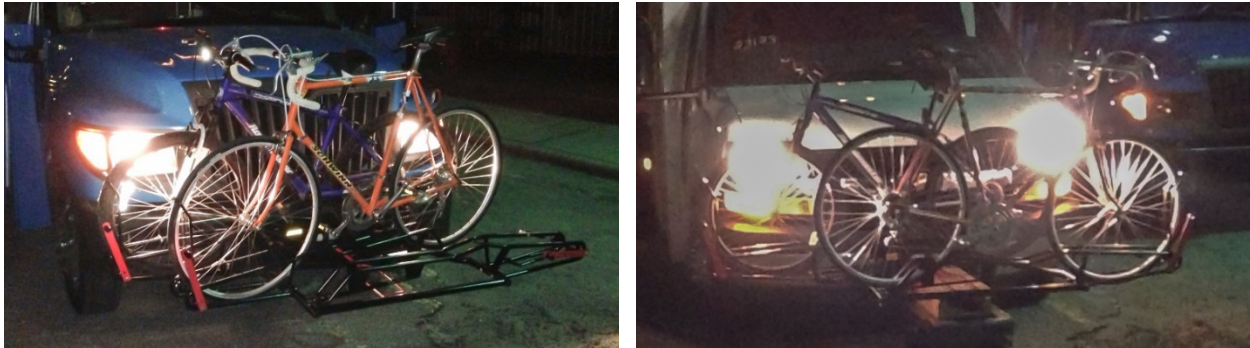


Figure 3: Obstructed Test Bicycle Positioning

Testing was performed on the same type of buses used previously, a 21 ft. Chevrolet and 29 ft. International. A 3-bike BykRak front rack was installed on the International, while a 2-bike BykRak was positioned in front of the Chevrolet (Figure 3). For all obstructed measurements, the same two bikes, a 27" twelve speed and 26" mountain bike, were used. The following seven configurations were tested (raw data available in appendix C):

- International - Bike rack stored, one measurement made
- International - Bike rack deployed no bikes, two measurements made
- International - 3-bike rack deployed two bikes, two measurements made with different bike position configurations
- Chevrolet - No rack, one measurement made
- Chevrolet - 2-bike rack propped with two bikes, one measurement made

Results:

Table 1: Headlight Obstruction by Configuration (row average)

	International Bike Config. 1			International Bike Config. 2			Chevrolet		
	Un. Lux	Ob. Lux	% Ob.	Un. Lux	Ob. Lux	% Ob.	Un. Lux	Ob. Lux	% Ob.
Row 30"	19	15	24%	19	11	42%	235	179	24%
Row 18"	152	119	22%	152	87	43%	186	129	31%
Row 6"	152	121	21%	152	97	36%	97	63	36%

The average obstruction caused by 2 bikes over all measurements recorded (3 different configurations) was 32%. In chart 1 the results are summarized by row averages (of all 11 points of each row) where the unobstructed lux, the obstructed lux, and the percent obstructed, are shown for all 3 tested configurations. A large variation by bike position and vehicle type is observed, with average row obstruction values ranging from 21% to 43% indicating a high degree of configuration sensitivity.

