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RATIONALE OF HARMONIZED PASSING (DIPPED) BEAM PATTERN

Transmitted by the Expert from the Working Party “Brussels 1952" (GTB)

Note: The text reproduced below was prepared by the Chairman of the GTB Coordinating Committee in order to propose a beam pattern which would be suitable world-wide and increase safety in night driving.

Note: This document is distributed to the Experts on Lighting and Light-Signalling only.

RATIONALE OF HARMONIZED PASSING (DIPPED) BEAM PATTERN

1. BACKGROUND

At its twenty-fourth session GRE formally requested GTB to prepare proposals on a new harmonized dipped beam pattern, given the scientific and industrial expertise of GTB in this field. GTB accepted this task and established the Coordinating Committee; whose members are:

Mr. Guy Dorleans, Valeo, Chairman GTB Harmonization Working Group (WG)
Mr. Jeff Erion, Visteon, Chairman SAE Lighting Committee
Mr. David Grainger, SMMT, representing OICA
Mr. Masao Muraoka, Koito, representing JASIC
Dr. Kare Rumar, Sweden, Swedish Research Institute
Dr. Hans Schmidt-Clausen, University of Darmstadt
Mr. Wim Van Dam, Philips, Chairman GTB Light Sources WG
Mr. Hanno Westermann, Hella, Chairman GTB SVP WG
Dr. David Moore, Continental Design, Chairman

The general approach of the Coordinating Committee has been to find a harmonized beam pattern that improves safety by offering better (or at least maintaining the present level of) driver visibility, but which at the same time can accommodate the present systems and headlamp construction principles of European, Japanese, and U.S. headlamps. This is meant to establish a dipped beam pattern which gives a good balance between adequate illumination for visibility and low illumination to control glare for oncoming traffic. The illumination for visibility should cover the following main target areas:

- Road in front of the vehicle;
- Road markings;
- Targets on or along the road;
- Areas straight ahead, also right and left;
- Signs, both along the road and above the roadway.

The established beam pattern should contain a reasonable number, but not an excessive number, of test points to maintain or improve seeing safety.
The work of the Coordinating Committee has been to prepare a bibliography of 94 technical papers relating to dipped beam headlamps. This bibliography provided the basis for future discussions and evaluations by the Committee. The Coordinating Committee commissioned a research study by the University of Michigan Transportation Research Institute. This study recommended 4 common test points. A consensus was reached within the Coordinating Committee that a slightly modified version of these 4 test points should form the basis of the harmonized beam pattern. These test points are:

Test Point 1	0.6D-1.3R
Test Point 2	0.86D-V
Test Point 3	0.86D-3.5L
Test Point 4	0.5U-1.5L

Several times since our original basic agreement these test points have been discussed and re-evaluated by the Committee. In each case a decision was made to retain the location of these test points. They still remain as listed above.

These test points form the core or basic component of a beam pattern. They cover the main seeing light area to the right (0.6D-1.3R); main seeing light area straight ahead (0.86D-V); left seeing light area (0.86D-3.5L); and a glare limit for opposing drivers (0.5U-1.5L).

While the four common test points are important and significant, they do not form a complete beam pattern. The next step was to determine the remainder of the test points to form a complete beam pattern. At a meeting in Skukuza, South Africa in November 1998, a consensus was reached on the complete beam pattern. This is summarized in Attachment 1. There are several tables at different voltages and a figure showing the test point, line, and zone locations.

The following rationale will explain the details of the test points, lines, zones, and intensity values.
All candela intensity numbers listed are meant to be:

In Europe: Type Approval values, reference luminous flux at approx. 12.0 V
In the U.S.: Design to Conform values, reference luminous flux at approx. 12.8 V

2. LIGHT BELOW THE HORIZONTAL

It is universally recognized that the predominant need for the driver in a night time driving situation is forward visibility. Driving with driving (high) beam headlamps illuminated all the time would be ideal. In fact, research has shown that for drivers, to be able to properly handle their driving task at night, and properly deal with pedestrians, objects on the road, and other unforeseen occurrences, each headlamp should be producing over 300,000 cd (Netherlands study by Padmos, 1988) to make the lighted environment comparable to daylight traffic). Only when auxiliary driving lamps are used is this value approached, with a severe penalty in energy consumption. In the dipped (low) beam situation, which is by far the most frequently used beam, the headlamp designer attempts to provide as much illumination into the forward field of view as practicable. In most developed countries approximately 75-90% of the night driving is done using low beam headlamps.

