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HEADLAMP LENS DETERIORATION



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Abstract

The average age of registered vehicles in the United States is 11.6 years. Headlamp lenses made of polycarbonate, or plastic, begin to yellow and otherwise show signs of deterioration at five years age (\pm two). Plastic lenses on automotive headlamps deteriorate due primarily to extended exposure to ultraviolet radiation and abrasion by road grit. The yellowing of the headlamp lenses results in a noticeable decrease in light output. Deteriorated headlamps – when the lens is opaque to the extent that the bulb is not clearly visible – are a safety hazard. This research quantifies the reduction in light output caused by deteriorated (yellowed) headlamp lenses as well as comparing the relative performance of headlamp repair and restoration options available to the consumer.

Research Questions:

1. On a vehicle with deteriorated headlamp lenses, how much is light output diminished?
2. Of the options available for headlamp restoration and/or replacement, which one improves light output the most?
 - a. Original Equipment Manufacturer (OEM) replacement headlamp assembly
 - b. Aftermarket replacement headlamp assembly (certified and non-certified)
 - c. Professional restoration
 - d. Do-it-yourself (DIY) restoration

Key Findings:

1. Deteriorated headlamps evaluated in this research produced only 22 percent light output (low beam) when compared with new, OEM headlight assemblies. This type of headlamp, halogen reflector, only supports night-time driving (low beam) on unlit roadways at speeds up to 39 miles per hour, when in new condition. A 78 percent reduction in forward lighting is a safety hazard.
2. OEM replacement headlamp assemblies provided the best combination of forward lighting in compliance with applicable standards for minimum and maximum intensity in specified areas, including road surface illumination (minimum values) and areas that can contribute to glare for oncoming or preceding vehicles (maximum values).
3. Aftermarket replacement headlamps, both certified and non-certified, performed nearly as well the OEM replacement, but were more likely to have failures in the compliance test for excessive light output in areas associated with glare.
 - a. Certified aftermarket replacement headlamps and non-certified aftermarket headlamps performed similarly to one another in terms of compliance to standards.
4. Restoration procedures, do-it-yourself or professional, improved headlight performance to almost the level of aftermarket replacement headlamp assemblies.
 - a. In the limited sample size tested, both professional and DIY restoration processes improved light substantially. The DIY process resulted in an average of 69.2 percent compared to the baseline of the OEM headlamp output (low beam and high beam). The professional restoration process resulted in 73.4 percent of the OEM performance.



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Headlamp Lens Deterioration

1 Overview

As consumers keep vehicles longer, specialized maintenance for age-related items such as deteriorated headlamp lenses becomes important. Previous research by AAA has demonstrated that cloudy headlamps reduce visibility¹ and, consequently, the safety of nighttime driving. Halogen reflector headlamps in almost new condition, like those evaluated in this research, provide adequate lighting for nighttime driving speeds on unlit roadways of only 39 mph on low beam. Deterioration of the headlamp lens reduces the light output and, as a result, the ability to drive safely at night on unlit roadways.

There are four options available to improve light output when a vehicle's headlamp lenses have become cloudy or yellow in appearance:

1. Replace headlamp assemblies with the OEM or dealer part
2. Replace headlamp assemblies with aftermarket parts
3. Professional restoration of the existing headlamp lenses
4. DIY restoration of the existing headlamp lenses

This research quantifies the specific limitations of light output caused by deteriorated headlamps as well as measures improvements in visibility and glare reduction following restoration and/or replacement of these lenses. The value of the different options for headlamp replacement or restoration is also compared to assist consumers in making an informed decision when their vehicle is due for this service.

Headlamps – forward lighting for an automobile or light truck – are among the most basic of vehicle safety systems. The headlamp assemblies that are used on road legal vehicles in the United States must be certified to meet or exceed performance requirements for lighting set forth in the Federal Motor Vehicle Safety Standard (FMVSS) 108². These criteria are what the photometry lab tests to determine pass/fail with regard to headlamp performance.

At one time, headlamps were made with glass lenses that were impact resistant due to their thickness and remained clear for the life of the vehicle. The first iterations of modern styling of headlamp

¹ "AAA Tests Shine High Beam on Headlight Limitations" <https://newsroom.aaa.com/2015/05/aaa-tests-shine-high-beam-headlight-limitations/>

² Federal Motor Vehicle Safety Standard, section 108 is published in the U.S. Code of Federal Regulations, Title 49 – Transportation, §571.108. <https://www.gpo.gov/fdsys/pkg/CFR-2004-title49-vol5/xml/CFR-2004-title49-vol5-sec571-108.xml>



assemblies, following body contours for improved aesthetics, were sealed-beam headlamps³ with incandescent bulbs and were made of glass. Once the styling element became part of headlamp design, production costs increased. There were not simply two round or two rectangular headlamps to fit every vehicle. Headlamp designs became unique to the body style, which typically only continued for four to five years before a model refresh.