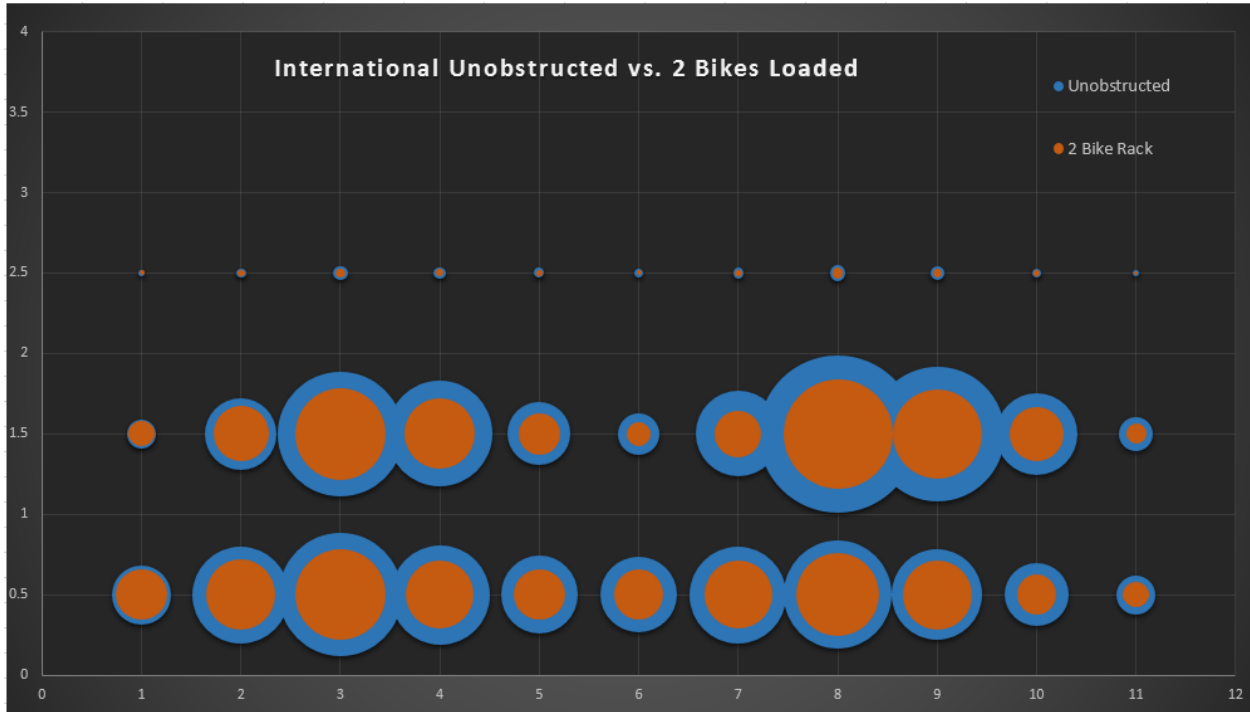


Figure 5: International Obstruction

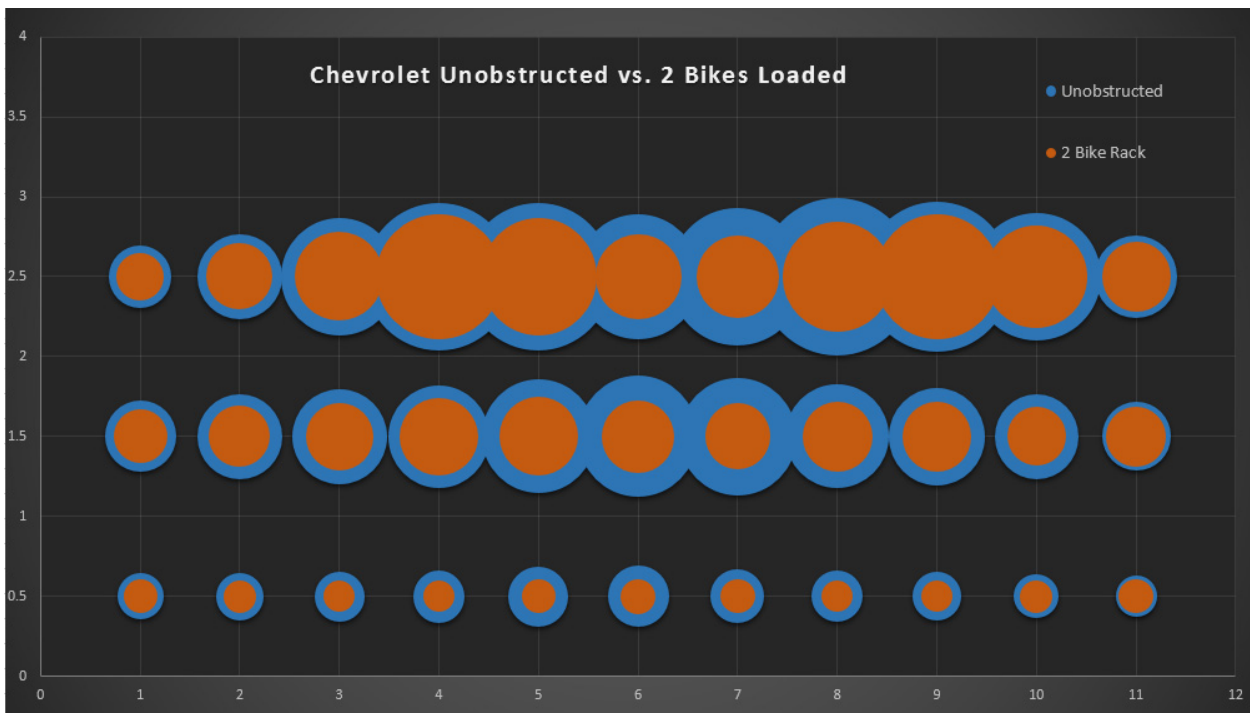


Figure 4: Chevrolet Obstruction Graph

The graphs above (Figure 4 & Figure 5) present the amount of light obstructed by the bikes in a different way. Here the amount of lux is plotted per measurement point (as if looking into the test apparatus box) with the blue circles representing the amount of unobstructed lux and the orange circles the amount of obstructed lux. The values shown in the International graph are the average of both configurations. It should be noted the large difference in the aim and distribution of the headlights between the two buses even though they were measured from the same distance and with the same (no) load.

Commentary:

The results show that bikes placed into front bike racks will obstruct a measureable amount of the headlamps output. However, the amount appears to be very configuration dependent (i.e., number of bikes, type of bikes, bike position). Further, the number of configurations and measurements made during this test is too limited to draw any broad conclusions. Whether the amount of obstruction measured is significant from a safety perspective also is unclear.

The chosen test distance was 35 ft. for this test and it seemed to work well. For comparison, most manufacturers' headlight aiming procedures use 25 ft. (with a range of 10 – 33 ft.) while ECE R112 uses 25 meters (82 ft.) to evaluate filament headlight performance. It should be noted that ECE R112 specifies an allowable lux range of 0-20 at its measurement distance of 82 ft., which would result in a high level of relative uncertainty using our meter.

The use of the side and top walls on the test apparatus to reduce ambient light does not seem necessary. Measured ambient light levels have been between 0-1 lux, a level low enough to have no effect on the overall results. Though not checked, there is a possibility that the side and top walls could be affecting the overall results by reflecting light onto the back wall that would ordinarily pass by. For comparison, ECE R112 uses a larger measuring surface (26 ft. x 11 ft.) with no side or top walls.

The evenly spaced matrix of measurement points seemed to work well. The reviewed headlight evaluation standards tend to use fewer points at more specific locations which works well for the criteria they are being evaluated for such as cutoff. However, since the intent of the conducted tests is to measure the degradation due to obstruction which can vary depending on the location of the obstruction a more regular spacing seems justified though it increases the testing time.

The precision (repeatability) of measurements was noted to be low. For example the International was measured with the bike rack deployed but no bikes twice at different times and the measurement varied by the %'s shown below from the average recorded value. For future tests at least three measurements should be taken and averaged in order to increase the quality of the results.

Table 2: Percentage difference between two identical configuration measurements (as indication of precision)

0.0%	-5.7%	-3.9%	-9.2%	-5.6%	0.0%	0.0%	7.0%	-8.3%	-5.8%	-8.6%
-3.9%	-0.8%	-1.3%	3.1%	-0.9%	5.3%	-1.9%	0.7%	-0.4%	-0.7%	-1.7%
6.5%	0.0%	0.0%	1.1%	-0.7%	-2.2%	3.5%	-0.5%	0.6%	4.4%	1.4%

The difference in headlight aim between the two chassis' can clearly be seen by comparing figure 4. and figure 5. In which the International has almost no output on the 30" row vs. the Chevrolet which has its highest level of output on the 30" row. Defining what is the "correct" headlight aim of a paratransit bus is should be done before conducting any future tests.

It was observed that the light and glare reflected back from the bikes at the bus driver from the bikes is considerable due to their close proximity to the headlamps. This would likely be very distracting though is beyond the scope of this report to comment on its effect from a safety perspective.

3. 40 ft. Gillig three bike configuration testing - 3/13/2013

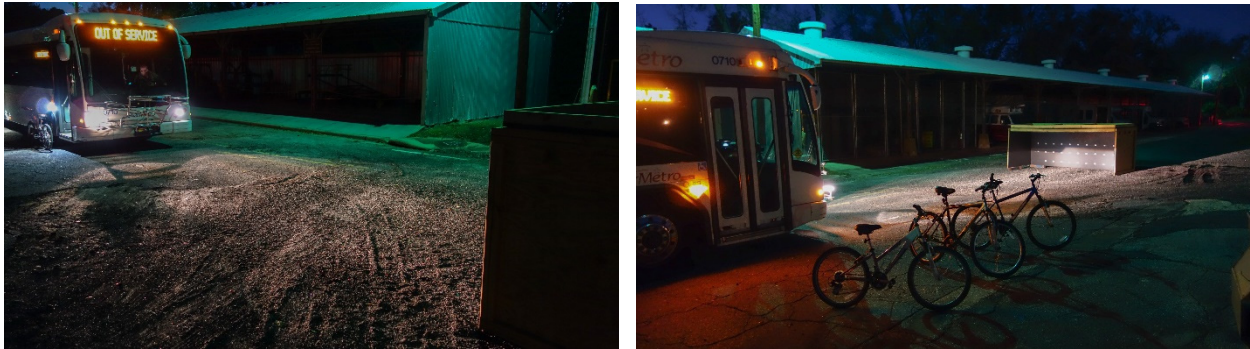


Figure 6: 40 ft. Gillig test setup

Testing was conducted on 3/13/13 at the FDOT Springhill test facility using a Gillig 40 ft. passenger bus with front mounted 3-bike rack manufactured by BykRak. The modified procedure test parameters detailed in section 2 were used for this round of testing (35 ft. distance, low beams only, 33 measurement points). The test setup is shown in the figure above. Headlight aim was not checked before testing. The following six configurations were tested:

- 40 ft. Gillig - Bike rack stored - two measurements made, one at the beginning and one at end of testing.
- 40 ft. Gillig - Bike rack deployed no bikes.
- 40 ft. Gillig - Three bike rack deployed with three bicycles - three measurements made with different bicycle position configurations (shown in the figure immediately below).