From a human factors standpoint, it is preferable for the driver to have his eyes focused as far down the road as possible to be able to maintain his lane position and recognize/react to objects and pedestrians on the road. In daylight, drivers focus their eyes several hundred feet ahead of the vehicle. It is important, therefore, to have the maximum intensity of the beam pattern relatively near the horizon and to have uniform luminance in the foreground. There is a reduction of driver performance when the eye position is guided toward excessively high or spotty foreground illumination. The driver must have sufficient time to prepare for his actions; to see the road and the possibility of any obstacles on or near the road.

From a safety related point of view, headlighting is more directly involved in the ability of the driver to see the road and roadway features and obstacles. Recent data by a researcher from Franklin & Marshall College (Owens, 1993) provides strong evidence for the relation between illumination and accidents.

Improved lighting would certainly play a part in reducing the number of nighttime accidents. Since the headlamps are so related to the environment, there must be a mutual effort from headlamp designers, headlamp manufacturers, vehicle manufacturers, and roadway engineers to accomplish the best balance of overall performance.

The highest practical output of the headlamp in combination with the lowest possible oncoming glare (or any other veiling light) should produce the best forward visibility. Most researchers agree that, in principal, this would be ideal. Considering the other requirements of a headlighting system to illuminate overhead signs and to be able to see different visibility objects, the allowed glare limits must be set to fulfil these needs. That means, for any increase in visibility, the level of forward illumination must be increased. Where the ratio between the forward illumination and the opposing glare/veiling glare/ambient light is the highest, we can expect the best overall visibility under glare conditions. There is a practical limit to the sharp gradient that is produced. A very sharp gradient becomes noticeable in the field of the view of the driver at about 60 m down the road. This occurred with the development of the projector style headlamps with very strong gradients and criticism was received from both U.S. and European drivers.

Test Point 1 is located at 0.6D-1.3R with a value of 10,000/8,000 cd minimum (U.S. 12.8 V/ECE 12.0 V). It ultimately controls the position of the high intensity portion of the beam down the road, and particularly along the right road edge. The closest test point in U.S. FMVSS 108 is at 0.5D-1.5R with a value of 10,000 - 20,000 cd (12.8 V), and the closest ECE test point is 0.57D-1.14R with a value of 12 lx (7,500 cd at 12.0 V). The proposed value for this point would represent a slight improvement in visibility illumination for the U.S., ECE, and Japan.

3. WIDE SPREAD

The vehicle lighting system must provide adequate illumination for the critical nighttime driving tasks of vehicle guidance, obstacle detection and recognition of traffic control devices. Driving on winding country roads places greater demands on the light available for vehicle guidance and obstacle detection through turns. Ensuring sufficient illumination under these conditions requires minimum light levels to be established at points in the beam pattern that illuminate areas of the road which provide guidance information or may contain obstacles that could be encountered while negotiating curves and turns at intersections. A German researcher, Damasky, concluded in his report on Geometry of the Road Area and Effects on Motor Vehicle Lighting that "Wide illumination is also practical in order to allow the course of the road to be recognized within sufficient time on curvy roads." It is also important and helpful for wide spread light to increase the peripheral detection for the driver’s guidance on the road.

Sufficient lateral spread is essential for safe visual performance on sharp curves and at intersections. Wide spread angles are warranted to provide adequate illumination for guidance through turns and under conditions of poor forward visibility such as fog, snow and rain. A survey of 119 of the world's lighting experts conducted and published in 1993 by Sivak and Flannagan, from the University of Michigan, found that of 16 visual-performance functions, lateral spread was considered the sixth most important. The most important functions were:

1. Right-side targets
2. Oncoming glare
3. Foreground
4. Left-side targets
5. Signs on the right shoulder
6. Lateral spread.