Polycarbonate headlamp lenses were introduced to meet these design needs in the mid-1980s. By the 1990s, most vehicles had transitioned to aerodynamic headlamp shapes with polycarbonate lenses and replaceable halogen bulbs. Polycarbonate thermoplastics are strong, impact resistant, lightweight, and can be manufactured to be optically transparent. They are easily worked and can be thermoformed and molded. These properties make polycarbonate an attractive alternative to glass for headlamp lenses. The down side to polycarbonate is that it is easily scratched and is subject to deterioration when exposed to ultraviolet (UV) light.

Extended exposure to UV light causes the yellowing commonly observed in aged headlamp lenses. When manufactured, polycarbonate headlamp lenses are coated with a thin film to improve scratch resistance and provide protection from UV light. Depending on the amount of UV exposure, this protective film may not last for the life of the automobile. The actual service life depends on the amount of UV exposure.

The polycarbonate materials and protective coatings used for headlamps are tested to remain transparent and structurally sound for a minimum of three years⁴. Requirements provided by the National Highway Traffic Safety Administration (NHTSA) and the Society of Automotive Engineers (SAE) prohibit accelerated aging of transparent plastics used for lenses in automotive applications, and as a result, are not included in this report.

When walking a parking lot, it is common to observe significant yellowing of headlamp lenses on vehicles. With the average age of the vehicle fleet in the United States at 11.6 years old, there is a potential safety hazard with vehicles driving at night with headlamps that are not capable of properly lighting the roadway.

³ FMVSS-108 performance requirements started with the Motor Vehicle Safety Act in 1966 and requirements related to glass (sealed beam) headlamps continue through today. Sealed beam headlamps were the only approved type in the United States during the 1970 until NHTSA approved the use of a standardized replaceable halogen bulb in 1983. Headlamp History and Harmonization, David W. Moore, UMTRI-98-21.

⁴ FMVSS-108 currently requires three year aging testing on materials used for headlamp lens material and coatings.



2 Methodology

2.1 Headlamp Assembly Selection

Headlamp assemblies used in this test represent each of the identified restoration or replacement options available to vehicle owners. All headlamps are for the left (driver's) side of the vehicle as the beam pattern is different from left to right. To quantify headlamp performance, AAA contracted a professional testing laboratory⁵ with expertise in photometry, the measurement of light in terms of its perceived brightness to the human eye, to perform testing on a range of automotive headlamps. The lab tested the light output of each headlamp assembly and these quantitative results provide a decisive means of comparing performance between the different types.

OEM Replacement Headlamp Assembly: purchased from a franchise dealership parts department and is identical to the headlamp assembly originally installed on the vehicle.

Aftermarket replacement headlamp assemblies are available in a wide range of price points depending on the vehicle. AAA selected one unit certified by either NSF or CAPA⁶ and one unit not listed as certified.

Aftermarket (Certified): is NSF certified. One goal of testing was to evaluate the performance of aftermarket headlamp assemblies (typically available at a lower cost) to the performance of OEM headlamps. If multiple certified assemblies were available from the supplier, the lowest cost option was selected for testing.

Aftermarket (Non-certified): is not listed as certified by either CAPA or NSF. If multiple certified assemblies were available from the supplier, the lowest cost option was selected for testing.

Used Headlamp Assembly (1): purchased from auto salvage and verified to be an OEM part.

Used Headlamp Assembly (2): purchased from auto salvage and verified to be an OEM part.

2.1.1 Subjective Comparison of OEM and Aftermarket Assemblies

A visual examination of the OEM lens assembly compared to either of the aftermarket assemblies found no discernable differences. The items appeared to be identical in appearance and observable detail, with the exception of "makers mark" production stampings on the body of the assembly. Photometry data from the testing laboratory provide a quantitative comparison between the headlamp assemblies along with baseline performance data for the used lamps (which are verified to be OEM components – not aftermarket parts).

⁵ ISO 17025 certified testing laboratory

⁶ Certification by either NSF International (NSF®) or CAPA® Certified Auto Parts is often required for a headlamp assembly to be acceptable as a crash repair part for a claim paid by auto insurance.

2.2 Vehicle Selection

The average age of vehicles in the U.S. is 11.6 years and increasing⁷. AAA selected the Chevrolet Malibu and the Nissan Altima, two automobiles with high sales volumes in 2007 and are still on the road in large numbers today. This vehicle selection represents one domestic and one import vehicle.



