

LAMPS, REFLECTIVE DEVICES AND ASSOCIATED EQUIPMENT FMVSS-108

Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb Headlamp

CALCOAST - ITL
Lighting Technology
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San Leandro, CA 94577



28 June 2018

FINAL INDICANT REPORT

PREPARED FOR

U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
1200 New Jersey Avenue SE
Washington, D.C. 20590

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Prepared By:



Approved By:



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16. Abstract The scope of this testing was to compare the performance from aged headlamps with lens haze against the performance from a brand new headlamp with no haze.		13. Type of Report and Period Covered	
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INDUSTRIAL TESTING LABORATORY

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INDICANT TEST REPORT

Report Date: 28 June 2018

Project Name: Haze Study -
2005 to 2007 Chevy Malibu VOR Replaceable Bulb Headlamp
NHTSA Indicant Report 108-CAN-18-012-ISubmitted by: NHTSA Office of Vehicle Safety Compliance
Washington, D.C. 20590Test Laboratory: Calcoast - ITL
San Leandro, CA 94577Samples Submitted: One (1) new 2005 Chevy Malibu LH Replaceable Bulb
Headlamp, supplied by NHTSA, designated "LH1"Four (4) aged 2005 to 2007 Chevy Malibu LH Replaceable
Bulb Headlamps, supplied by NHTSA, designated "H-LH1"
to "H-LH4"**SUMMARY**

The above samples' Lower Beam function were measured and compared to determine the effect of haze due to age and exposure.

Written by:

Approved by:

A blue ink signature of Douglas G. Cummins, written in a cursive style.

Douglas G. Cummins
Photometric Engineer

A blue ink signature of Mark A. Evans, written in a cursive style.

Mark A. Evans
Laboratory Director

SUMMARY SHEET

Project Name: Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb Headlamp

DESCRIPTION:

Four (4) aged driver's side (Left Hand or LH) headlamps from 2005 to 2007 Chevy Malibu vehicles were purchased by NHTSA from various auto recycling yards and sent directly to CCITL. CCITL labeled the headlamps H-LH1 through H-LH4.

Brand new 2005 Chevy Malibu headlamps were purchased by NHTSA and sent directly to CCITL as a part of NHTSA Compliance Report No. 108-CAN-18-012. Sample LH1 was used as a comparison to the aged headlamps. LH1's bulb was used as a light source for the aged headlamps.

PROCEDURE:

Samples mounted on headlamp fixture provided by the lamp manufacturer. Headlamp fixture was mounted on level goniometer with Lower Beam light source located at goniometer center of rotation and tilt with fixture markings aligned parallel and perpendicular to detector axis at HV, then adjusted the headlamp aim hardware until the Lower Beam cutoff was located at H/2.0R and balanced from H/1.0R to H/3.0R (VOR aim). If the Lower Beam cutoff was not suitable for aiming photoelectrically (e.g. on lamps with noticeable haze), the test engineer would attempt to aim the beam visually. If the beam was not able to be aimed visually, the Lower Beam maximum was placed at the same approximate vertical location as on the new headlamp.

After aiming, each sample was tested to FMVSS 108 Table XIX Lower Beam requirements and its color measured at 1.5D/2.0R. Then the luminous intensity from 5U to 10D, 20L to 20R was measured in 0.5° increments and compiled into an isoscan plot. Two additional 5° x 5° isoscan sub-plots were provided to highlight key areas in the scan. The luminous intensity in vertical slices from 10U to 10D in 0.1° increments was also measured at the 1L and V horizontal locations.

The isoscan measured data was then used to generate an isolux plot of the illuminance on the road. The data from the single LH headlamp sample was used to produce the isolux plot of a pair of headlamps with the given mounting height and lamp separation. No data was provided on the headlamps' mounting height or separation so arbitrary values were used representing the mounting height and separation of a similar vehicle's headlamps.

PHOTOMETRIC TEST DATA SHEET

Project Name: Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb Headlamp

Headlamp Aim

LH1 (New)

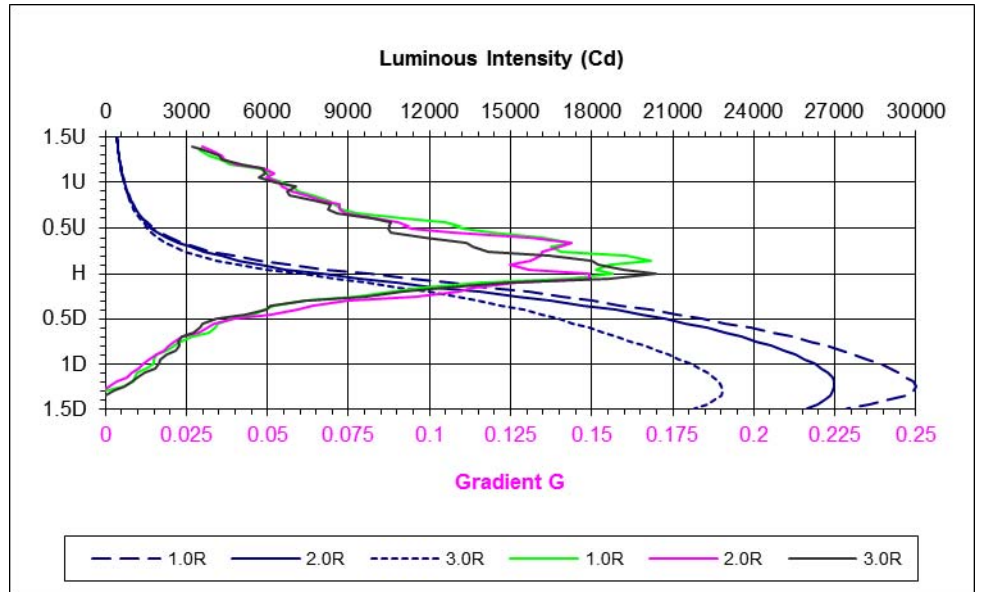
VOR Aim

Maximum Vertical Gradient

Location	Value	Required
0.15U/1.0R	0.168	> 0.13
H/2.0R	0.149	
H/3.0R	0.170	

Horizontal width of cutoff is greater than 2° centered at 2.0R.

Maximum inclination of cutoff is within ±0.2°.



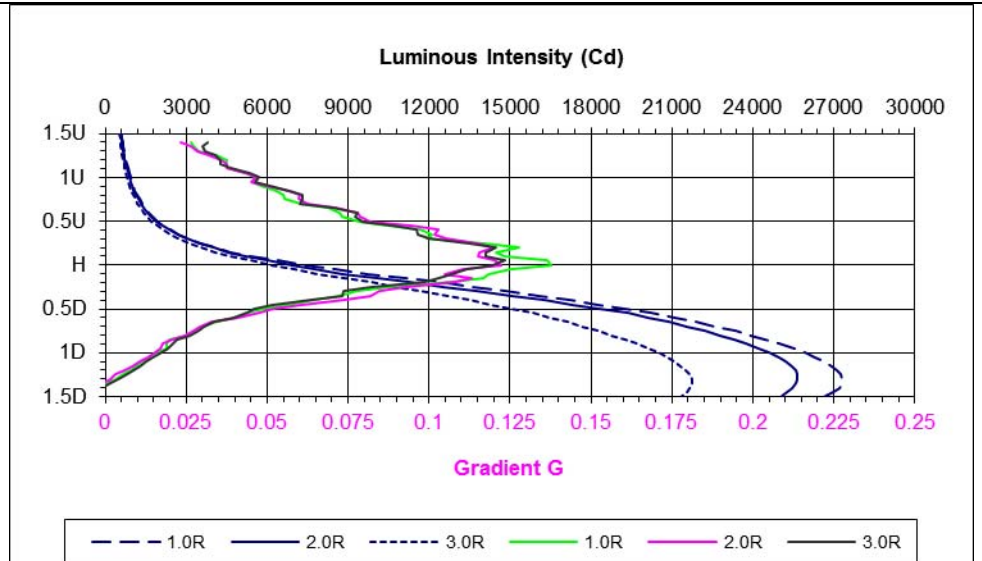
H-LH1 (Haze)

VOR Aim

Maximum Vertical Gradient

Location	Value	Required
H/1.0R	0.138	> 0.13
H/2.0R	0.122*	
0.05U/3.0R	0.124*	

* - denotes failure.



New sample meets S10.18.9 Visual/Optical Aiming cutoff requirements.
 Aged samples do **NOT** meet S10.18.9 Visual/Optical Aiming cutoff requirements.

PHOTOMETRIC TEST DATA SHEET

Project Name: Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb Headlamp

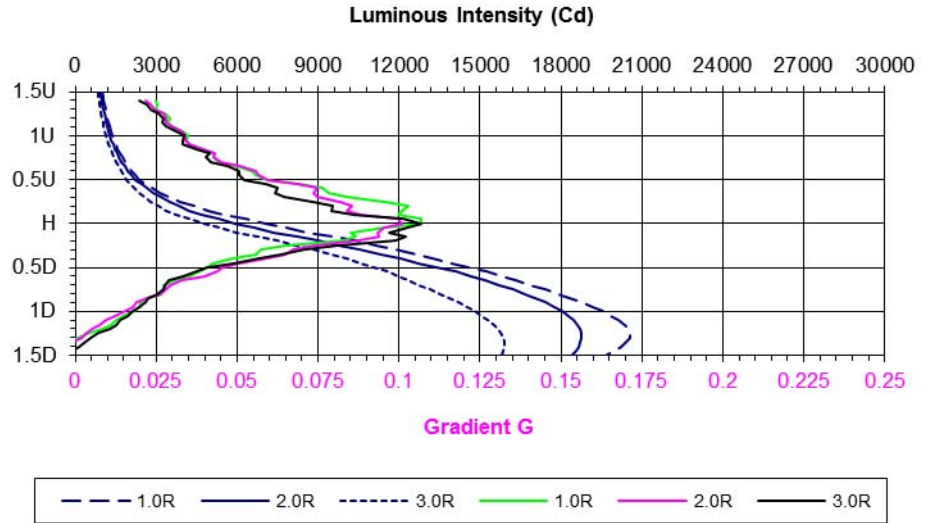
H-LH2 (Haze)

VOR Aim

Maximum Vertical Gradient

Location	Value	Required
0.05U/1.0R	0.107*	> 0.13
H/2.0R	0.101*	
H/3.0R	0.107*	

* - denotes failure.