Test Points 6; 2D-15L & 2D-15R control illumination into the area between 20 and 30 meters down the road and out 4 to 5 meters to either side of the road. Test Points 7; 4D-20L & 4D-20R control illumination into the area between 8 and 20 meters down the road and out 3 to 4 meters to either side of the road. Together, these points cover the area that needs to be illuminated to provide guidance and obstacle detection during sharp turns and adverse weather conditions that reduce down road visibility. The photometry values chosen, 1000/800 cd and 300/240 cd (U.S. 12.8 V/ECE 12.0 V), respectively, provide sufficient light for the guidance function of headlamps.

4. LIGHT ABOVE THE HORIZONTAL

The importance of the control of light above the horizontal has been recognized by all of the Committee members. Test points, lines, and zones are in the beam pattern to provide glare limits and minimum sign light requirements. Illumination of overhead signs, referred to as "sign light" has also been covered in the beam pattern by Test Point 9 and the eight sign light test points. While the sign light test points are now in the ECE Regulations and in FMVSS 108, there are some revisions in this proposal from the present regulations.

Test Point 4, 0.5U-1.5L, (one of the four common test points) replaces the existing B50L (0.57U-3.43L) now in the ECE Regulations. The proposed Test Point 1 and Zone 1 intensity value (840/672 cd at U.S. 12.8 V/ECE 12.0 V) is slightly increased (23%) from the present ECE regulation Zone III value. The present Type Approval value in ECE Zone III is 0.7 lux at 12.0 V. Transforming this to 12.8 V is a 25% increase (0.7 lux at 12.0 V becomes 0.875 lux at 12.8 V). 0.875 lux equals 547 cd. 840/547 = 1.228, approx 1.23. Also the associated distance to the opposing driver's eyepoint is also increased; (0.5U-1.5L is closer to H-V, than B50L (0.57U-3.43L)). The U.S. intensity of 840 cd is a 16% reduction from 1000 cd presently allowed in FMVSS 108 at this test point. Furthermore, this intensity is far below the value recommended by a Dutch researcher, Alferdinck, as a reasonable maximum value at this point (1,370 cd). Because the actual headlamp beam pattern intensity decreases as the test point moves to the left from the vertical line and as the test point moves up from the horizontal line, having a maximum regulation value of 840 cd (12.8 V) at 0.5U-1.5L is practically unchanged from 438 cd (12.0v) at B50L (0.57U-3.43L). The conversion factor for 12.0 V to 12.8 V is 25%. An approximate conversion from a test point at 1.5L to a test point at 3.43L is 40% (the exact number depends on the headlamp bulb being used and the accompanying beam pattern).

438 x 1.25 x 1.4 = 766

During actual driving situations; hills, curves, and turns; the location of the opposing drivers' eyepoint changes. A beam pattern makes a compromise to select one point for testing.

Zone 1, Zone 2, and Zone 3 are essentially equivalent to Zone III of the present ECE Regulations. These new zones are shown in Attachment 1. Zone 1 has a maximum value of 840 cd at 12.8 V. All of the explanations above for Test Point 4 apply exactly for Zone 1. Zone 2, directly above Zone 1, allows a general maximum intensity of 250 cd (12.8 V) with a very localized maximum (2° conical angle) of 750 cd (12.8 V). Zone 3, directly above Zone 2, allows a general maximum intensity of 125 cd (12.8 V) with a very localized maximum (2° conical angle) of 500 cd (12.8 V). It is the intent that Zones 2 and 3 are not scanned throughout the complete zones or boundaries, but they are checked "in case of doubt", where there are some streaks or intense concentrations of light. Lines 12, 13, and 14 are to be scanned through the total length specified. The eight sign light test points contained in or near Zone 1 provide the only minimum requirements in or near Zone 1. Line 14 from 10U to 90U provides control of glare light that would be detrimental in fog or snow conditions. This new line has a maximum value of 125 cd (12.8 V). This limit will provide improved visibility to the driver in fog or snow. Lines 12, 13, and 14 also have the localized maximum (2° conical angle) tolerance allowed with the stated maximum values.

Test Point 9 provides another sign light (minimum value) requirement which has been added at 0.5U-2.0R. The minimum value of 600 cd (12.8 V) is increased from the value of 500 cd contained in FMVSS 108. This will provide improved visibility for right road side retroreflective signs. A maximum value of 2500 cd, is decreased from the value of 2700 cd now in FMVSS 108, and is specified to help control glare in this area, see Attachment 1. This also helps control the light directly below Zone 1 which is only 1.0° away in the vertical direction with a maximum limit of 840 cd.