Figure 1: Images of headlamp assemblies

⁷ 2018 Lang Aftermarket Annual Report, <http://www.langmarketing.com/lang-auto-aftermarket-annual-report.php>

2.3 Laboratory Test Descriptions

2.3.1 Test Procedure – Laboratory Photometry

Testing was performed by an ISO 17025 accredited testing laboratory and followed industry standard practices for isocandela photometric scans and birds-eye plots. FMVSS-108 standards were tested according to regulation with no modifications to the headlamp assemblies under test or to the test procedures.

New bulbs were used for both high beam and low beam operation in each individual headlamp. The bulbs were seasoned (turned on at operating voltage) for one percent of average design life or 10 hours, whichever is less. The bulbs for the Chevy Malibu headlamps were operated for 5.5 hours (1% design life) and the Nissan Altima bulbs were operated for 10 hours since no design life was specified.

All headlamp tests were conducted on a laboratory grade goniophotometer. This machine allows mounting of the headlamps to a platform that is precisely rotated in specific increments in both horizontal and vertical directions. A light intensity reading is captured from the headlamp under test at each of the rotation coordinates. The isocandela scans performed rotate the headlamp assembly in a range encompassing four degrees downward from horizontal, 90 degrees to the left, 90 degrees to the right, and 90 degrees upward. This span provides 68,229 data points.



Figure 2: Chevy Malibu headlamp mounted on goniophotometer



Figure 3: Laser aimed at headlamp for initial alignment

The initial alignment of the headlamp is accomplished with a laser from the goniophotometer and specific markings on the headlamp lens. Each Department of Transportation (DOT) certified headlamp lens includes a small circle or cross on the headlamp lens, which is aligned with the center of the headlamp beam. An image of the alignment process is shown to the left.

During testing, a re-aim of up to one half degree is permitted to improve performance relative to testing criteria.



2.3.1.1 FMVSS-108 Photometry

All automobiles sold in the U.S. must be equipped with headlamps that comply with FMVSS-108, which identifies luminous intensity requirements to ensure adequate illumination of the roadway and prevention of distracting glare from oncoming vehicles and the surrounding environment. FMVSS-108 defines specific points and lines within the beam pattern of a headlamp with minimum and maximum luminous intensity (candela) values. Point scans are made to validate the minimum performance of headlamp beams for safety. Each compliance point is defined by a vertical and horizontal angle relative to the headlamp optical axis.

2.3.1.2 Isocandela Scans

This test measures the intensity of the headlamp light over a large matrix of evenly spaced test points in order to define the beam pattern. The intensity in glare regions is noted and light output is shown in a graphical representation of the data, referred to as a heat map. Isocandela scans collect candela (Cd) measurements over a high-resolution grid of test points defined by horizontal and vertical angles from the headlamp optical axis. The resulting dataset displays the shape and gradient of the headlamp beam pattern and shows the directionality of the light emitted from the headlamp. It is useful for revealing any “hot spots” or “dead spots” in the beam pattern as well as assessing the uniformity of the beam pattern beyond the specific test points defined in FMVSS-108. Test points are 64 feet⁸ from the headlamp light source (the bulb).

2.3.1.3 Birds-eye Plot

The birds-eye plot measures candela values and the mounting height of the headlamp when installed on a vehicle. This information is used to develop a representation of a top-down view of the headlamp beam and shows how well it illuminates the road surface and how well the light is distributed. The birds-eye plot shows how far and wide the headlamp beam pattern illuminates the roadway to provide surface visibility for the driver.

2.3.2 Measurement Parameters and Terminology

The measurement of visible light uses a number of terms and is defined in this section in accordance with the National Institute of Standards and Technology⁹ (NIST).

Brightness and Luminance: brightness may be used to describe two distinct concepts - brightness and luminance. Brightness is subjective – the human eye senses lighting in one room as “brighter” than in another. Brightness really has no meaning in terms of photometry. Luminance is an objective term and

⁸ This specification is an appropriate operating window for the measurement equipment. The minimum test distance required by FMVSS-108 is 60 feet.

⁹ <https://web.archive.org/web/20130516045041/http://www.nist.gov/pml/div685/grp03/photometry.cfm>
NIST is an agency of the U.S. Department of Commerce.

it is measured with instruments (see lumen). Lighting output quantified in this report is in units of lumen or candela.

Watt: measure of the power consumption of a light source (electric) derived by Volts x Amps. A 12V automotive lamp that consumes five Amps of current is rated at 60 Watts. It is important to note that Watts are a measurement of power consumption, not light output. A higher wattage bulb is not necessarily brighter as it depends on the technology of the light source. Watts can also be used to indicate the amount of energy emitted in the form of waves. Spectral radiance is the amount of energy emitted in a certain wavelength (for example, visible light, or infrared) in a certain direction. When radiance is weighted by human perception, the result is Candela (Cd).