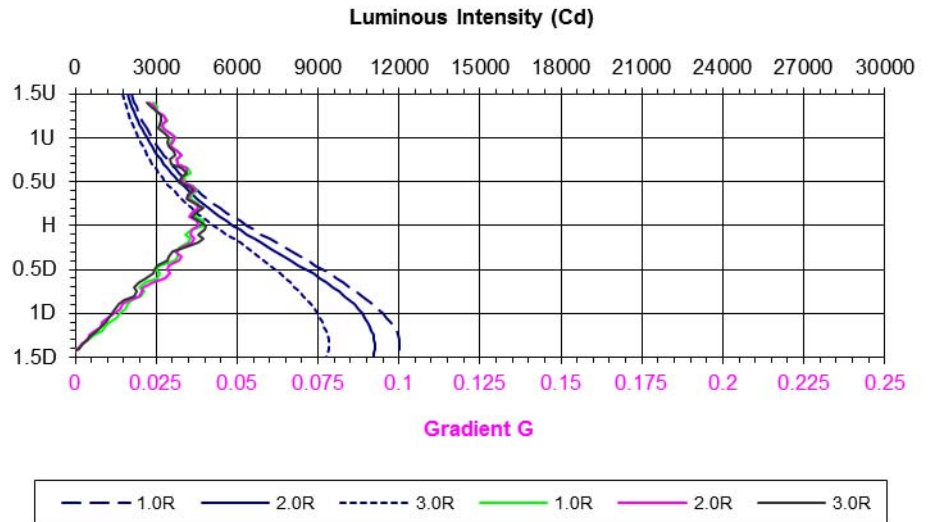
H-LH3 (Haze)

VOR Aim

Maximum Vertical Gradient

Location	Value	Required
0.05U/1.0R	0.040*	> 0.13
0.20U/2.0R	0.038*	
H/3.0R	0.040*	

* - denotes failure.



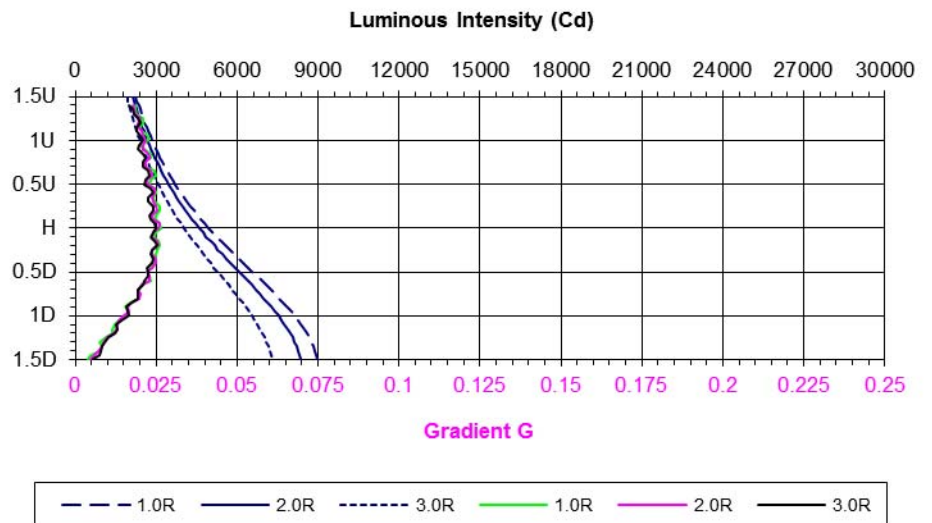
H-LH4 (Haze)

VOR Aim

Maximum Vertical Gradient

Location	Value	Required
H/1.0R	0.026*	> 0.13
0.05U/2.0R	0.026*	
0.20D/3.0R	0.025*	

* - denotes failure.



PHOTOMETRIC TEST DATA SHEET

Project Name: Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb
Headlamp

Sample Number: LH1 (new)

Specification: FMVSS108 Table XIX-a: LB2V (VO Headlamp - 2 Lamp System)

Color: White, Lower Beam

Luminous Intensity, Candela

Test Point	Location	Measured	Reaim	Minimum	Maximum
4.0U 8.0L		182.06		64	-
4.0U 8.0R		169.02		64	-
2.0U 4.0L		316.88		135	-
1.5U 1.0R TO 3.0R	3.0R	424.50		200	-
1.5U 1.0R TO R	5.0R	462.29		-	1400
1.0U 1.5L TO L	1.5L	686.30		-	700
0.5U 1.5L TO L	1.5L	1628.31	968.65	-	1000
0.5U 1.0R TO 3.0R	3.0R	1598.98		500	-
0.5U 1.0R TO 3.0R	1.0R	1833.89		-	2700
H 8.0L		2133.08		64	-
H 4.0L		3810.38		135	-
H V		9406.28		-	-
0.6D 1.3R		23957.12		10000	-
0.9D 3.5L		12045.64	10179.49	1800	12000
0.9D V		26014.73		4500	-
1.5D 2.0R		25930.31		15000	-
2.0D 15.0L		3177.45		1000	-
2.0D 9.0L		7881.39		1250	-
2.0D 9.0R		6927.08		1250	-
2.0D 15.0R		3191.21		1000	-
4.0D 20.0L		1379.45		300	-
4.0D V		4000.10		-	-
4.0D 4.0R		3661.58		-	12500
4.0D 20.0R		1360.14		300	-

MAXIMUM	1.2D 0.6R	29947.89		-	-
MX(10U-90U/90L-90R)	10.0U 5.7L	110.06		-	125

Sample meets test requirements at all points.

Bulb: Seasoned Philips H11 furnished with sample @ 12.80V / 4.535A

Aim: Sample mounted on fixture provided by Varroc. Fixture mounted on level goniometer with H11 filament located at goniometer center of rotation and tilt with fixture markings aligned parallel and perpendicular to detector axis at HV. Adjusted aim hardware until LB Gmax located at H/2.0R and level from H/1.0R to H/3.0R (VOR aim).

PHOTOMETRIC TEST DATA SHEET

Project Name: Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb
Headlamp

Sample Number: H-LH1 (aged)

Specification: FMVSS108 Table XIX-a: LB2V (VO Headlamp - 2 Lamp System)

Color: White, Lower Beam

Luminous Intensity, Candela

Test Point	Location	Measured	Reaim	Minimum	Maximum
4.0U 8.0L		212.58		64	-
4.0U 8.0R		171.94		64	-
2.0U 4.0L		430.21		135	-
1.5U 1.0R TO 3.0R	3.0R	491.44		200	-
1.5U 1.0R TO R	1.1R	606.12		-	1400
1.0U 1.5L TO L	1.5L	897.20	721.32*	-	700
0.5U 1.5L TO L	1.5L	1723.68	1184.28*	-	1000
0.5U 1.0R TO 3.0R	3.0R	1755.13		500	-
0.5U 1.0R TO 3.0R	1.7R	1975.29		-	2700
H 8.0L		2020.15		64	-
H 4.0L		2985.89		135	-
H V		7013.75		-	-
0.6D 1.3R		21159.35		10000	-
0.9D 3.5L		9572.32		1800	12000
0.9D V		22562.26		4500	-
1.5D 2.0R		25157.66		15000	-
2.0D 15.0L		2747.23		1000	-
2.0D 9.0L		6554.13		1250	-
2.0D 9.0R		6271.27		1250	-
2.0D 15.0R		3093.05		1000	-
4.0D 20.0L		946.73		300	-
4.0D V		4087.22		-	-
4.0D 4.0R		3756.52		-	12500
4.0D 20.0R		1424.52		300	-
MAXIMUM	1.3D 0.8R	27294.97		-	-
MX(10U-90U/90L-90R)	10.0U 1.5L	125.41*		-	125

* - Denotes Failure.

Bulb: Seasoned Philips H11 furnished with sample "LH1" @ 12.80V / 4.537A

Aim: Sample mounted on fixture provided by Varroc. Fixture mounted on level goniometer with H11 filament located at goniometer center of rotation and tilt with fixture markings aligned parallel and perpendicular to detector axis at HV. Adjusted aim hardware until LB Gmax located at H/2.0R and level from H/1.0R to H/3.0R (VOR aim).