5. H-V TEST POINT

Zone 1 includes most of the area of the possible eyepoint locations of opposing drivers. There is some percentage of time when eyepoints will be at the H-V location. In flat straight roads the opposing drivers' eyepoint at H-V will be at a long distance. During dynamic driving situations with hills, curves, and turns the opposing driver's eyepoint will move around but the length of time at H-V, if at all, will be rather small. In passing situations on two lane roads, at short distances 50-100 m, the opposing driver's eyepoint is only very rarely at H-V.

There are two test points and one zone near H-V which will significantly control the light intensity at H-V. Test Point 1, 0.6D-1.3R and Test Point 2, 0.86D-V each have a minimum intensity requirement. Zone 1 has a maximum intensity requirement of 840 cd (12.8 V).

The Coordinating Committee has had more discussion about H-V and the associated intensity value than any other part of the beam pattern. The results of all of our discussions are as follows: At H-V for the U.S., Design to Conform, 12.8 V the specified value will be 1,800 cd maximum. The nominal aim for photometry will be:

Vertical 0.4°D
Horizontal 0° (Evaluate the SVP results whenever they are available)

The allowed tolerances for photometry will be:

Vertical 0.3°D to 0.8°D
Horizontal ±0.5°L-R

At H-V for Europe, Type Approval, 12.0 V the specified value will be 1,200 cd maximum.
The nominal aim for photometry will be:
Vertical 1%D (0.57°D)
Horizontal Kink on V-V

The allowed tolerances for photometry will be:
Vertical 0.3°D to 0.8°D
Horizontal ±0.5°L-R

There is very close agreement considering the differences in voltage and the difference between Type Approval, COP, and Design to Conform. The following will explain this with numbers and words.

In the U.S. at 12.8 V, under Design to Conform, most cars will have headlamps with the H-V candela intensity value below 1,800 cd. If the ECE Type Approval value at 12.0 V is 1,200 cd (1.92 lux) maximum, in COP this will be increased 0.3 lux (187.5 cd) or may be 0.5 lux (312.5 cd). Then when these numbers are converted to 12.8 V 1,387.5 cd (12.0 V) becomes 1,734 cd (12.8 V) and 1,512.5 cd (12.0 V) becomes 1,890 cd (12.8 V). Cars in Europe are going to be below the specified COP value which corresponds to the U.S. Design to Conform values. Even though the numbers look different they really are almost equivalent.

6. CONCLUSION

The Coordinating Committee felt that it has been able to find a good lighting engineering compromise between all of the conflicting goals it has faced. The Committee has succeeded in proposing a beam pattern that, if implemented, will increase safety in night driving all over the world.

HARMONIZED BEAM PATTERN--GTB COORDINATING COMMITTEE PROPOSAL AFTER WARWICK, ENGLAND; MAY 11, 1999
TYPE APPROVAL VALUES; REFERENCE LUMINOUS FLUX at 12.0v