Figure 8: 40 ft. Gillig loaded test configurations

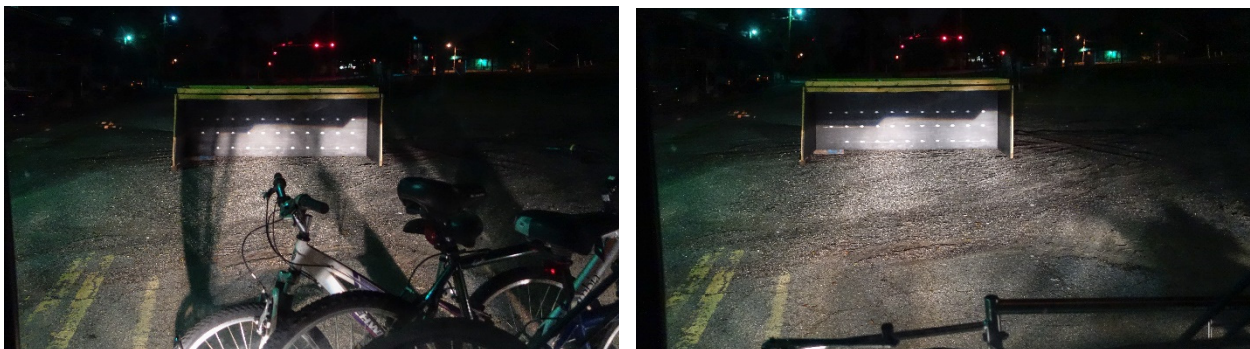


Figure 7: 40 ft. Gillig comparison of obstructed and unobstructed configuration from drivers view

The pictures below illustrate the obstruction from one of the configurations from the approximate perspective of the driver, with this particular case casting very dark shadows on the left side. The sharp cut-off due to the projector headlights is also very visible here.

Results:

The average overall obstruction caused by the 3 bikes on the 40 ft. Gillig as compared to the stowed rack was 27% (as compared with the 2 bike obstruction of 28% for the Chevrolet and 36% for the International). The table below summarizes the test results by row.

Table 3: Headlight Obstruction by Configuration (row averages of measured LUX) (average percent obstructed)

	Gillig no bikes (Lux)			Gillig 3 bikes (Lux)			Average % obstructed		
	Stowed	Deploy	Stowed	Config 1	Config 2	Config 3	Un. Lux	Ob. Lux	% Ob.
Row 30"	7	7	5	3	3	5	6	4	41%
Row 18"	72	74	73	52	51	60	73	54	26%
Row 6"	84	83	81	54	60	68	83	61	27%

For the reasons mentioned in the section 2 commentary, the 27% percent overall obstruction was determined from averaged results. For the unobstructed values the two stowed rack measurements and single deployed w/o bikes measurement were averaged (there was no difference between stowed and deployed). The obstructed values were an average of the three different 3-bike configuration measurements tested. As with the tests conducted before, the results were sensitive to the arrangement of bikes. This can be seen in the row averages for the 3 different loaded configurations and also by comparing the overall per configuration obstruction values, 33%, 30%, and 18%.

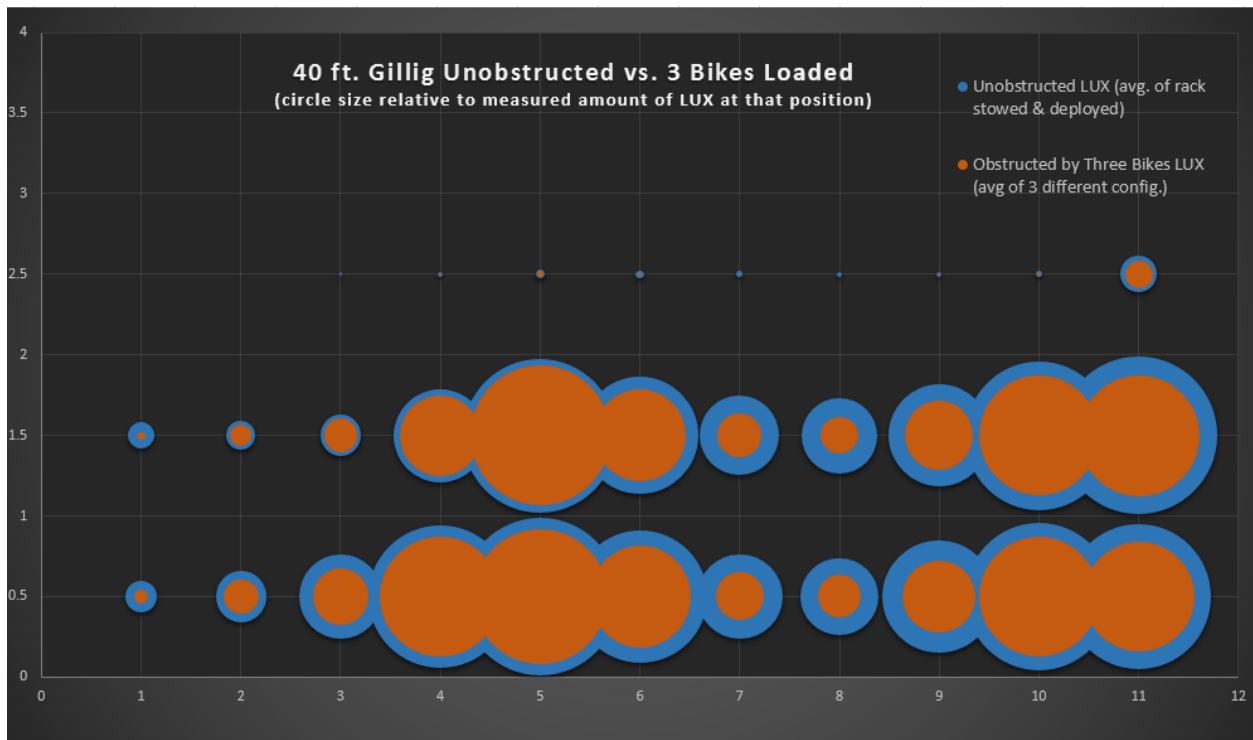


Figure 9: 40 ft. Gillig comparison of average obstructed and unobstructed LUX measurements

The graph above presents the amount of light obstructed by the bikes in a different way. Here the amount of lux is plotted per measurement point (as if looking into the test apparatus box) with the blue circles representing the relative amount of unobstructed lux and the orange circles the relative amount of obstructed lux. The sharp cut-off of the projector headlights in the Gillig result in very little light measured in the topmost row.

Appendix A

Altair Test Procedure ALTPD-TP-137 Method of Evaluating
Obstruction of Motor Vehicle Headlamp Output

Altair Test Procedure
ALTPD-TP-137



Method of Evaluating Obstruction of Motor Vehicle Headlamp Output

Table of Contents

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Note: All material presented in this proposal is confidential to Altair ProductDesign, Inc. and is to be treated as confidential by all recipients of this document.

A. Scope

The procedure defined herein is to be used to evaluate the obstruction of headlamp output due to front vehicle mounted equipment or accessories such as snow plows, bike racks, etc. The test identifies the level of light output degradation due to obstructions.