PHOTOMETRIC TEST DATA SHEET

Project Name: Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb
Headlamp

Sample Number: H-LH2 (aged)

Specification: FMVSS108 Table XIX-a: LB2V (VO Headlamp - 2 Lamp System)

Color: White, Lower Beam

Luminous Intensity, Candela

Test Point	Location	Measured	Reaim	Minimum	Maximum
4.0U 8.0L		256.04		64	-
4.0U 8.0R		248.63		64	-
2.0U 4.0L		563.70		135	-
1.5U 1.0R TO 3.0R	3.0R	846.58		200	-
1.5U 1.0R TO R	1.0R	982.26		-	1400
1.0U 1.5L TO L	1.5L	1269.69	1020.15*	-	700
0.5U 1.5L TO L	1.5L	2016.27	1520.65*	-	1000
0.5U 1.0R TO R	3.0R	1970.31		500	-
0.5U 1.0R TO 3.0R	1.1R	2490.85		-	2700
H 8.0L		1716.04		64	-
H 4.0L		2756.39		135	-
H V		6645.01		-	-
0.6D 1.3R		15788.02		10000	-
0.9D 3.5L		7628.71		1800	12000
0.9D V		17096.46		4500	-
1.5D 2.0R		18313.33		15000	-
2.0D 15.0L		2614.09		1000	-
2.0D 9.0L		4922.14		1250	-
2.0D 9.0R		4823.25		1250	-
2.0D 15.0R		2242.48		1000	-
4.0D 20.0L		1233.19		300	-
4.0D V		3992.47		-	-
4.0D 4.0R		3645.76		-	12500
4.0D 20.0R		1243.21		300	-
MAXIMUM	1.2D 0.9R	20319.78		-	-
MX(10U-90U/90L-90R)	10.0U 0.2L	142.02*		-	125

* - Denotes Failure.

Bulb: Seasoned Philips H11 furnished with sample "LH1" @ 12.80V / 4.536A

Aim: Sample mounted on fixture provided by Varroc. Fixture mounted on level goniometer with H11 filament located at goniometer center of rotation and tilt with fixture markings aligned parallel and perpendicular to detector axis at HV. Adjusted aim hardware until LB Gmax located at H/2.0R and level from H/1.0R to H/3.0R (VOR aim).

PHOTOMETRIC TEST DATA SHEET

Project Name: Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb
Headlamp

Sample Number: H-LH3 (aged)

Specification: FMVSS108 Table XIX-a: LB2V (VO Headlamp - 2 Lamp System)

Color: White, Lower Beam

Luminous Intensity, Candela

Test Point	Location	Measured	Reaim	Minimum	Maximum
4.0U 8.0L		553.17		64	-
4.0U 8.0R		477.32		64	-
2.0U 4.0L		1206.03		135	-
1.5U 1.0R TO 3.0R	3.0R	1720.25		200	-
1.5U 1.0R TO R	1.0R	2016.48	1766.47*	-	1400
1.0U 1.5L TO L	1.5L	2580.65	2143.92*	-	700
0.5U 1.5L TO L	1.5L	3489.05	2915.39*	-	1000
0.5U 1.0R TO 3.0R	3.0R	3366.24		500	-
0.5U 1.0R TO 3.0R	1.0R	4150.19	3328.95*	-	2700
H 8.0L		1987.03		64	-
H 4.0L		3174.69		135	-
H V		6319.41		-	-
0.6D 1.3R		9461.41	10493.86	10000	-
0.9D 3.5L		5818.19		1800	12000
0.9D V		10506.85		4500	-
1.5D 2.0R		11035.27	11035.27*	15000	-
2.0D 15.0L		1889.39		1000	-
2.0D 9.0L		3986.85		1250	-
2.0D 9.0R		3798.61		1250	-
2.0D 15.0R		1949.32		1000	-
4.0D 20.0L		1020.96		300	-
4.0D V		3615.10		-	-
4.0D 4.0R		3315.69		-	12500
4.0D 20.0R		1130.90		300	-
MAXIMUM	1.3D 0.9R	11882.46		-	-
MX(10U-90U/90L-90R)	10.0U 1.7L	305.27*		-	125

* - Denotes Failure.

Bulb: Seasoned Philips H11 furnished with sample "LH1" @ 12.80V / 4.534A

Aim: Sample mounted on fixture provided by Varroc. Fixture mounted on level goniometer with H11 filament located at goniometer center of rotation and tilt with fixture markings aligned parallel and perpendicular to detector axis at HV. Adjusted aim hardware until LB Gmax located at H/2.0R and level from H/1.0R to H/3.0R (VOR aim).

PHOTOMETRIC TEST DATA SHEET

Project Name: Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb
Headlamp

Sample Number: H-LH4 (aged)

Specification: FMVSS108 Table XIX-a: LB2V (VO Headlamp - 2 Lamp System)

Color: White, Lower Beam

Luminous Intensity, Candela

Test Point	Location	Measured	Reaim	Minimum	Maximum
4.0U 8.0L		564.72		64	-
4.0U 8.0R		567.26		64	-
2.0U 4.0L		1488.29		135	-
1.5U 1.0R TO 3.0R	3.0R	2348.39		200	-
1.5U 1.0R TO R	1.0R	2733.47	2428.11*	-	1400
1.0U 1.5L TO L	1.5L	3259.82	2761.70*	-	700
0.5U 1.5L TO L	1.5L	4076.55	3564.70*	-	1000
0.5U 1.0R TO 3.0R	3.0R	3983.39		500	-
0.5U 1.0R TO 3.0R	1.0R	4868.43	4117.89*	-	2700
H 8.0L		2181.98		64	-
H 4.0L		3344.03		135	-
H V		6377.15		-	-
0.6D 1.3R		8213.05	8558.48*	10000	-
0.9D 3.5L		5174.05		1800	12000
0.9D V		8606.20		4500	-
1.5D 2.0R		8403.75	8505.30*	15000	-
2.0D 15.0L		1665.74		1000	-
2.0D 9.0L		3156.15		1250	-
2.0D 9.0R		2896.25		1250	-
2.0D 15.0R		1516.07		1000	-
4.0D 20.0L		795.94		300	-
4.0D V		3533.16		-	-
4.0D 4.0R		3129.95		-	12500
4.0D 20.0R		764.69		300	-
MAXIMUM	1.2D 0.7R	9065.68		-	-
MX(10U-90U/90L-90R)	10.0U 2.0R	276.13*		-	125

* - Denotes Failure.

Bulb: Seasoned Philips H11 furnished with sample "LH1" @ 12.80V / 4.534A

Aim: Sample mounted on fixture provided by Varroc. Fixture mounted on level goniometer with H11 filament located at goniometer center of rotation and tilt with fixture markings aligned parallel and perpendicular to detector axis at HV. Due to lack of a strong cutoff it was not possible to aim using VOR photoelectric aim or visual aim methodology. The lamp was adjusted vertically until the maximum was located as approximately the same vertical location as the new test lamps.

COLOR TEST DATA SHEET

Project Name: Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb Headlamp

Requirement: FMVSS 108 S14.4.1 Color Test
 Test Method: FMVSS 108 S14.4.1.4 Tristimulus Method
 Average of 3 reads
 Instrument: Photo Research PR-655 Spectroradiometer with SRS-3 Target
 Location: 1.5D/2.0R (Lower Beam), 25 ft
 Voltages: 12.8V (Lower Beam)

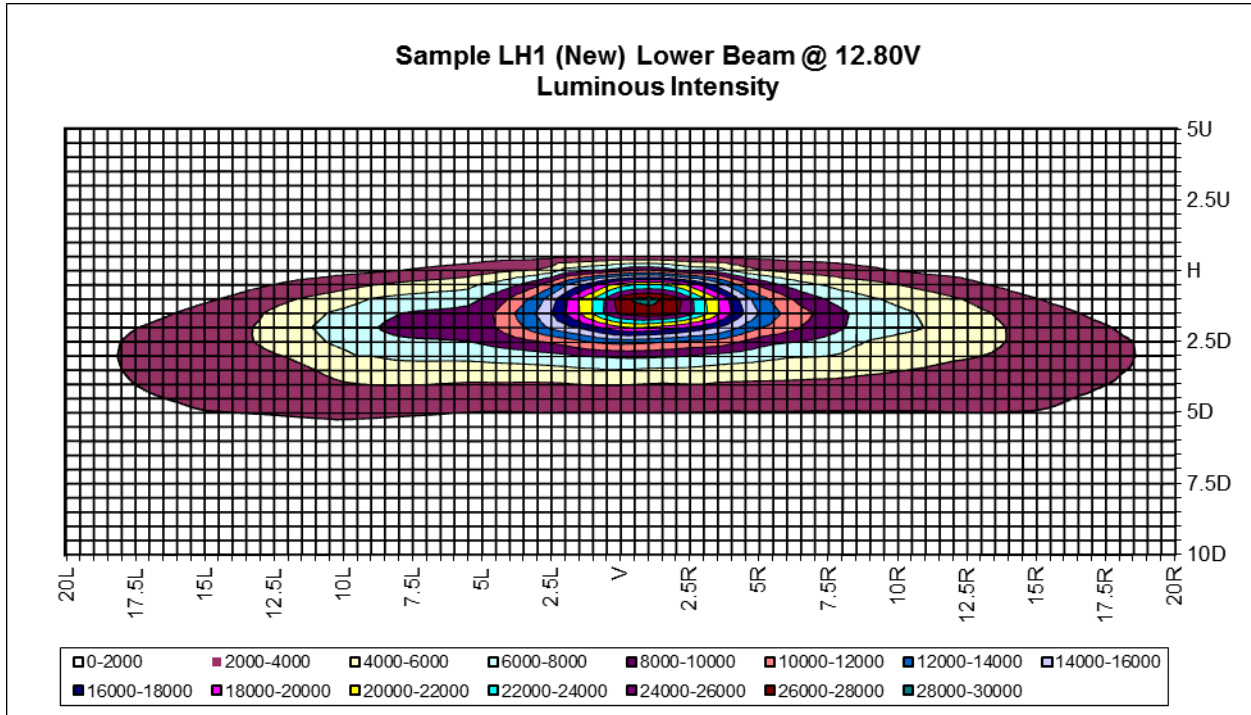
Measured (x, y)	Required	Chart
<u>New</u> LH1 (0.4304, 0.4032)		<p>The chart, titled 'FMVSS 108 White', plots color coordinates x (0.30 to 0.52) and y (0.27 to 0.45). A magenta 'White Boundary' is defined by a series of connected line segments. Test results are shown as blue diamonds for 'Lower Beam' and orange squares for 'Aged Lower Beam'. The Lower Beam points are clustered around (0.43, 0.40), and the Aged Lower Beam points are clustered around (0.44, 0.41).</p>
<u>Aged</u> H-LH1 (0.4340, 0.4060)	$0.31 \leq x \leq 0.50$	
H-LH2 (0.4373, 0.4066)	$0.38 \leq y \leq 0.44$	
H-LH3 (0.4413, 0.4095)	$y \geq 0.75x + 0.05$	
H-LH4 (0.4550, 0.4136)	$y \leq 0.64x + 0.15$	