Lumen: measure of the total visible light emitted from a source in every direction. Imagine a sphere positioned around a light bulb. Measuring the amount of light striking the entire inner surface of the sphere represents the output of the bulb in lumens.

Candela: measure of the intensity of visible light from a source in a specific direction.

Foot-candles and Lux: both terms refer to the amount of visible light falling on a specified surface.

Cutoff: low-beam headlights have a feature that limits forward light output above or near horizontal. European compliant headlamps have a very distinct cutoff line. U.S. compliant lamps have a more diffuse cutoff line that is intended to provide less distracting glare to oncoming traffic.



Figure 4: Low beam headlamp pattern showing horizontal cutoff

2.4 Headlight Lens Restoration

There are two options for restoring clarity to deteriorated headlamp lenses. DIY kits and professional restoration. The headlamp restorations performed in this project are not intended to provide a comprehensive evaluation of headlamp restoration products – professional or consumer-grade.

2.4.1 Professional Restoration

Professional headlight lens restoration can be done by a body shop or other facility that offers automotive services. Many used car centers perform this service on vehicles as part of their overall reconditioning process.

All of the professional systems that AAA researchers studied used a power sanding technique to remove all of the original protective film from the polycarbonate headlamp lens. Once the film is completely removed, the resulting scratched surface of the polycarbonate is polished using



increasingly finer grades of sanding discs. In the process followed by AAA, the original film was removed with 320 grit¹⁰ and then polished with 600, 1200, and 2000-grit sanding discs.

After the sanding/polishing is completed, a protectant film is applied to the entire surface of the headlamp lens. The film is advertised to be equivalent to that used in the original manufacture of the headlamp lens assembly, and is claimed to last five years. The protective film is then cured to a hard finish using a UV light source.

The following is a time-shortened video of the restoration process using the professional restoration process and materials.

- [Video of process](#)

2.4.2 DIY Restoration

As observed by AAA researchers, most DIY kits instruct the user to remove only the discolored surface of the original protective film from the headlamp lens. Some provide instructions to remove all of the coating, others do not specify. Some also include a liquid or spray application of UV protectant intended to extend the clarity of the headlamp lens following restoration.

The kit utilized in AAA's research did not specify the amount of coating to remove, and did include a spray-on UV protectant. The kit claimed to keep headlights clear for one year. No specific guarantee was provided.

The following is a time-shortened video of the restoration process using the DIY kit.

- [Video of process](#)

¹⁰ Grit is the measurement of coarseness for sand paper or sanding discs. A smaller number is coarser and removes material faster, but leaves the surface relatively rough and scratched. Higher grit numbers indicate increasingly smoother sanding materials, which progressively remove the scratches from lower grit numbers and eventually result in a smooth, polished surface.



3 Inquiry #1: On a vehicle with deteriorated headlamps, how much is light output diminished?

3.1 Objective

Perform lab testing to determine differences in light output and glare from deteriorated headlamps and repeat testing following restoration of the headlamps.

3.2 Methodology

Six light output tests are performed on each headlamp assembly (three each on low and high beam). Used headlamps are initially evaluated by the lab in the deteriorated condition. Then used headlamp (1) is restored using a professional headlamp restoration product with a UV curing lamp. The lab then re-evaluates the light output from the headlamp. The same lab testing is conducted on used headlamp (2). Then the headlamp lens is restored using the DIY product and procedure and the lab re-evaluates the light output from the headlamp.

3.3 Key Findings

Restoration of deteriorated headlamp lenses provides improvement in light output. The result is dependent on the condition of the particular headlamp and the skill with which the selected restoration technique is conducted. For the headlamps restored in this test, low beam light output averaged 22.43 percent of the OEM baseline value. After restoration, the average light output improved to an average value of 70.40 percent of the OEM value. None of the restored headlamps was fully compliant with FMVSS-108 evaluation criteria for low beam or high beam light output.

The light output from the used headlamps in the deteriorated state was extremely diffuse and showed almost no cutoff. Total light output from the used lamps in deteriorated condition is summarized in comparison to the OEM reference standard in the chart below.