B. Apparatus

1. Wallboard assembly structure consisting of:
 - a) 4' H x 12' W x 1/4" Thick minimum panel board placed vertically with its long dimension positioned laterally, to be used for vertical light measurement surface
 - b) Necessary structure to support panel board in a vertical position, to be located on the side of the board that is opposite the vehicle headlamps. This structure will additionally be used to raise the wallboard assembly to account for vehicle headlamp positions exceeding 48".
 - c) 4' H x 12' W x 1/4" Thick minimum panel board to be mounted horizontally to the top of the vertical panel board on the face of the panel board that faces the vehicle headlamps, to serve as a light shield by reducing ambient light interference from overhead
 - d) 4' H x 4' W x 1/4" Thick minimum panel board to be mounted at the sides of the vertical panel board and supporting the horizontal panel board light shield, to serve as a light shield by reducing ambient light interference from the side
 - e) Fabric material to be attached to the top side of the vertical panel board , on the side of the board opposite the headlamps, to serve as a cloak for the photometer
2. Darkened facility or nighttime ambient light in open space
3. Tape Measure
4. Photometer (Light Measurement Device)
5. Bubble Level

C. Test Procedure

Low Beam Evaluation

1. Locate test vehicle (or apparatus simulating front of vehicle) in test area.
2. Induce low ambient light condition by darkening building or initiating test at night with low ambient light condition.
3. Aim Low Beam Headlamps per industry guidelines.
4. Set-up Wallboard assembly structure 150 ft in front of vehicle or test apparatus for low beam headlamp evaluation. Place shims under corners of wallboard structure to insure it is level and plumb.
5. Turn-on low beam lights and locate focal point for left and right headlamp patterns.
6. Drill 2" diameter holes at left and right low beam headlamp pattern focal point locations.
7. Drill additional 2" holes horizontally on each side of the focal point holes, at a distance 17" from focal point hole locations. If the two centermost holes are greater than 17" apart, drill another hole midway between those holes for a total of (7) hole locations.
8. Turn off headlamps.
9. Positioning photometer on back side of wallboard assembly and centered behind each of the (7) holes, take light measurement to record ambient light condition at each hole location.
10. Turn on low beam headlamps (unobstructed condition).
11. Positioning photometer on back side of wallboard assembly and centered behind each of the (7) holes, take light measurement to record unobstructed light condition at each hole location.
12. Install or deploy front mounted vehicle obstruction. In the case of a bike rack, install maximum number of bikes in bike rack.
13. Positioning photometer on back side of wallboard assembly and centered behind each of the (7) holes, take light measurement to record obstructed light condition at each hole location.

High Beam Evaluation

1. Locate test vehicle (or apparatus simulating front of vehicle) in test area.
2. Induce low ambient light condition by darkening building or initiating test at night with low ambient light condition.

3. Aim High Headlamps per industry guidelines.
4. Set-up Wallboard assembly structure 450 ft in front of vehicle or test apparatus for high beam headlamp evaluation. Place shims under corners of wallboard structure to insure it is level and plumb.
5. Turn-on high beam lights and locate focal point for left and right headlamp patterns.
6. Drill 2" diameter holes at left and right high beam headlamp pattern focal point locations.
7. Drill additional 2" holes horizontally on each side of the focal point holes, at a distance 17" from focal point hole locations. If the two centermost holes are greater than 17" apart, drill another hole midway between those holes for a total of (7) hole locations.
8. Turn off headlamps.
9. Positioning photometer on back side of wallboard assembly and centered behind each of the (7) holes, take light measurement to record ambient light condition at each hole location.
10. Turn on high beam headlamps (unobstructed condition).
11. Positioning photometer on back side of wallboard assembly and centered behind each of the (7) holes, take light measurement to record unobstructed light condition at each hole location.
12. Install or deploy front mounted vehicle obstruction. In the case of a bike rack, install maximum number of bikes in bike rack.
13. Positioning photometer on back side of wallboard assembly and centered behind each of the (7) holes, take light measurement to record obstructed light condition at each hole location.

D. Reporting

1. Prepare light output matrix document identifying:
 - a) Ambient light output for high and low beam headlamp configurations, maximum (14) positions to be measured at the beginning of testing, as a zero reference
 - b) Unobstructed Low beam light output, maximum (7) positions
 - c) Obstructed Low beam light output, maximum (7) positions
 - d) Unobstructed High beam light output, maximum (7) positions
 - e) Obstructed High beam light output, maximum (7) positions
 - f) Ambient light output for high and low beam headlamp configurations, maximum (14) positions to be measured at the end of testing, as a zero reference
2. Determine percentage of light output degradation between obstructed and unobstructed conditions for:
 - a) Low beam headlamp configuration
 - b) High beam headlamp configuration

Appendix B

Measuring Light Intensity

Measuring Light Intensity**Lumens
Footcandles and Lux
Candlepower**

In doing lighting efficiency work, you need to measure light intensity. You also need to know how to express light intensity for selecting lamps and for laying out the overall lighting configuration. Unfortunately, lighting terminology tends to be confusing and somewhat inconsistent. This brief Note introduces you to the terms that the lighting trade uses to communicate about light intensity, and it points out which of these terms are important to know.

Lumens

“Lumen” is the unit of total light output from a light source. If a lamp or fixture were surrounded by a transparent bubble, the total rate of light flow through the bubble is measured in lumens. Lumens indicate a rate of energy flow. Thus, it is a power unit, like the watt or horsepower.

Typical indoor lamps have light outputs ranging from 50 to 10,000 lumens. You use lumens to order most types of lamps, to compare lamp outputs, and to calculate lamp energy efficiencies (which are expressed as lumens per watt).

Note that lumen output is not related to the light distribution pattern of the lamp. A large fraction of a lamp’s lumen output may be useless if it goes in the wrong directions.

Footcandles and Lux

“Footcandles” and “lux” are units that indicate the density of light that falls on a surface. This is what light meters measure. For example, average indoor lighting ranges from 100 to 1,000 lux, and average outdoor sunlight is about 50,000 lux.

The footcandle is an older unit based on English measurements. It is equal to one lumen per square foot. It is being replaced by lux, a metric unit equal to one lumen per square meter. One footcandle is 10.76 lux. Although footcandles are now officially obsolete, they probably will continue to be used because many existing light meters are calibrated in footcandles.

The general term for lux or footcandles is “illuminance.” The general term is sometimes used by lighting engineers, but the units of lux or footcandles are more commonly used.

**Brightness
In Summary ...**

You use footcandles or lux to measure the adequacy of lighting on the task. Footcandles and lux relate only to the task area, not to the lighting equipment or to the geometry of the space. For example, you could create an illumination level of 100 lux on a surface by using a single spotlight located far away, or by using many cove lights nearby.

For energy conservation work in existing facilities, you need a light meter that measures illuminance in footcandles or lux. You will use it continually as you lay out lighting, select fixtures to be delamped, etc. Light meters have become inexpensive, so you can afford to spend the money to get a rugged electronic unit of good quality, rather than the older type that uses a fragile meter movement. Figure 1 shows a footcandle meter.

Candlepower

“Candlepower” is a measure of lighting concentration in a light beam. It is used primarily with lamps that focus, such as spotlights and PAR lamps. In lamps where candlepower is specified, the candlepower rating usually applies only to a small spot in the center of the beam.



WESINC

Fig. 1 Footcandle meter The meter is used to measure “illuminance.” It is the only measuring instrument that you need for most applied lighting efficiency work. Being an older model, this meter indicates in units of footcandles. Newer models indicate in units of lux.

The official unit of candlepower is the “candela,” which is equal to one lumen per steradian. (A steradian is a fraction of the surface area of a sphere that is equal to the square of the radius divided by the total surface area. This is approximately 8% of the total surface area.) This term is rarely used in practical work. Lamp catalogs usually list “candlepower” rather than candelas. This is like using “horsepower” as both a general term and a specific unit. To confuse matters further, candelas were earlier called “candles.”