PHOTOMETRIC TEST DATA SHEET

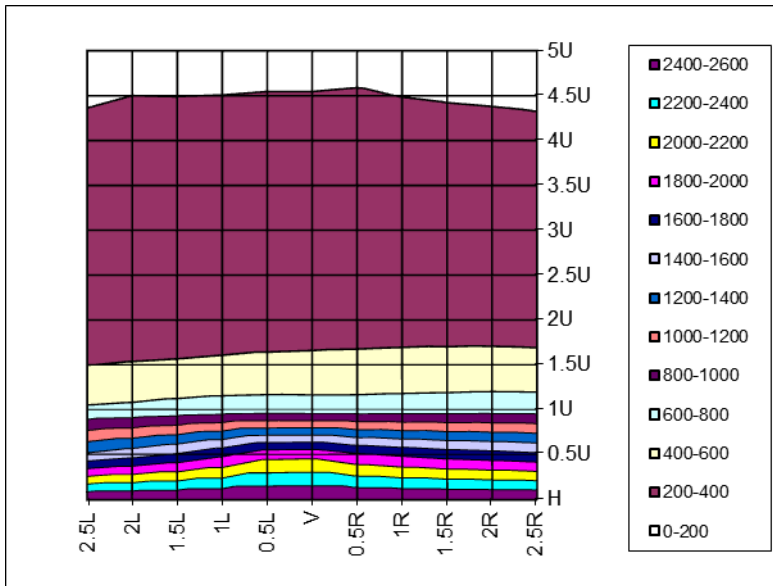
Project Name: Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb Headlamp

ISO Scans

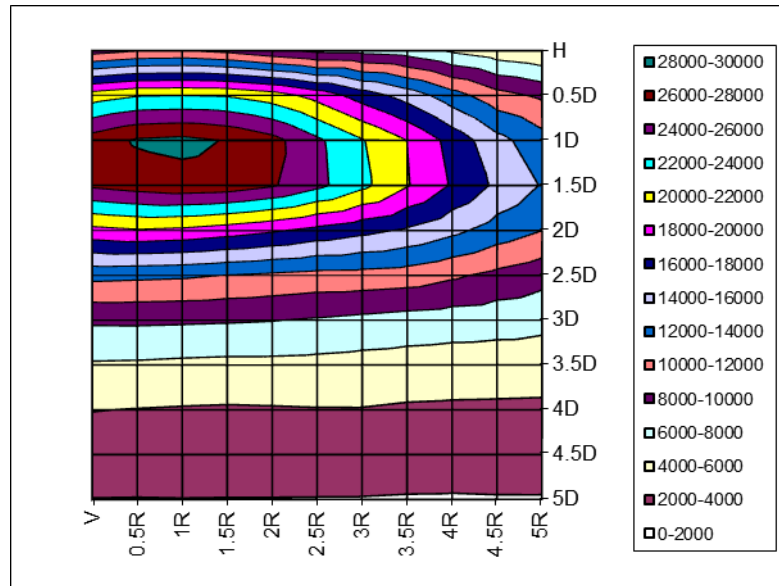
5U to 10D / 20L to 20R / 0.5° increments



Max Intensity: 28543 Cd @ 1.0D / 1.0R
Beam Flux: 387 Lm



5U to H / 2.5L to 2.5R



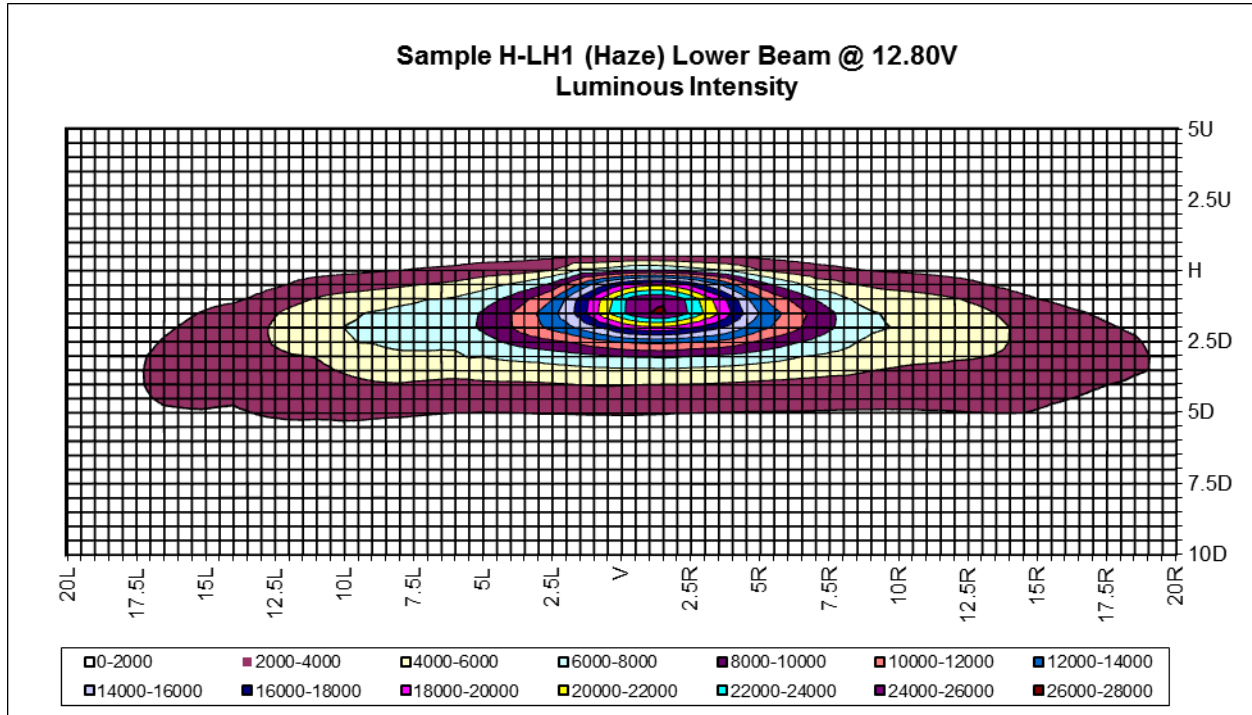
H to 5D / V to 5R

PHOTOMETRIC TEST DATA SHEET

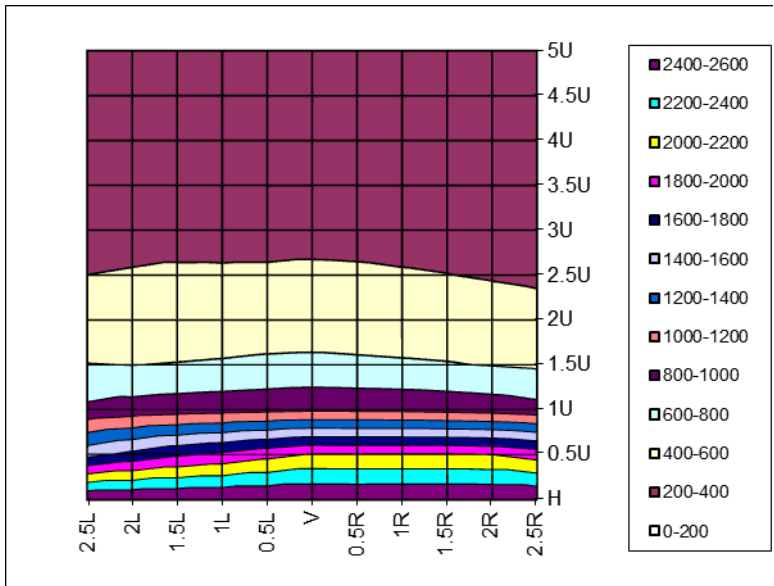
Project Name: Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb Headlamp

ISO Scans

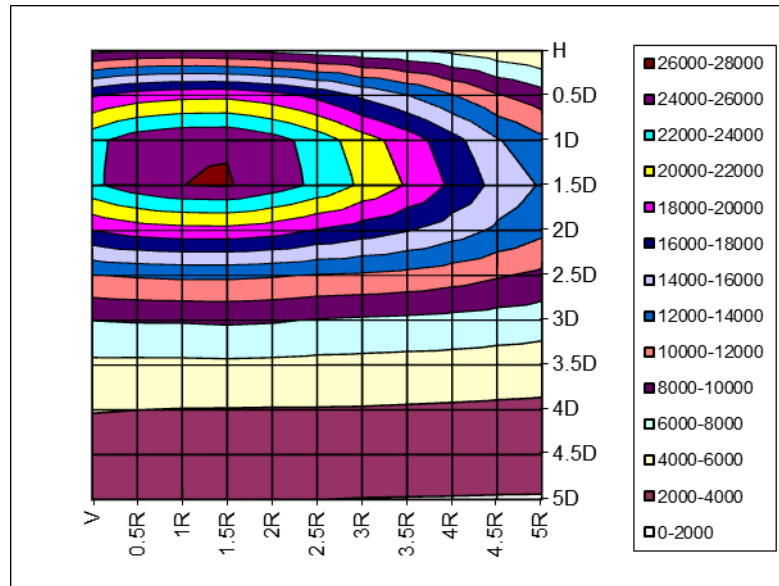
5U to 10D / 20L to 20R / 0.5° increments