	Used in Deteriorated Condition		
	OEM	Altima	Malibu
Low Beam	100%	26.21%	18.65%
High Beam	100%	24.95%	24.95%

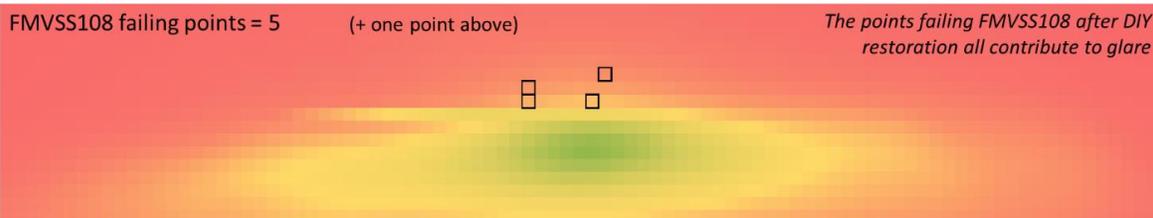
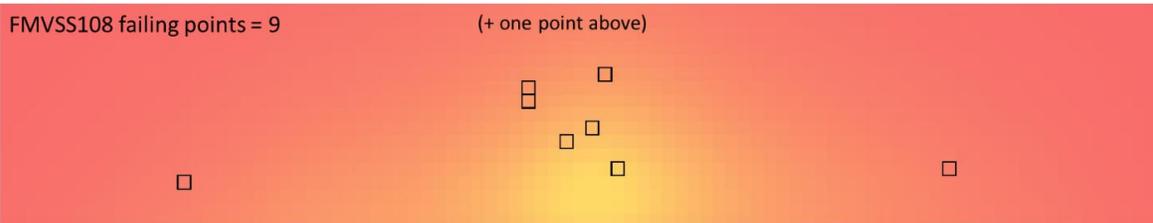
Figure 5: Illumination Performance of Used Headlamps in Deteriorated Condition



Figure 6: Low Beam Illumination Performance Comparison

The example below indicates the failure points for testing the Nissan Altima used (1) headlamp on low beam. Appendix B is exhaustive in comparing OEM to aftermarket, certified to non-certified part and before and after restoration of used parts.

Altima Used #1 Low Beam in deteriorated condition



Altima Used #1 Low Beam restored with DIY kit

Figure 7: FMVSS-108 Low Beam failure points for Altima Used #1



Based on AASHTO¹¹ guidelines, the lighting distance that low-beam settings provide is insufficient at speeds above 39 mph (halogen reflector), 45 mph (halogen projector/HID) and 52 mph (LED) when used on roadways without additional overhead lighting¹². High beam headlights provide an average of 28 percent more forward illumination than low beams.

The following two charts show the deteriorated and post-restoration light output of the used headlamps.