TEST POINT	Position in B-β Grid Vertical β	Horizontal B	Minimum Intensity cd **	Maximum Intensity cd **	Radial Illuminance in Lux at 25 m Minimum	Maximum
1	0.60 D	1.3 R	8,000	-	12.8	-
2	0.86 D	0	3,600	-	5.8	-
3	0.86 D	3.5 L	1,440	9,600	2.3	15.4
4	0.50 U	1.50 L	-	672		1.08
5	0.50 D	4.0 R	4,000	-	6.4	-
6	2.00 D	15 L & 15 R	800	-	1.28	-
7	4.00 D	20 L & 20 R	240	-	0.38	-
8	0	0	-	1200	-	1.92
9	0.50 U	2 R	480	2,000	0.77	3.2
Line 10	4.00 D	4 L to 4 R	-	< 30% of Max. Intensity and in any case < 8,000	-	< 30% of Max. Intensity and in any case < 12.8
Line 11	2.00 D	9 L to 9 R	1,000	-	1.6	-
Line 12	7.00 U	10 L to 10 R	-	200; but 600 if within 2° cone	-	0.3; but 0.96 if within 2° cone
Line 13	10.00 U	10 L to 10 R	-	100; but 400 if within 2° cone	-	0.15; but 0.64 if within 2° cone
Line 14	10 U to 90 U	0	-	100; but 400 if within 2° cone	-	0.15; but 0.64 if within 2° cone
15*	4.00 U	8.0 L	62.5*	672	0.1*	1.08
16*	4.00 U	0	62.5*	672	0.1*	1.08
17*	4.00 U	8.0 R	62.5*	672	0.1*	1.08
18*	2.00 U	4.0 L	125*	672	0.2*	1.08
19*	2.00 U	0	125*	672	0.2*	1.08
20*	2.00 U	4.0 R	125*	672	0.2*	1.08
21*	0	8.0 L	62.5*	-	0.1*	-
22*	0	4.0 L	125*	672	0.2*	1.08
Zone 1	1U/8L-4U/8L-4U/8R-2U/8R-1.5U/6R-1.5U/1.5R-0/1L-0/4L-1U/8L		-	672	-	1.08
Zone 2	>4U to <10 U	10 L to 10 R	-	200; but 600 if within 2° cone	-	0.3; but 0.96 if within 2° cone
Zone 3	10 U to 90 U	10 L to 10 R	-	100; but 400 if within 2° cone	-	0.15; but 0.64 if within 2° cone

Notes on the next page.

Notes:

* During measurement of these points, the front position lamp, if combined or reciprocally incorporated-may be switched on.

** 0.25° tolerance allowed independently at each test point for photometry unless indicated otherwise.

Other general text:

ECE-Type Approval at reference luminous flux according to Regulation No. 37 or at objective luminous flux for gas-discharge light sources according to Regulation No. 99.

Nominal aim for photometry:
Vertical: 1%D (0.57°D)
Horizontal: Kink on V-V

Allowed tolerances for photometry:
Vertical: 0.3°D to 0.8°D
Horizontal: ±0.5° L-R

HARMONIZED BEAM PATTERN--GTB COORDINATING COMMITTEE PROPOSAL
(AFTER WARWICK, ENGLAND; MAY 11, 1999)
DESIGN TO CONFORM VALUES; REFERENCE LUMINOUS FLUX at 12.8 V

TEST POINT	Position in B-β Grid		Minimum Intensity cd **	Maximum Intensity cd **
	Vertical β	Horizontal B		
1	0.60 D	1.3 R	10,000	-
2	0.86 D	0	4,500	-
3	0.86 D	3.5 L	1,800	12,000
4	0.50 U	1.50 L	-	840
5	0.50 D	4.0 R	5,000	-
6	2.00 D	15 L & 15 R	1000	-
7	4.00 D	20 L & 20 R	300	-
8	0	0	-	1800
9	0.50 U	2 R	600	2,500
Line 10	4.00 D	4 L to 4 R	-	< 30% of Max. Intensity and in any case < 10,000
Line 11	2.00 D	9 L to 9 R	1,250	-
Line 12	7.00 U	10 L to 10 R	-	250; but 750 if within 2° cone
Line 13	10.00 U	10 L to 10 R	-	125; but 500 if within 2° cone
Line 14	10 U to 90 U	0	-	125; but 500 if within 2° cone
15*	4.00 U	8.0 L	77*	840
16*	4.00 U	0	77*	840
17*	4.00 U	8.0 R	77*	840
18*	2.00 U	4.0 L	155*	840
19*	2.00 U	0	155*	840
20*	2.00 U	4.0 R	155*	840
21*	0	8.0 L	77*	-
22*	0	4.0 L	155*	840
Zone 1	1U/8L-4U/8L-4U/8R-2U/8R-1.5U/6R-1.5U/1.5R-0/1L-0/4L-1U/8L		-	840
Zone 2	>4U to <10 U	10 L to 10 R	-	250; but 750 if within 2° cone
Zone 3	10 U to 90 U	10 L to 10 R	-	125; but 500 if within 2° cone

Notes on the next page.

Notes:

* During measurement of these points, the front position lamp-if combined or reciprocally incorporated-may be switched on.