Max Intensity: 26263 Cd @ 1.5D / 1.5R
Beam Flux: 366 Lm



5U to H / 2.5L to 2.5R



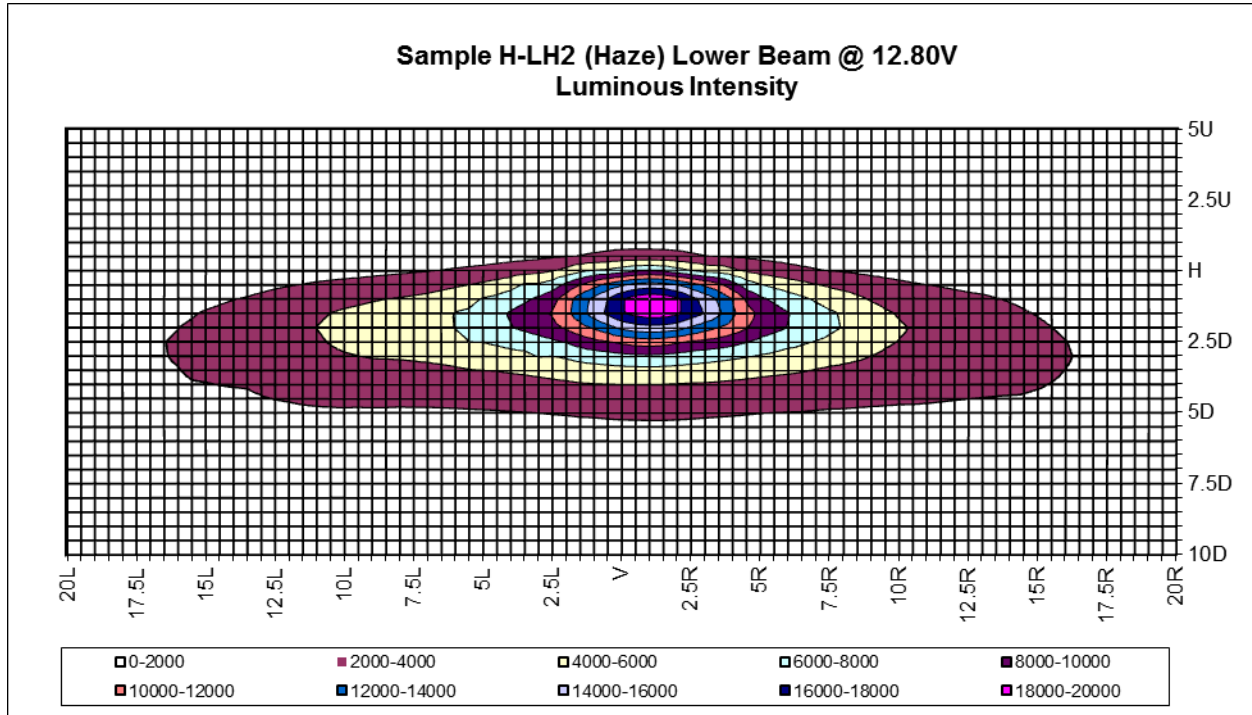
H to 5D / V to 5R

PHOTOMETRIC TEST DATA SHEET

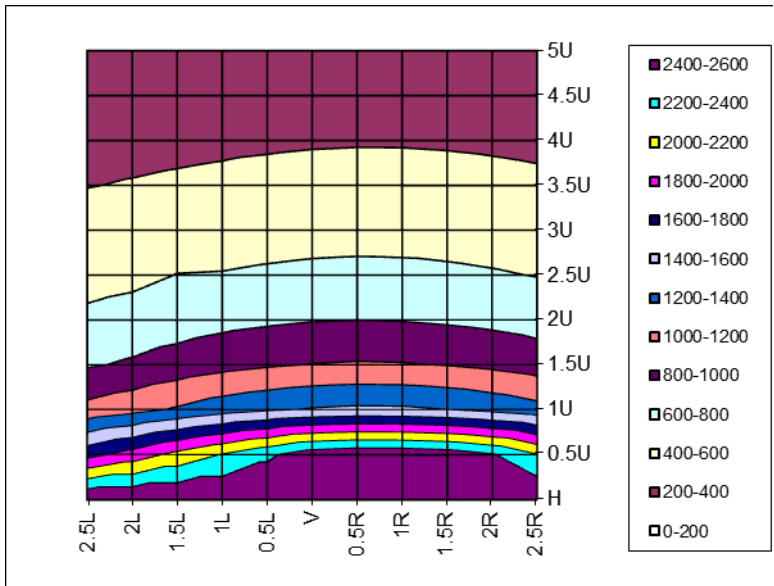
Project Name: Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb Headlamp

ISO Scans

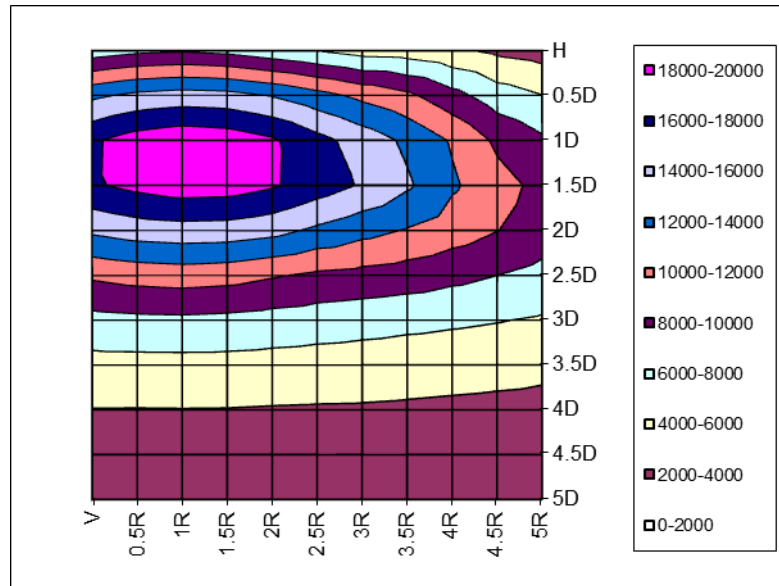
5U to 10D / 20L to 20R / 0.5° increments



Max Intensity: 19474 Cd @ 1.0D / 1.0R
Beam Flux: 312 Lm



5U to H / 2.5L to 2.5R



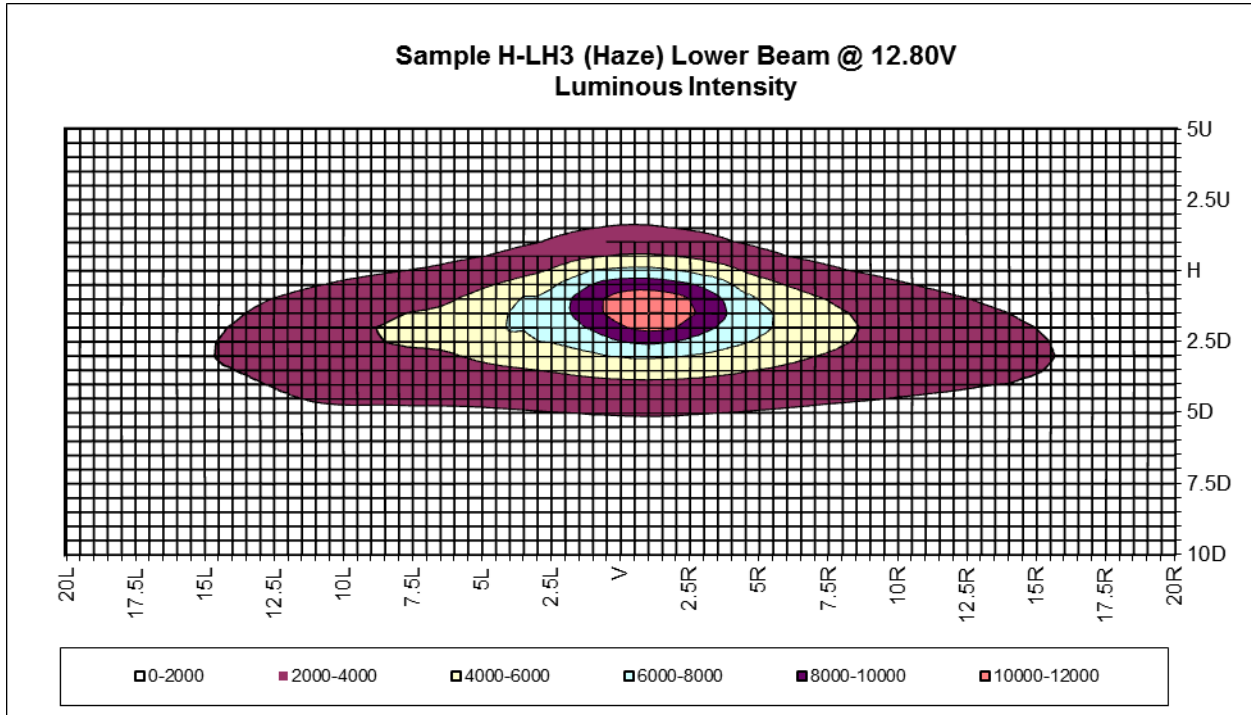
H to 5D / V to 5R

PHOTOMETRIC TEST DATA SHEET

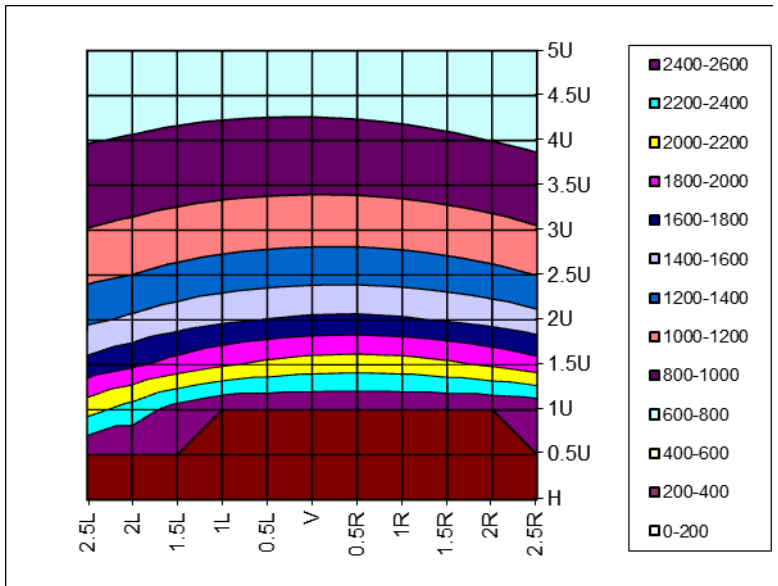
Project Name: Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb Headlamp