Brightness

In general, “brightness” is an expression of the amount of light emitted from a surface per unit of area. “Brightness” is not an official term of the lighting trade, and lighting designers may become huffy when you use it. However, the concept is essential for understanding visual quality, especially in relation to contrast and glare.

Brightness does not inherently relate to lamps, or even to light sources. The light could be reflected or transmitted. For example, the bright surface could be the surface of a fluorescent tube, a page of a book, a window with a view of the sky, or a store window with reflections.

The closest official term is “luminance,” which is expressed as candelas per square meter of light emitting surface. (Luminance used to be measured in “footlamberts,” which is now an obsolete term.) For example, the luminance of a heavily overcast sky is about 1,000 candelas per square meter, and the luminance of a typical frosted light bulb is about 100,000 candelas per square meter.

Luminance is defined in terms of the direction of light emission. The details get technical, and you probably will not need to deal with them. In brief, the brightness of an object usually depends on the direction from which you look at it.

Note that luminance has nothing to do with size of the light emitting surface. The light source could be as

small as a lamp filament, or it could be as large as the whole sky, or it could be a task area, such as a desk top.

Measuring brightness (“luminance”) is tricky and requires specialized equipment. For practical work, learn how to avoid excessive brightness, so you won’t need to measure it. If you do a good job of laying out lighting, people within the space will not be subjected to brightness that is severe enough to cause glare.

Luminance is the converse of illuminance. The former describes the intensity of light that is leaving a surface, whereas the latter describes the intensity of light that is falling on a surface. For light reflected from a surface, luminance equals illuminance multiplied by the percentage of reflectance.

“Brightness” also is used to describe the subjective sensation of light intensity. This sensation largely depends on the overall layout of the scene surrounding the viewer. An uncomfortable level of brightness is described as “glare.” (The term “glare” is used in several ways. It is an important concept, but is not precisely defined by the lighting trade. Various types of glare are explained in Reference Note 51, Factors in Lighting Quality.)

In Summary ...

So, here is the overall picture. A lamp produces a certain amount of light, measured in lumens. This light falls on surfaces with a density that is measured in footcandles or lux. A person looking at the scene sees different areas of his visual field in terms of levels of brightness, or luminance, measured in candelas per square meter.

Many characteristics other than light intensity are important in selecting light sources. These include color, operating temperature, starting time, etc. To learn about all of them, see Reference Note 52, Comparative Light Source Characteristics.



Appendix C

Raw Data Modified Procedure Development Testing 1/24/2013

Modified Procedure Development Testing 1/24/2013 Raw Data

International 2 bikes (1)

9	14	20	16	13	9	13	21	19	16	9
47	112	198	155	79	42	87	212	197	125	51
98	157	183	140	97	81	115	157	143	96	61

International rack down no bikes (2)

11	18	26	23	19	15	20	31	26	18	12
52	128	226	188	115	73	155	280	243	151	61
102	174	222	180	141	138	170	197	161	111	68

International rack stowed (3) (some data may be incorrect due to % button on meter)

10	18	26	21	17	14	18	22	22	17	12
52	129	227	191	111	75	156	289	241	144	60
110	175	217	176	136	137	175	188	165	115	73

International 2 bikes to curbside (4)

9	12	15	11	10	9	13	16	13	8	5
45	86	131	100	69	44	82	182	125	68	23
86	94	141	102	86	98	129	143	107	47	32

International rack down no bikes (5)

11	17	25	21	18	15	20	33	24	17	11
50	127	223	194	114	77	152	282	242	150	60
109	174	222	182	140	135	176	196	162	116	69

Chevy unobstructed (6)

120	162	226	285	285	242	263	302	288	247	160
137	163	184	197	220	233	226	200	187	163	132
89	91	97	101	115	118	104	100	94	86	79

Chevy 2 bike rack propped with 2 bikes (7)

90	128	171	242	225	166	159	212	241	197	133
104	118	131	150	151	139	127	136	134	114	115
65	62	61	59	64	68	66	59	61	62	66

Appendix D

ECE R112 – Approval of Motor Vehicle Equipped with Filament Headlamps
(only portion related to headlamp measurement, section 6)

that, in each of its two settings, the filament lamp will be held in position with the precision required for headlamps designed for traffic on only one side of the road. Conformity with the requirements of this paragraph shall be verified by visual inspection and, where necessary, by a test fitting.

- 5.7. Complementary tests shall be done according to the requirements of Annex 4 to ensure that in use there is no excessive change in photometric performance.
- 5.8. If the lens of the headlamp is of plastic material, tests shall be done according to the requirements of Annex 6.
- 5.9. On headlamps designed to provide alternately a driving beam and a passing beam, or a passing beam and/or a driving beam designed to become bend lighting, any mechanical, electromechanical or other device incorporated in the headlamp for these purposes shall be so constructed that:
- 5.9.1. the device is strong enough to withstand 50,000 operations without suffering damage despite the vibrations to which it may be subjected in normal use;
- 5.9.2. in the case of failure the illumination above the line H-H shall not exceed the values of a passing beam according to paragraph 6.2.5.; in addition, on headlamps designed to provide a passing and/or a driving beam to become a bend lighting, a minimum illumination of at least 5 lux shall be fulfilled in test point 25 V (VV line, D 75 cm).
- 5.9.3. either the passing beam or the driving beam shall always be obtained without any possibility of the mechanism stopping in between two positions;
- 5.9.4. the user cannot, with ordinary tools, change the shape or position of the moving parts.

6. ILLUMINATION

6.1. General provisions

- 6.1.1. Headlamps shall be so made that they give adequate illumination without dazzle when emitting the passing beam, and good illumination when emitting the driving beam.
- 6.1.2. The illumination produced by the headlamp shall be determined by means of a vertical screen set up 25 m forward of the headlamp and at right angles to its axes as shown in Annex 3 to this Regulation.
- 6.1.3. The headlamps shall be checked by means of an uncoloured standard (étalon) filament lamp designed for a rated voltage of 12 V. During the checking of

the headlamp, the voltage at the terminals of the filament lamp shall be regulated so as to obtain the reference luminous flux as indicated at the relevant data sheet of Regulation No. 37.

6.1.4. The headlamp shall be considered acceptable if it meets the requirements of this paragraph 6 with at least one standard (étalon) filament lamp, which may be submitted with the headlamp.

6.2. Provisions concerning passing beams

6.2.1. The passing beam must produce a sufficiently sharp "cut-off" to permit a satisfactory adjustment with its aid. The "cut-off" must be a horizontal straight line on the side opposite to the direction of the traffic for which the headlamp is intended; on the other side, it must not extend beyond either the broken line HV H₁ H₄ formed by a straight line HV H₁ making a 45° angle with the horizontal and the straight line H₁ H₄, 25 cm above the straight line hh, or the straight line HV H₃, inclined at an angle of 15° above the horizontal (see Annex 3). A cut-off extending beyond both line HV H₂ and line H₂ H₄ and resulting from a combination of the two above possibilities shall in no circumstances be permitted.