** 0.25° tolerance allowed independently at each test point for photometry unless indicated otherwise.

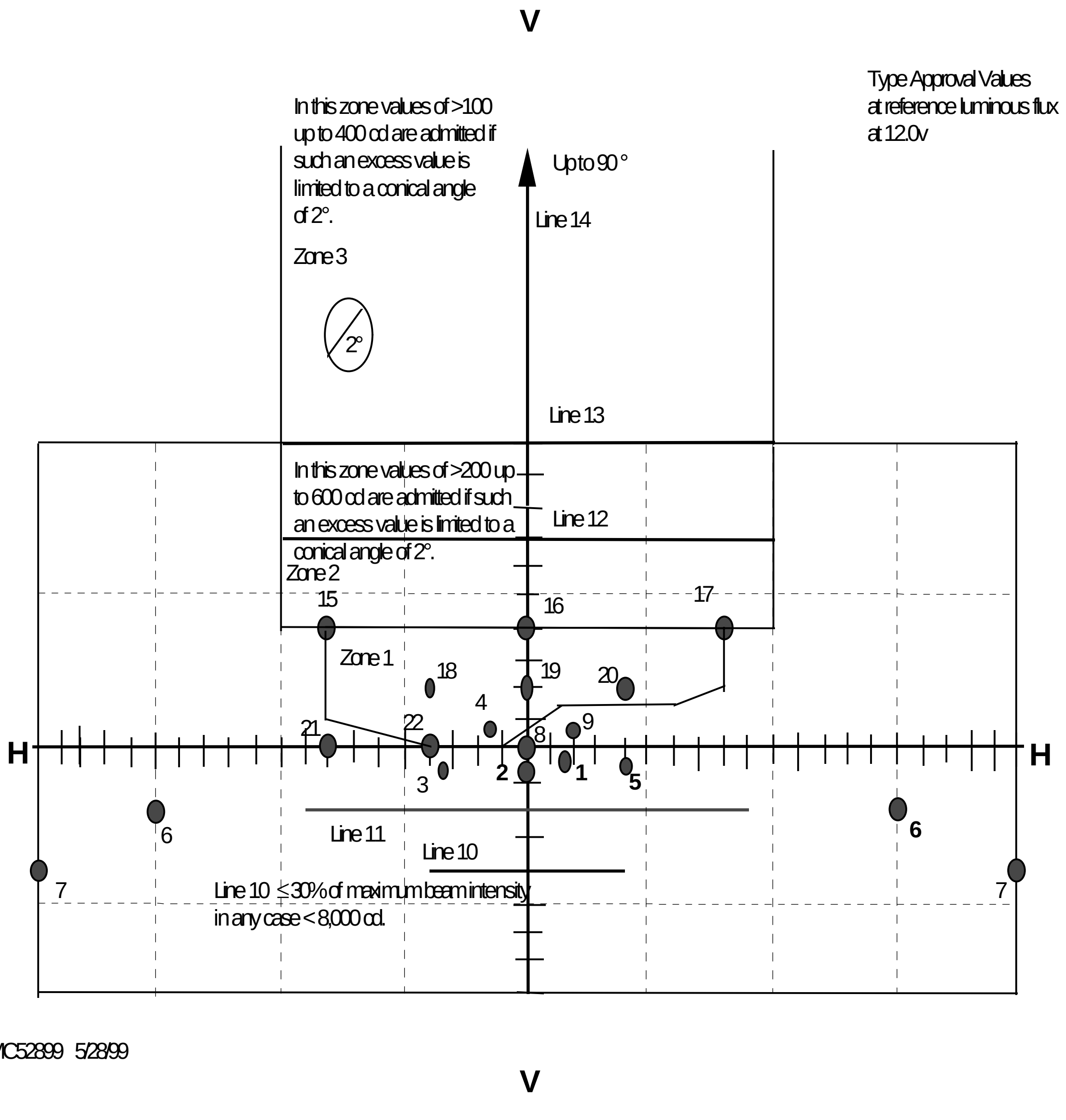
Other general text:

Design to Conform values; reference luminous flux at 12.8v.