ISO Scans

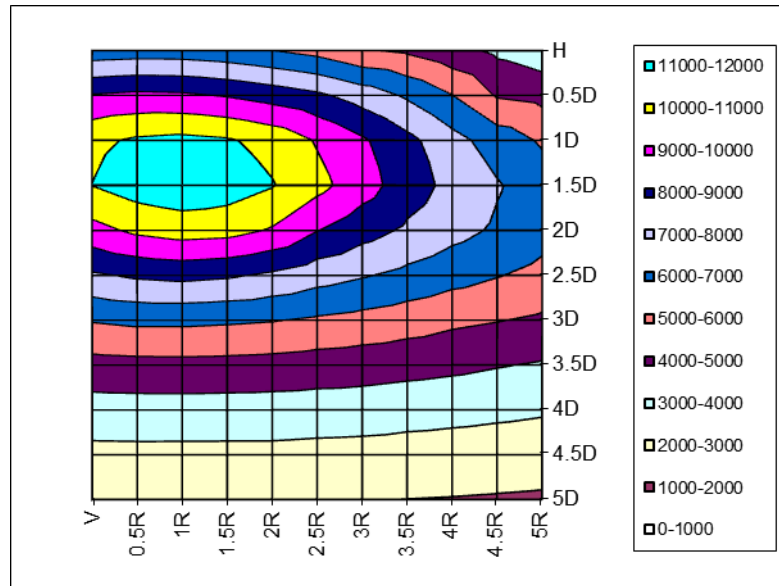
5U to 10D / 20L to 20R / 0.5° increments



Max Intensity: 11709 Cd @ 1.5D / 1.0R
Beam Flux: 285 Lm



5U to H / 2.5L to 2.5R



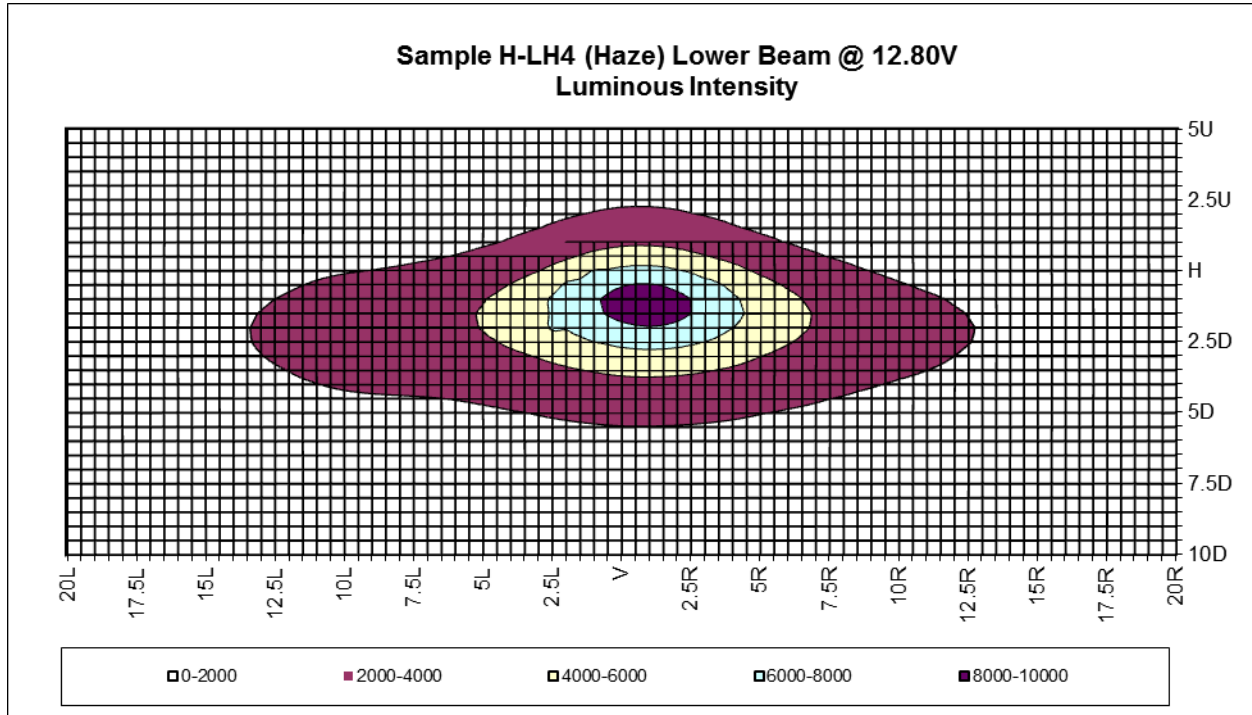
H to 5D / V to 5R

PHOTOMETRIC TEST DATA SHEET

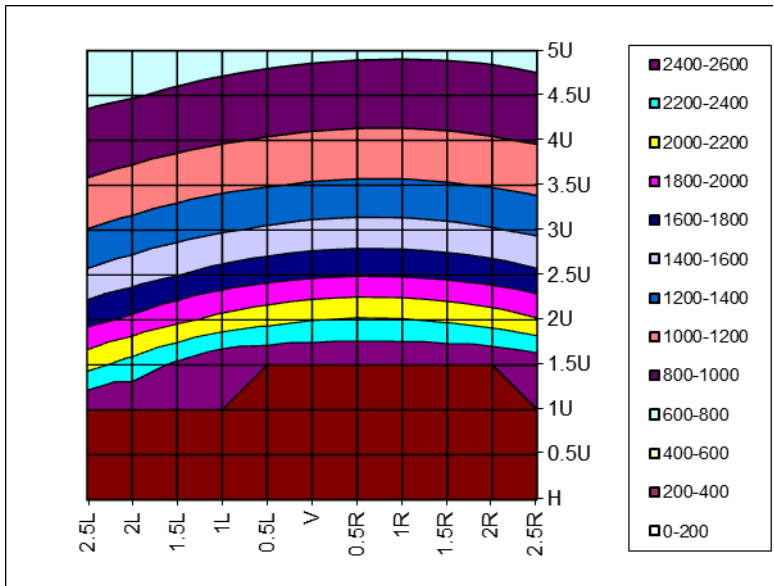
Project Name: Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb Headlamp

ISO Scans

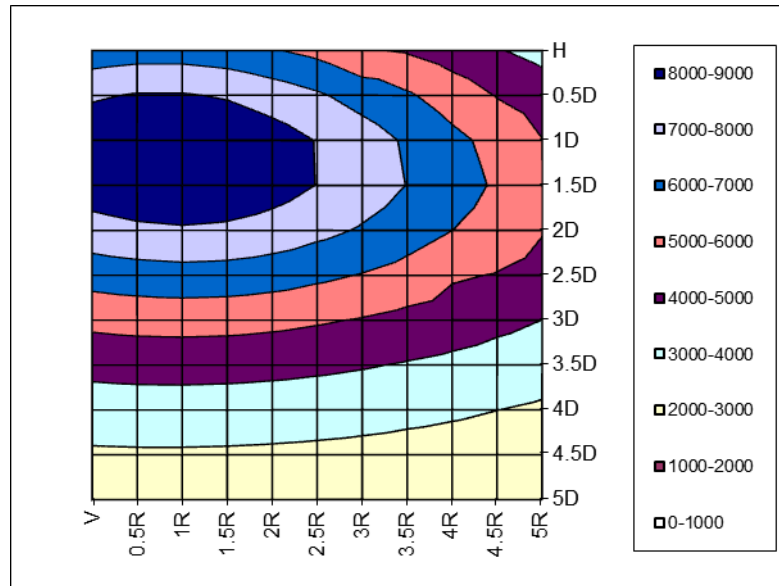
5U to 10D / 20L to 20R / 0.5° increments