6.2.2. The headlamp shall be so aimed that:

6.2.2.1. in the case of headlamps designed to meet the requirements of right-hand traffic, the "cut-off" on the left-half of the screen 8/ is horizontal and, in the case of headlamps designed to meet the requirements of left-hand traffic, the "cut-off" on the right-half of the screen is horizontal;

6.2.2.2. this horizontal part of the "cut-off" is situated on the screen 25 cm below the level hh (see Annex 3);

6.2.2.3. the "elbow" of the "cut-off" is on line vv. 9/

6.2.3. When so aimed, the headlamp need, if its approval is sought solely for provision of a passing beam, 10/ comply only with the requirements set out in

8/ The test screen must be sufficiently wide to allow examination of the "cut-off" over a range of at least 5° on either side of the line vv.

9/ If the beam does not have a cut-off with a clear "elbow", the lateral adjustment shall be effected in the manner which best satisfies the requirements for illumination at points 75 R and 50 R for right-hand traffic and for points 75 L and 50 L for left-hand traffic.

10/ Such a special "passing beam" headlamp may incorporate a driving beam not subject to requirements.

paragraphs 6.2.5. to 6.2.7. and 6.2.9. below; if it is intended to provide both a passing beam and a driving beam, it shall comply with the requirements set out in paragraphs 6.2.5. to 6.2.7. and 6.3.

6.2.4. Where a headlamp so aimed does not meet the requirements set out in paragraphs 6.2.5. to 6.2.7. and 6.3., its alignment may be changed, provided that the axis of the beam is not displaced laterally by more than 1° (= 44 cm) to the right or left. 11/ To facilitate alignment by means of the "cut-off", the headlamp may be partially occulted in order to sharpen the "cut-off".

6.2.5. The illumination produced on the screen by the passing beam shall meet the following requirements:

Point on measuring screen		Required illumination in lux	
Headlamps for right-hand traffic	Headlamps for left-hand traffic	Class A headlamp	Class B headlamp
Point B 50 L	Point B 50 R	≤ 0.4	≤ 0.4
Point 75 R	Point 75 L	≥ 6	≥ 12
Point 75 L	Point 75 R	≤ 12	≤ 12
Point 50 L	Point 50 R	≤ 15	≤ 15
Point 50 R	Point 50 L	≥ 6	≥ 12
Point 50 V	Point 50 V	-	≥ 6
Point 25 L	Point 25 R	≥ 1.5	≥ 2
Point 25 R	Point 25 L	≥ 1.5	≥ 2
Any point in zone III		≤ 0.7	≤ 0.7
Any point in zone IV		≥ 2	≥ 3
Any point in zone I		≤ 20	≤ 2E <u>*/</u>
<u>*/</u> E is the actually measured value in points 50R respectively 50L			

6.2.6. There shall be no lateral variations detrimental to good visibility in any of the zones I, II, III and IV.

6.2.7. The illumination values in zones "A" and "B" as shown in figure C in Annex 3 shall be checked by the measurement of the photometric values of

11/ The limit of realignment of 1° towards the right or left is not incompatible with upward or downward vertical realignment. The latter is limited only by the requirements of paragraph 6.3. However, the horizontal part of the "cut-off" should not extend beyond the line hh (the provisions of paragraph 6.3. are not applicable to headlamps intended to meet the requirements of this Regulation only for provision of a passing beam).

points 1 to 8 on this figure; these values shall lie within the following limits: 12/

$$1 + 2 + 3 \geq 0.3 \text{ lux, and}$$

$$4 + 5 + 6 \geq 0.6 \text{ lux, and}$$

$$0.7 \text{ lux} \geq 7 \geq 0.1 \text{ lux and}$$

$$0.7 \text{ lux} \geq 8 \geq 0.2 \text{ lux}$$

- 6.2.8. Headlamps designed to meet the requirements of both right-hand and left-hand traffic must, in each of the two setting positions of the optical unit or of the filament lamp, meet the requirements set forth above for the corresponding direction of traffic.
- 6.2.9. The requirements in paragraph 6.2.5. above shall also apply to headlamps designed to provide bend lighting and/or that include the additional light source referred to in paragraph 6.2.10.2.
- 6.2.9.1. If bend lighting is obtained by:
- 6.2.9.1.1. swivelling the passing beam or moving horizontally the kink of the elbow of the cut-off, the measurements shall be carried out after the complete headlamp assembly has been reaimed horizontally, e.g. by means of a goniometer;
- 6.2.9.1.2. moving one or more optical parts of the headlamp without moving horizontally the kink of the elbow of the cut-off, measurements shall be carried out with these parts being in their extreme operating position;
- 6.2.9.1.3. means of one additional light source without moving horizontally the kink of the elbow of the cut-off, measurements shall be carried out with this light source activated.
- 6.2.10. Only one principal light source is permitted for each passing beam headlamp. However, a maximum of two additional light sources are permitted as follows:
- 6.2.10.1. One additional light source inside the passing beam headlamp according to Regulation No. 37 may be used to contribute to bend lighting.

12/ Illumination values in any point of zones A and B, which also lies within zone III, shall not exceed 0.7 lux.

6.2.10.2. One additional light source according to Regulation No. 37, inside the passing beam headlamp, may be used for the purposes of generating infrared radiation. It shall only be activated at the same time as the principal light source. In the event that the principal light source fails, this additional light source shall be automatically switched off.

6.2.10.3. In the event of failure of an additional light source, the headlamp shall continue to fulfil the requirements of the passing beam.

6.3. Provisions concerning driving beams

6.3.1. In the case of a headlamp designed to provide a driving beam and a passing beam, measurements of the illumination produced on the screen by the driving beam shall be taken with the same headlamp alignment as for measurements under paragraphs 6.2.5. to 6.2.7. above; in the case of a headlamp providing a driving beam only, it shall be so adjusted that the area of maximum illumination is centred on the point of intersection of lines hh and vv; such a headlamp need meet only the requirements referred to in paragraph 6.3.

6.3.2. It is possible to use several light sources for the driving beam.

6.3.3. The illumination produced on the screen by the driving beam shall meet the following requirements.

6.3.3.1. The point of intersection (HV) of lines hh and vv shall be situated within the isolux 80 per cent of maximum illumination. This maximum value (E_M) shall not be less than 32 lux for Class A headlamps and 48 lux for Class B headlamps. The maximum value shall in no circumstances exceed 240 lux; in addition, in the case of a combined passing and driving headlamp, this maximum value shall not be more than 16 times the illumination measured for the passing beam at point 75 R (or 75 L).