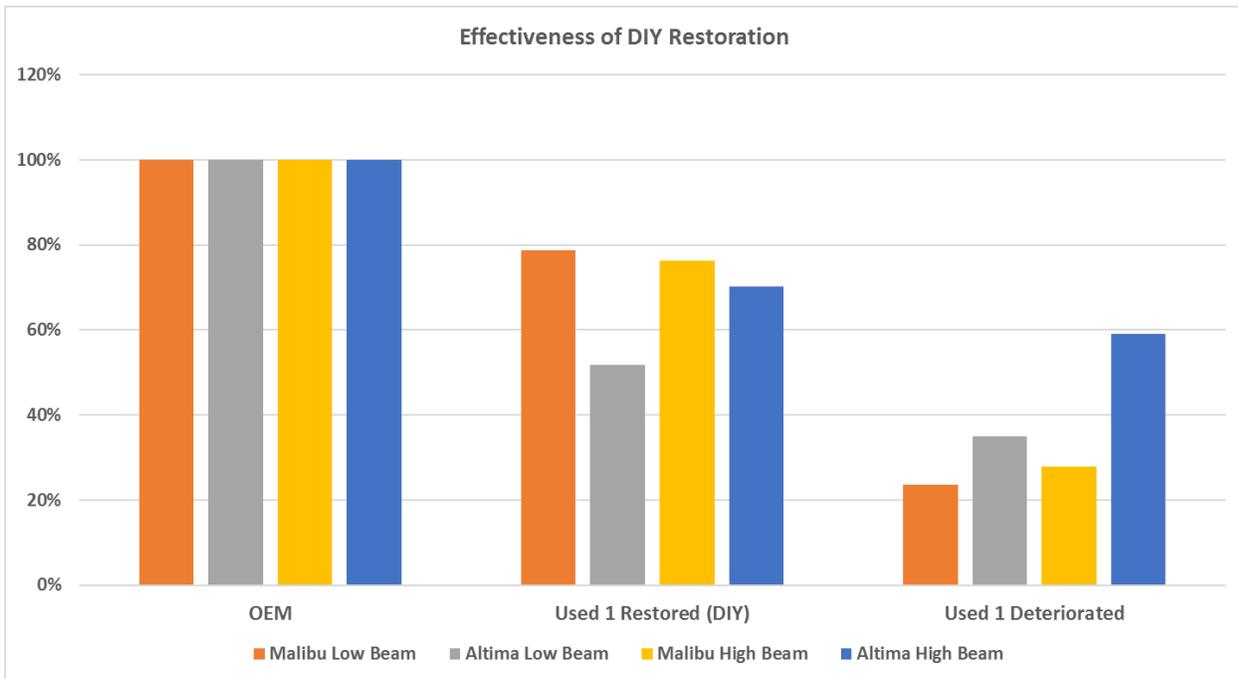


Figure 8: Effectiveness of DIY Headlamp Lens Restoration

¹¹ American Association of State Highway and Transportation Officials, <https://www.transportation.org/home/organization/>
¹² “AAA Tests Shine High Beam on Headlight Limitations” <https://newsroom.aaa.com/2015/05/aaa-tests-shine-high-beam-headlight-limitations/>

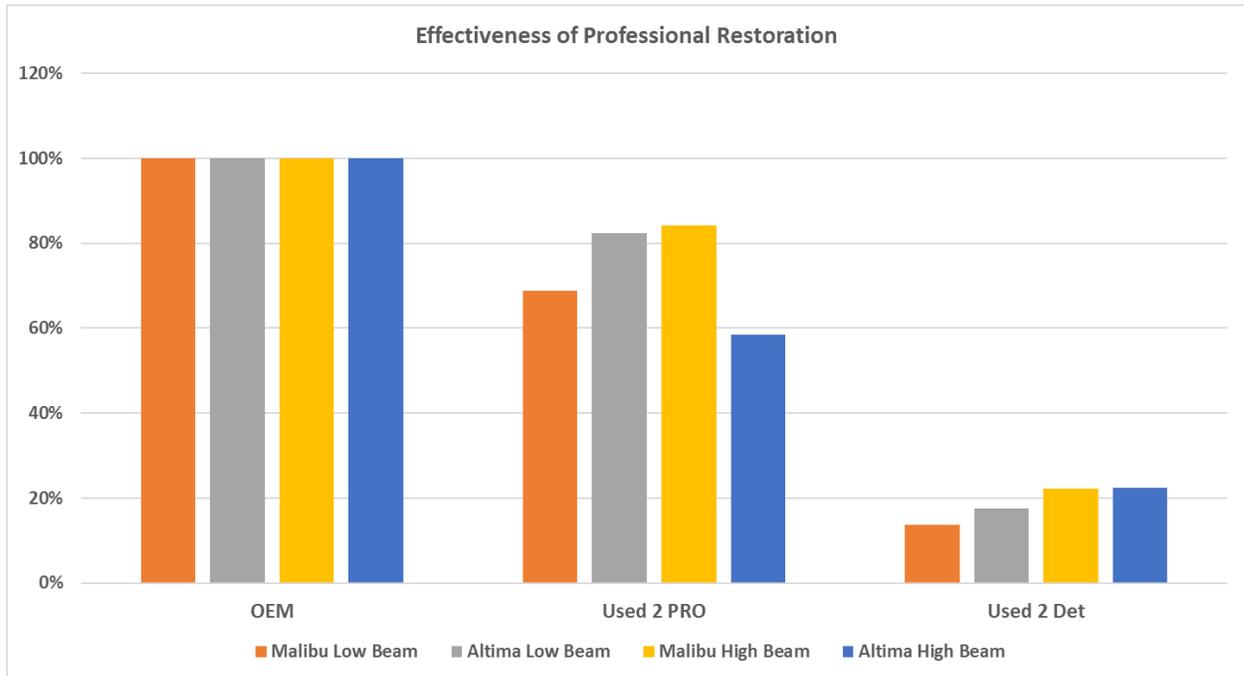


Figure 9: Effectiveness of Professional Headlamp Lens Restoration



4 Inquiry #2: Of the options available for headlamp restoration and/or replacement, which one improves light output the most?

4.1 Objective

Perform lab testing to determine differences in light output and glare from a range of headlight replacement options. Results are intended to inform consumers about the relative value of purchasing OEM vs. aftermarket headlamp assemblies vs. headlamp restoration options.

4.2 Methodology

Six light output tests are performed on each headlamp assembly (three each on low and high beam). The headlamps are evaluated for compliance with FMVSS-108 criteria for both low beam and high beam. This includes delivering at least the minimum required light intensity where required and not exceeding maximum light intensity in other areas. Refer to Appendix B for images of the headlight beam scans and additional information on the points and areas evaluated for compliance with FMVSS-108.