Max Intensity: 8975 Cd @ 1.0D / 1.0R
Beam Flux: 273 Lm



5U to H / 2.5L to 2.5R



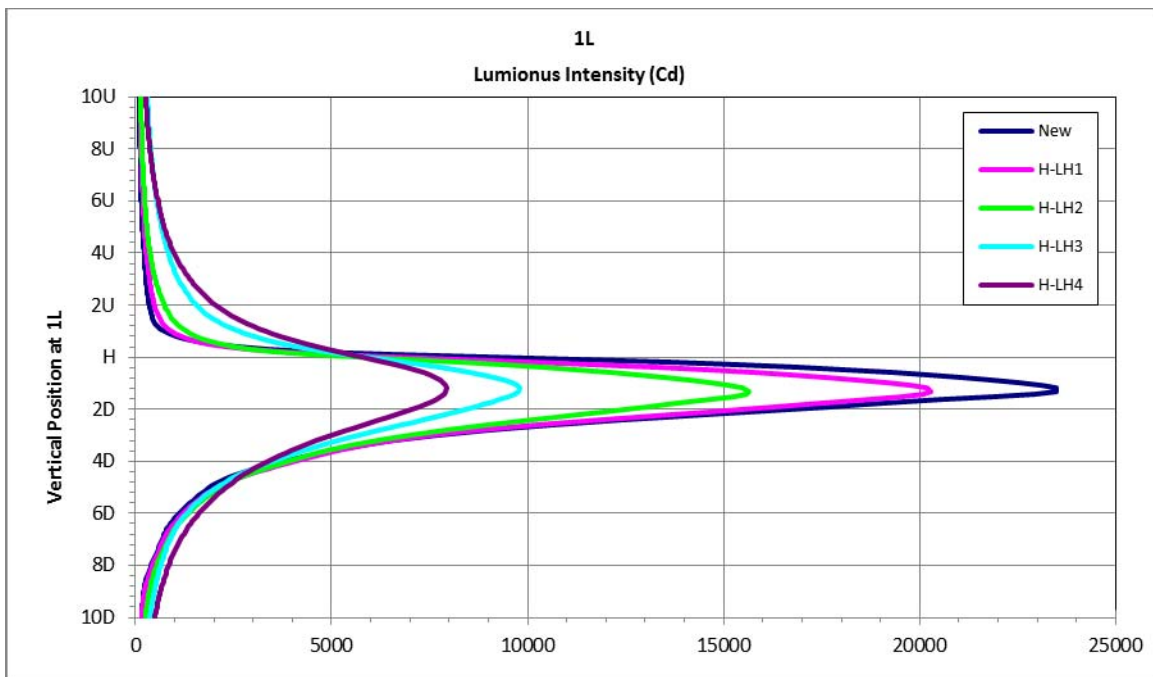
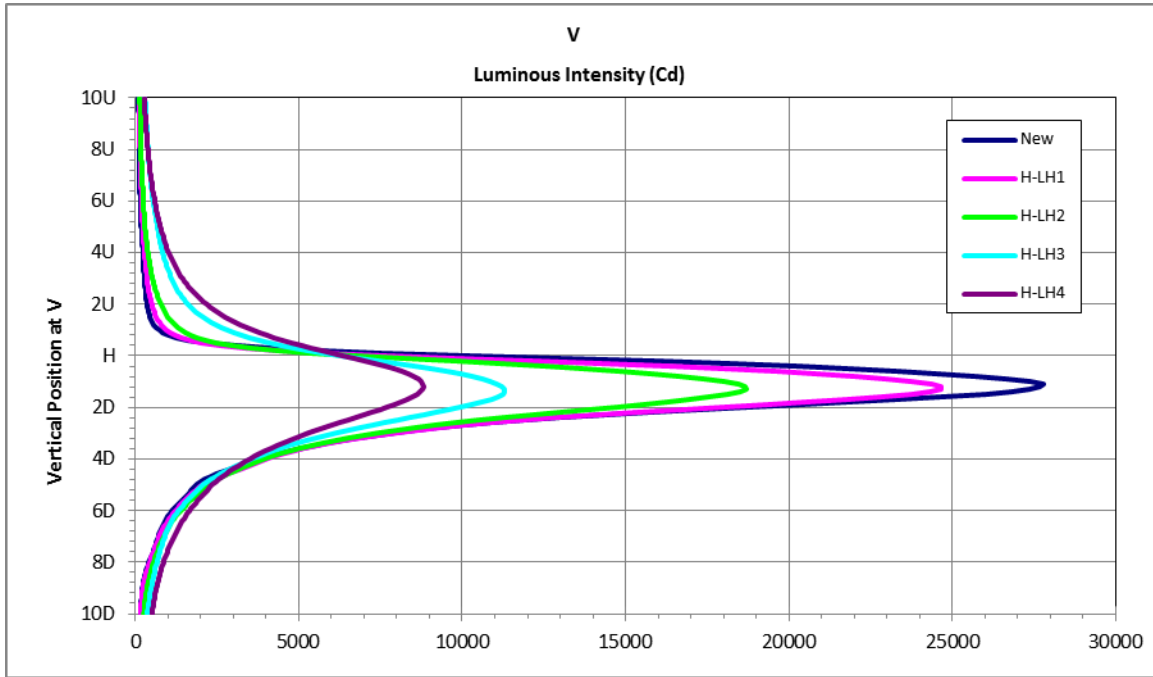
H to 5D / V to 5R

PHOTOMETRIC TEST DATA SHEET

Project Name: Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb Headlamp

Vertical Line Scans

10U to 10D / 0.1° increments along the V-V line and at 1L



PHOTOMETRIC TEST DATA SHEET

Project Name: Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb Headlamp

IsoLux projection on road

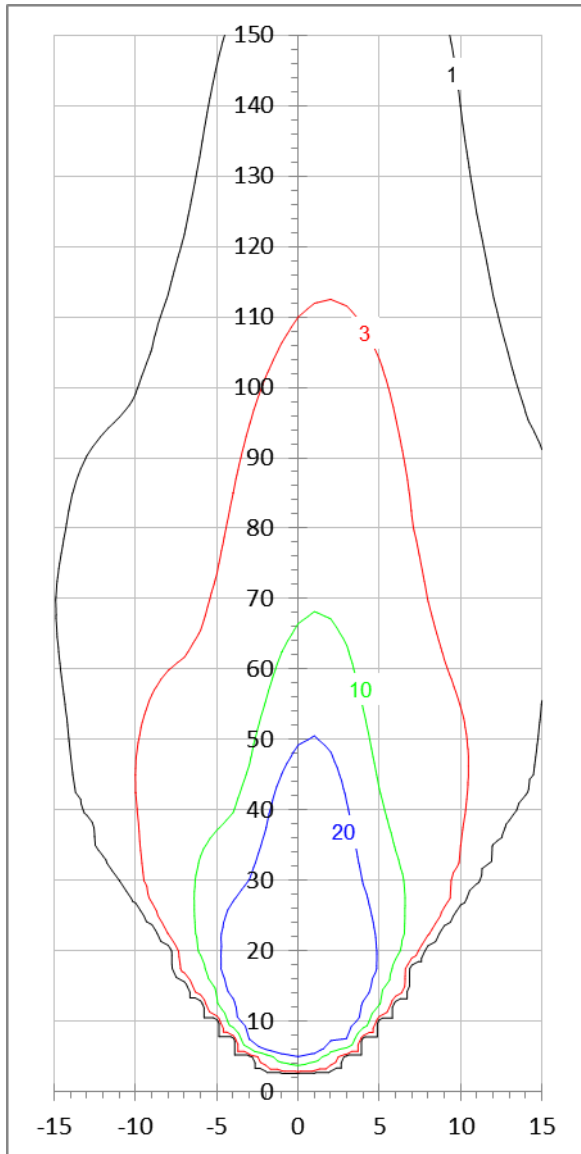
Lateral dimensions (from vehicle centerline): -15 m to 15 m, 1 m increments

Road Dimension (from lamp source): 0 m to 150 m, 2.5 m increments

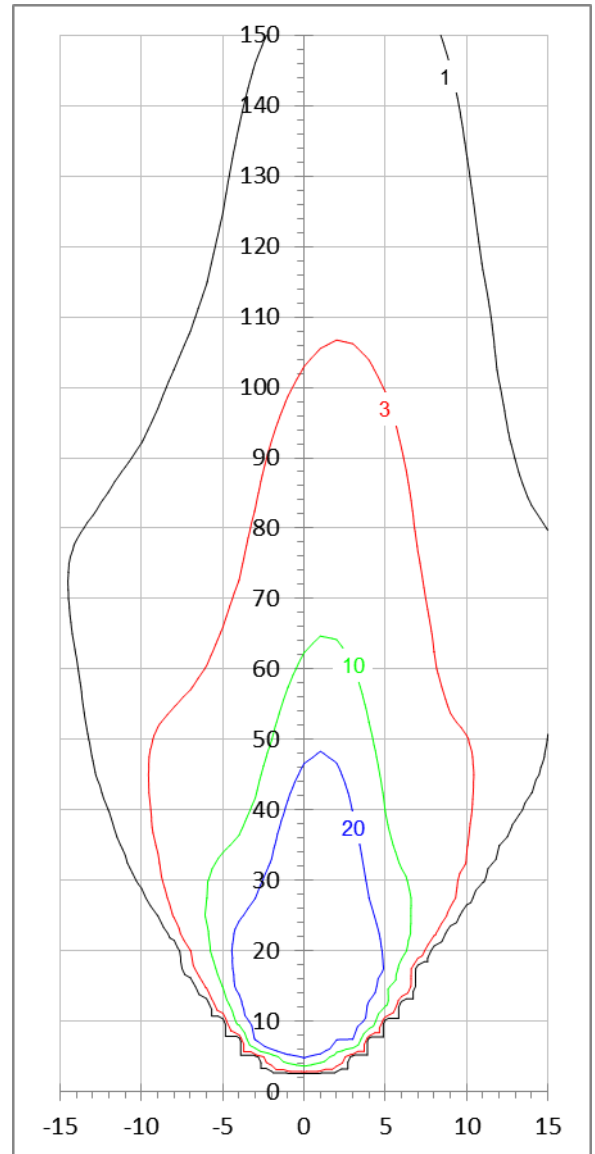
Isolux contour lines of 1, 3, 10, and 20 lux