6.3.3.1.1. The maximum intensity (I_M) of the driving beam expressed in thousands of candelas shall be calculated by the formula:

$$I_M = 0.625 E_M$$

6.3.3.1.2. The reference mark (I'_M) of this maximum intensity, referred to in paragraph 4.2.2.7. above, shall be obtained by the ratio:

$$I'_M = \frac{I_M}{3} = 0.208 E_M$$

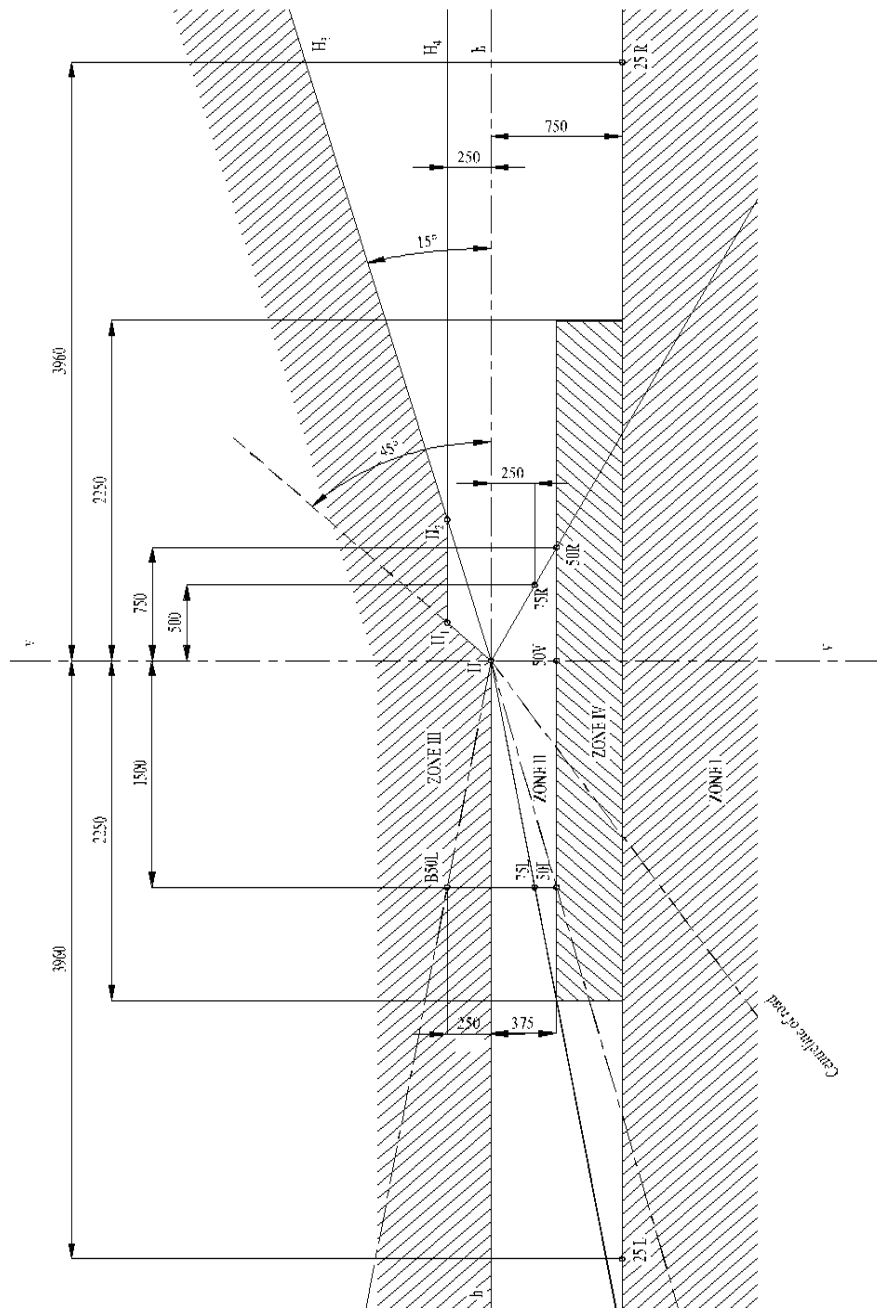
This value shall be rounded off to the value 7.5 - 10 - 12.5 - 17.5 - 20 - 25 - 27.5 - 30 - 37.5 - 40 - 45 - 50.

- 6.3.3.2. Starting from point HV, horizontally to the right and left, the illumination shall be not less than 16 lux for Class A headlamp and 24 lux for Class B headlamp up to a distance of 1.125 m and not less than 4 lux for Class A headlamp and 6 lux for Class B headlamp up to a distance of 2.25 m.
- 6.4. In the case of headlamps with adjustable reflector the requirements of paragraphs 6.2. and 6.3. are applicable for each mounting position indicated according to paragraph 2.1.3. For verification the following procedure shall be used:
- 6.4.1. Each applied position is realized on the test goniometer with respect to a line joining the centre of the light source and point HV on a aiming screen. The adjustable reflector is then moved into such a position that the light pattern on the screen corresponds to the aiming prescriptions of paragraphs 6.2.1. to 6.2.2.3. and/or 6.3.1;
- 6.4.2. with the reflector initially fixed according to paragraph 6.4.1., the headlamp must meet the relevant photometric requirements of paragraphs 6.2. and 6.3;
- 6.4.3. additional tests are made after the reflector has been moved vertically $\pm 2^\circ$ or at least into the maximum position, if less than 2° , from its initial position by means of the headlamps adjusting device. Having re-aimed the headlamp as a whole (by means of the goniometer for example) in the corresponding opposite direction the light output in the following directions shall be controlled and lie within the required limits:
- passing beam : points HV and 75 R (75 L respectively);
driving beam : E_M and point HV (percentage of E_M).
- 6.4.4. if the applicant has not indicated more than one mounting position, the procedure of paragraphs 6.4.1. to 6.4.3. shall be repeated for all other positions;
- 6.4.5. if the applicant has not asked for special mounting positions, the headlamp shall be aimed for measurements of paragraphs 6.2. and 6.3. with the headlamps adjusting device in its mean position. The additional test of paragraph 6.4.3. shall be made with the reflector moved into its extreme positions (instead of $\pm 2^\circ$) by means of the headlamps adjusting device.
- 6.5. The screen illumination values mentioned in paragraphs 6.2.5. to 6.2.7. and 6.3. above shall be measured by means of a photo receptor, the effective area of which shall be contained within a square of 65 mm side.