4.3 Key Findings

4.3.1 Required Levels of Illumination

All headlamp assemblies were tested under FMVSS-108 to determine if the illumination produced met applicable federal requirements. Low beam was evaluated at 17 points and seven ranges (a continuous line of points or a larger area) for 24 total evaluation criteria. High beam was evaluated at 19 individual points. Refer to Appendix B for illustrations and additional explanation of FMVSS-108 test criteria.

- OEM headlamps passed FMVSS-108 criteria with one exception (high beam Nissan Altima: 1 point failed)
- Aftermarket certified parts performed nearly as well with only two failures (low beam Chevy Malibu: one point failed, and high beam Nissan Altima: one point failed)
- Aftermarket non-certified parts had the same total number of failures (low beam Nissan Altima: 2 points failed)
- Professional restored headlamps were improved from the deteriorated state, but retained multiple failure points (18 points failed compared to 34 in the deteriorated state)
- DIY restored headlamps were improved from the deteriorated state, but retained multiple failure points (18 points failed compared to 49 in the deteriorated state)



The isocandela scan (ISO) of the Chevy Malibu original equipment headlamp (new), operating on low beam is shown below with an overlay of the FMVSS-108 test points. The test is evaluated as “complies” or “fail” for each specified test point or range. For a headlamp assembly to be approved for use (DOT certified), it must comply with specified light output values (maximum, minimum, or both) for all test points and ranges.

FMVSS-108 test points (Low Beam) overlaid on zoomed ISO scan

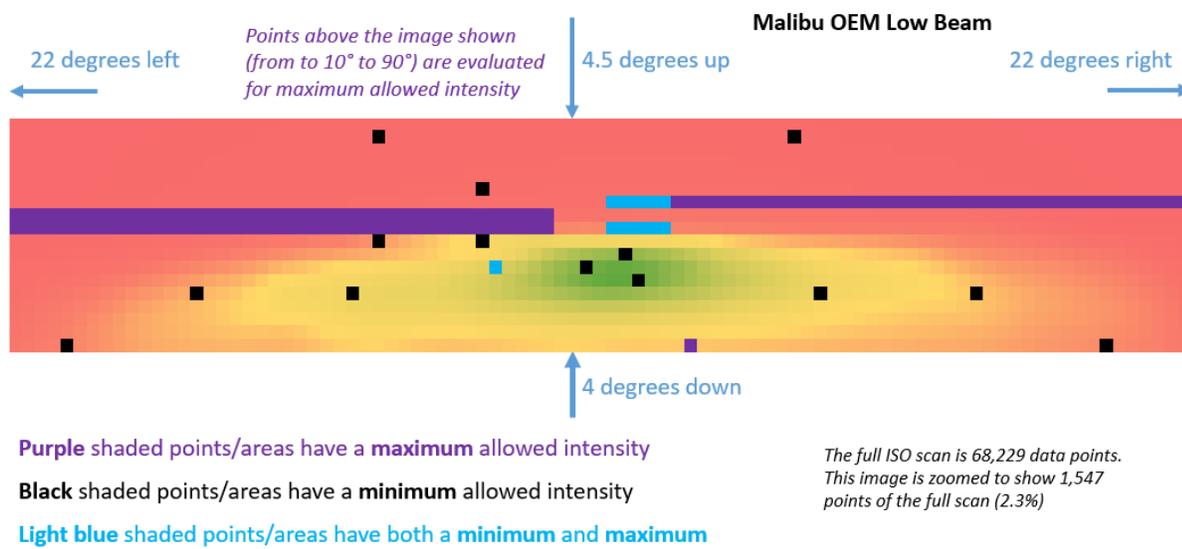


Figure 10: Diagram of low beam test points and regions for FMVSS-108

Refer to Appendix B for isocandela graphical images for each headlamp in both low and high beam operation. Each cell contains data from one point of measurement. Applying conditional formatting creates the color-coded image of luminous intensity. Low and high beam headlights have different test criteria. Where a lamp failed to meet FMVSS 108 test values (minimum or maximum illuminance), the area of failure is noted on the image.



Headlamp Performance to FMVSS-108

Low Beam

2007 Chevy Malibu	
OEM dealer part	All values passed
Aftermarket #1 (NSF)	1 point failed
Aftermarket #2	All values passed
Used #1 (deteriorated)	9 points failed
Used #1 (PRO restored)	5 points failed
Used #2 (deteriorated)	11 points failed
Used #2 (DIY restored)	5 points failed

2007 Nissan Altima	
OEM dealer part	All values passed
Aftermarket #1 (NSF)	All values passed
Aftermarket #2	2 points failed
Used #1 (deteriorated)	8 points failed
Used #1 (PRO restored)	7 points failed
Used #2 (deteriorated)	11 points failed
Used #2 (DIY restored)	7 points failed