Mounting Height: 0.75 m

Headlamp Separation: 1.4 m



LH1 (New)



H-LH1 (Haze)

PHOTOMETRIC TEST DATA SHEET

Project Name: Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb Headlamp

IsoLux projection on road

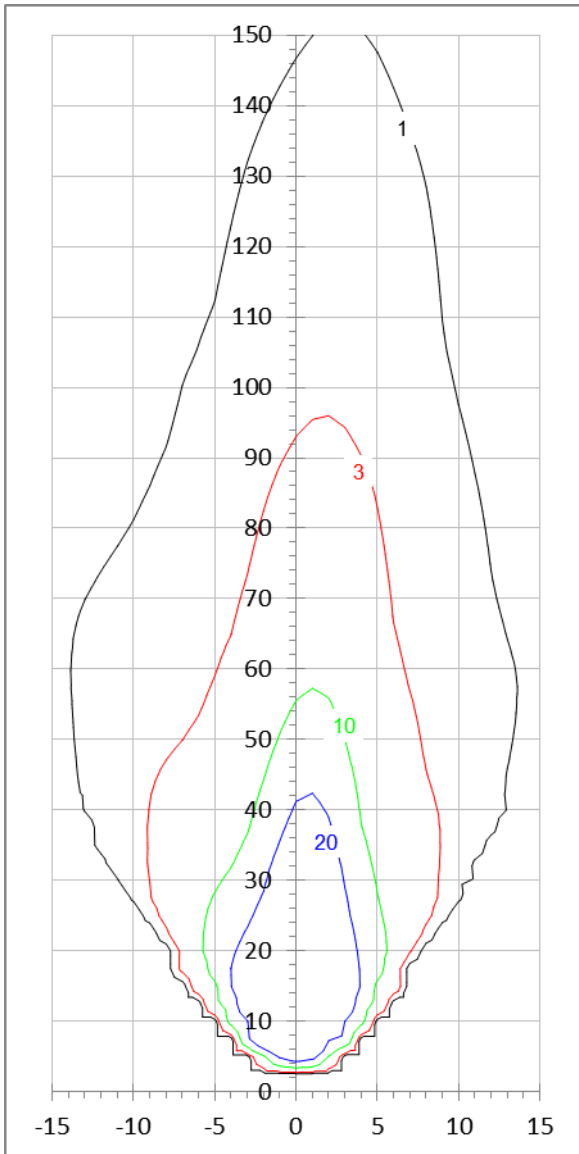
Lateral dimensions (from vehicle centerline): -15 m to 15 m, 1 m increments

Road Dimension (from lamp source): 0 m to 150 m, 2.5 m increments

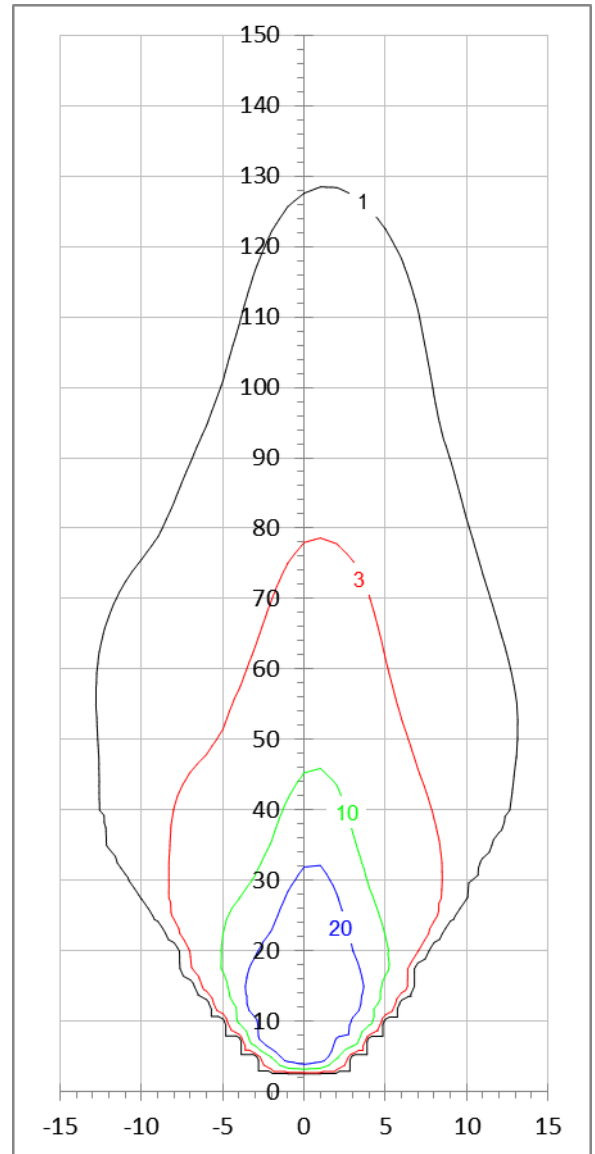
Isolux contour lines of 1, 3, 10, and 20 lux

Mounting Height: 0.75 m

Headlamp Separation: 1.4 m



H-LH2 (Haze)



H-LH3 (Haze)

PHOTOMETRIC TEST DATA SHEET

Project Name: Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb Headlamp

IsoLux projection on road

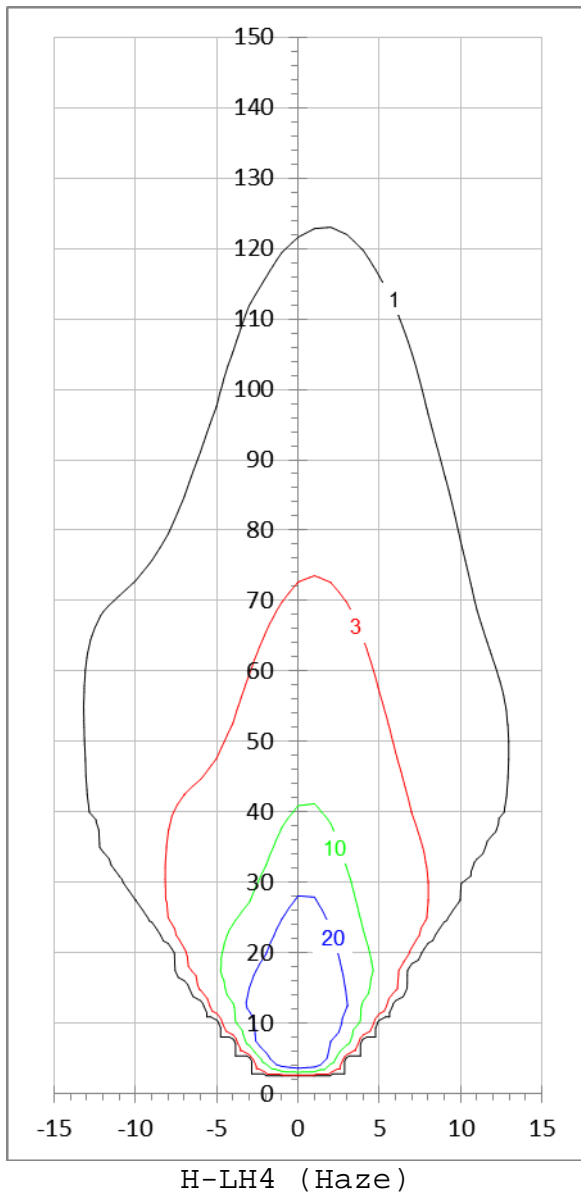
Lateral dimensions (from vehicle centerline): -15 m to 15 m, 1 m increments

Road Dimension (from lamp source): 0 m to 150 m, 2.5 m increments

Isolux contour lines of 1, 3, 10, and 20 lux

Mounting Height: 0.75 m

Headlamp Separation: 1.4 m



PHOTOGRAPH SHEET

Project Name: Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb Headlamp



LH1 (New) for 2005 Chevy Malibu



Lamp on Provided Fixture

PHOTOGRAPH SHEET

Project Name: Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb Headlamp



H-LH1 from 2007 Chevy Malibu



H-LH2 from 2005 Chevy Malibu
(lens markings cleaned off with alcohol prior to testing)

PHOTOGRAPH SHEET

Project Name: Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb Headlamp



H-LH3 from 2007 Chevy Malibu



H-LH4 from 2005 Chevy Malibu

EQUIPMENT LIST

Project Name: Haze Study - 2005 to 2007 Chevy Malibu VOR Replaceable Bulb
Headlamp

PHOTOMETRY / COLOR

Last Calibrated

Goniometer

ITL Custom with Aerotech ART-330, 320 Stepper Motors07 Jan 2015
[resolution 0.001°, accuracy ±0.01°(±0.05%)][due every 5 years]

Luminous Intensity

Hoffman TSP-7501(HG), S/N 106015 Jan 2018
[0.1 Cd to 600 kCd, ±0.01 Cd, accuracy ±2.0%] [due every 12 months]

Color - Spectroradiometric

Photoresearch PR-655 w/MS-75 lens & SRS-3 target,
S/N 65160706 20 June 2018
[resolution ±2nm, (x, y) ±0.001, ±4% luminance] [due every 12 months]

ELECTRICAL

Last Calibrated

DC Power Supply

HP6652A, S/N 3347A-01634N/A
[500W, 0-20V, 0-25A] [use DMMS for measurement]

Voltage

Fluke 45 (#1), S/N 793401915 Jan 2018
[resolution 0.01V, accuracy ±0.02%] [due every 12 months]

Current

Keithley 197A (#1), S/N 74143015 Jan 2018
[resolution 0.001A, accuracy ±0.02%] [due every 12 months]