Annex 3

MEASURING SCREEN

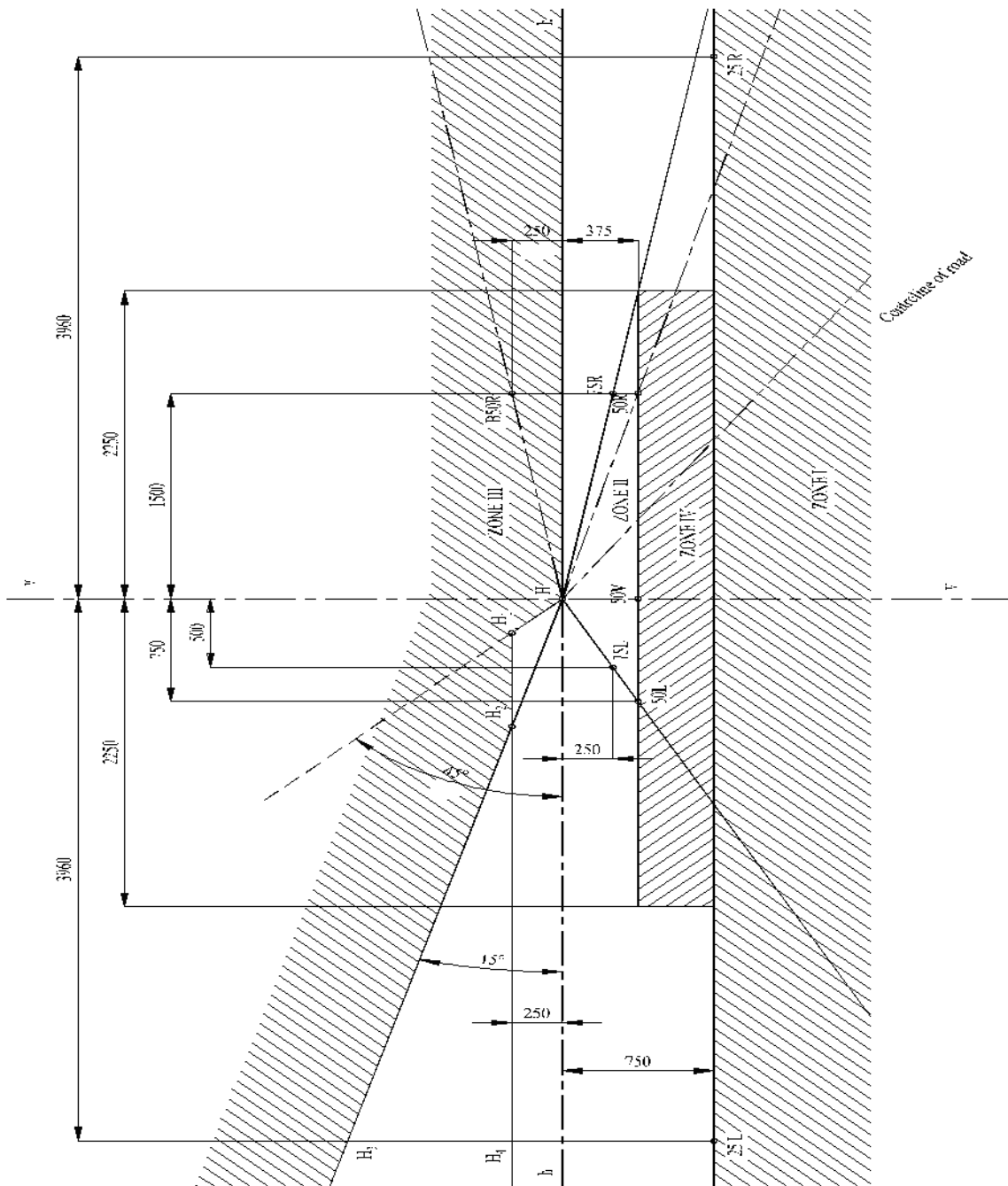
A. Headlamp for right-hand traffic
 (dimension in mm with screen at 25 m distance)



h-h : horizontal plane) passing through
 v-v : vertical plane) focus of headlamp

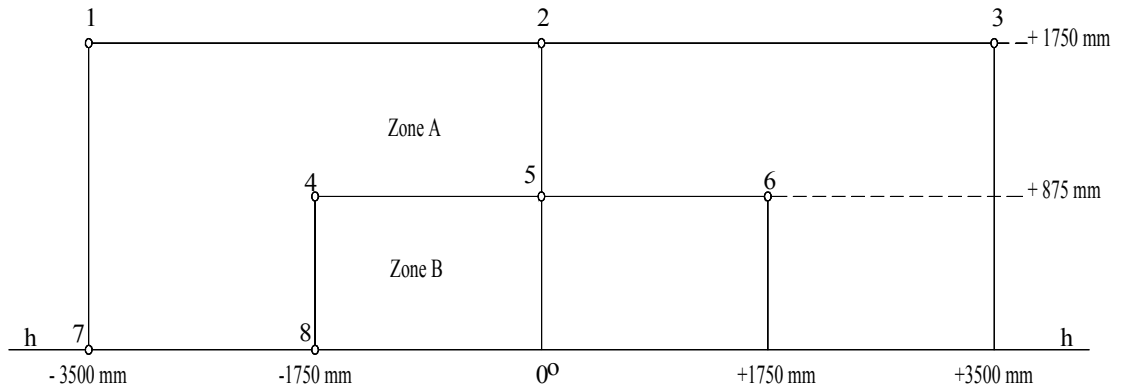
B. Headlamp for left-hand traffic
 (dimension in mm with screen at 25 m distance)

STANDARD EUROPEAN BEAM



h-h : horizontal plane) passing through
 v-v : vertical plane) focus of headlamp

Figure C



Note: Figure C shows the measuring points for right-hand traffic. Points 7 and 8 move to their corresponding location at the right-hand side of the picture for left-hand traffic.

Appendix E

Raw Data 40 ft. Gillig Testing 3/13/2013

40 ft. Gillig 3/13/13 (LUX measured at 1 ft. intervals)

											Row Avg.	Total Lux	% Obstr.
No Bikes, rack stowed - (test 1)													
1	2	3	5	7	7	6	5	5	6	28	6.8		
20	19	21	74	120	91	63	59	80	117	122	71.5		
27	41	66	114	123	105	68	60	90	115	112	83.7	1782	
No Bikes, rack down - (test 2)													
1	2	3	5	7	7	5	5	5	6	28	6.7		
22	25	37	71	120	92	62	59	80	116	124	73.5		
25	40	68	112	122	104	66	61	89	116	113	83.3	1798	
Three bikes, config. 1 - (test 3)													
0	0	0	2	4	2	0	0	1	3	18	2.7		
1	4	11	61	110	71	35	19	49	96	109	51.5		
5	15	17	99	103	79	37	23	43	88	88	54.3	1193	33%
Three bikes, config. 2 - (test 4)													
0	0	1	2	5	3	1	0	2	3	16	3.0		
4	20	32	67	106	70	36	19	49	91	65	50.8		
9	35	57	90	99	76	36	25	60	94	72	59.4	1245	30%
Three bikes, config. 3 - (test 5)													
0	0	2	3	6	5	3	3	3	4	30	5.4		
13	25	35	61	109	74	32	49	62	92	108	60.0		
17	32	57	92	115	81	39	52	67	95	99	67.8	1465	18%
No bikes, rack stowed - (test 6)													
0	0	2	3	6	5	3	3	3	4	30	5.4		
21	25	38	73	119	93	61	58	77	114	123	72.9		
24	38	63	108	121	103	66	59	85	112	112	81.0	1752	
No bikes, average (tests 1, 2, 6)													
0.7	1.3	2.7	4.3	6.7	6.3	4.7	4.3	4.3	5.3	28.7	6.3		
21.0	23.0	32.0	72.7	119.7	92.0	62.0	58.7	79.0	115.7	123.0	72.6		
25.3	39.7	65.7	111.3	122.0	104.0	66.7	60.0	88.0	114.3	112.3	82.7	1777.3	
Three bikes, average (config 1, 2, 3)													
0.0	0.0	1.0	2.3	5.0	3.3	1.3	1.0	2.0	3.3	21.3	3.7		
6.0	16.3	26.0	63.0	108.3	71.7	34.3	29.0	53.3	93.0	94.0	54.1		
10.3	27.3	43.7	93.7	105.7	78.7	37.3	33.3	56.7	92.3	86.3	60.5	1301.0	
Reduction in LUX from avg. unobstructed to 3 bike configuration													
0.7	1.3	1.7	2.0	1.7	3.0	3.3	3.3	2.3	2.0	7.3	2.6		
15.0	6.7	6.0	9.7	11.3	20.3	27.7	29.7	25.7	22.7	29.0	18.5		
15.0	12.3	22.0	17.7	16.3	25.3	29.3	26.7	31.3	22.0	26.0	22.2	476.3	27%
Average percent reduction (per measurement)													
100%	100%	63%	46%	25%	47%	71%	77%	54%	38%	26%	41%		
71%	29%	19%	13%	9%	22%	45%	51%	32%	20%	24%	26%		
59%	31%	34%	16%	13%	24%	44%	44%	36%	19%	23%	27%		