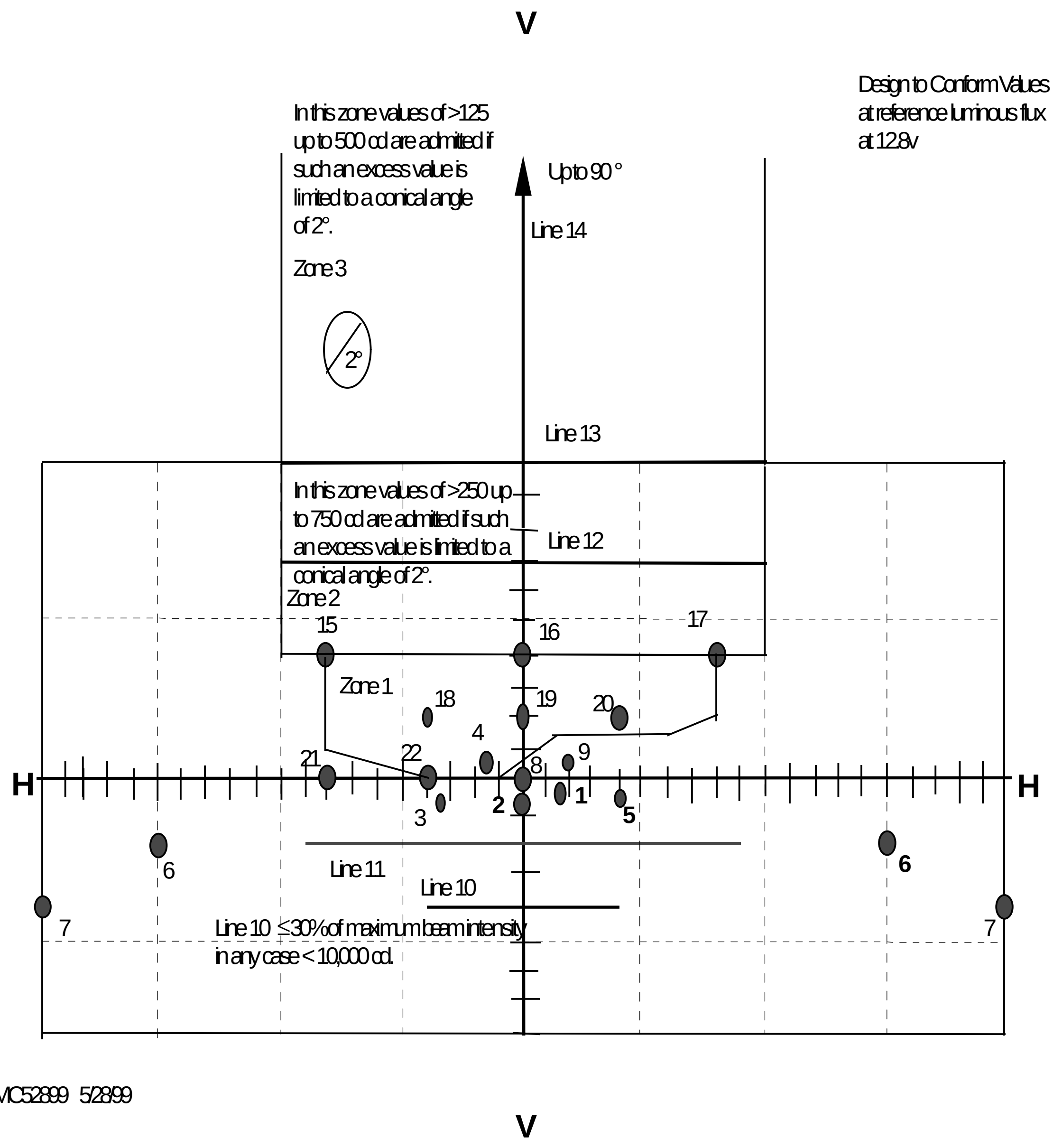
Nominal Aim For Photometry:
Vertical: 0.4°D)
Horizontal: 0° [Evaluate SVP results whenever they are available.]

Allowed Tolerances for Photometry:
Vertical: 0.3°D to 0.8°D
Horizontal: ±0.5° L-R

HARMONIZED LOW BEAM PROPOSAL 5/11/99



HARMONIZED LOW BEAM PROPOSAL 5/11/99



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