High Beam

2007 Chevy Malibu	
OEM dealer part	All values passed
Aftermarket #1 (NSF)	All values passed
Aftermarket #2	All values passed
Used #1 (deteriorated)	11 points failed
Used #1 (PRO restored)	1 points failed
Used #2 (deteriorated)	12 points failed
Used #2 (DIY restored)	1 points failed

2007 Nissan Altima	
OEM dealer part	1 point failed
Aftermarket #1 (NSF)	1 point failed
Aftermarket #2	All values passed
Used #1 (deteriorated)	6 points failed
Used #1 (PRO restored)	5 points failed
Used #2 (deteriorated)	15 points failed
Used #2 (DIY restored)	5 points failed

Figure 11: Headlamp Performance to FMVSS-108



The following charts summarize the light output statistic used to compare performance between the headlamp assemblies. Low beam and high beam performance are graphed separately.

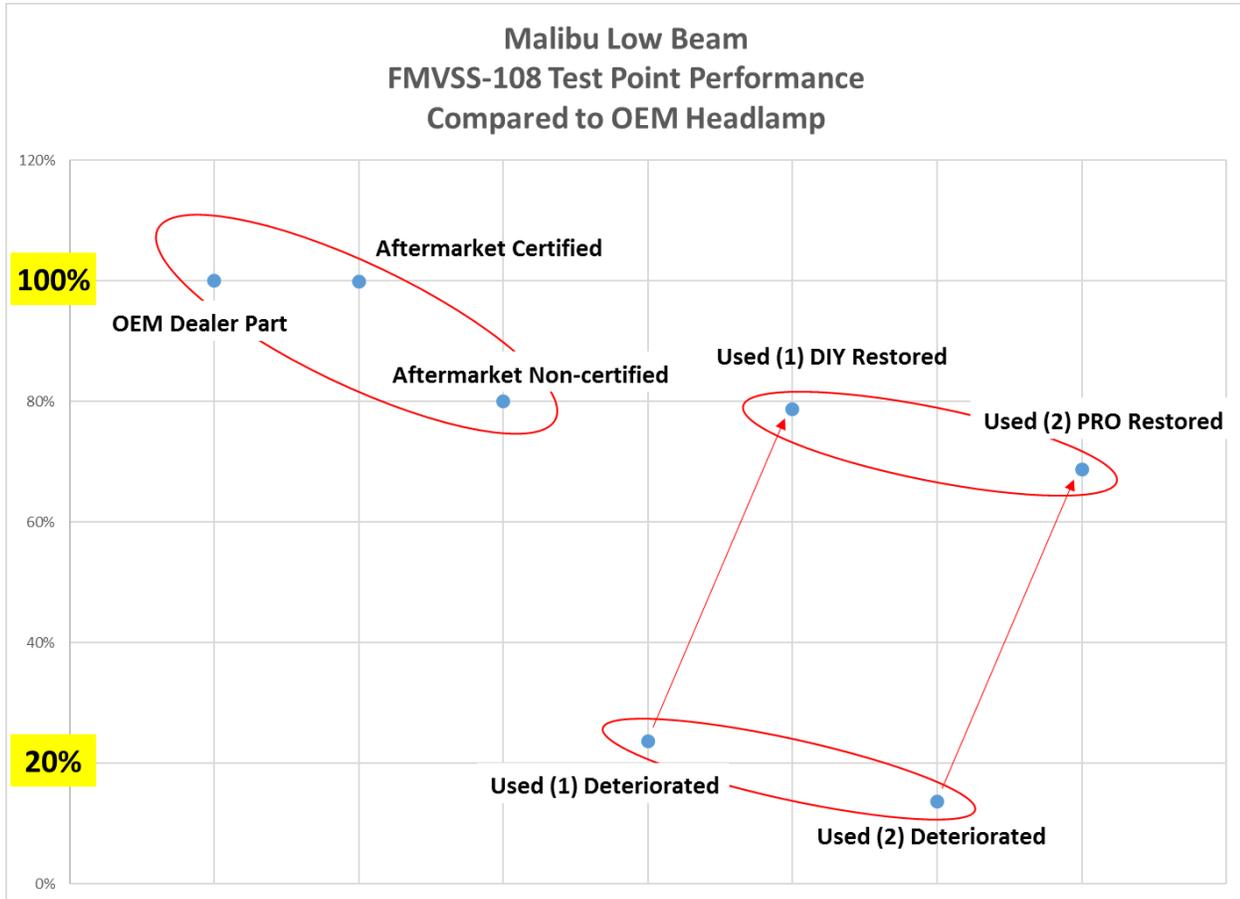


Figure 12: Chevy Malibu Low Beam performance compared to OEM

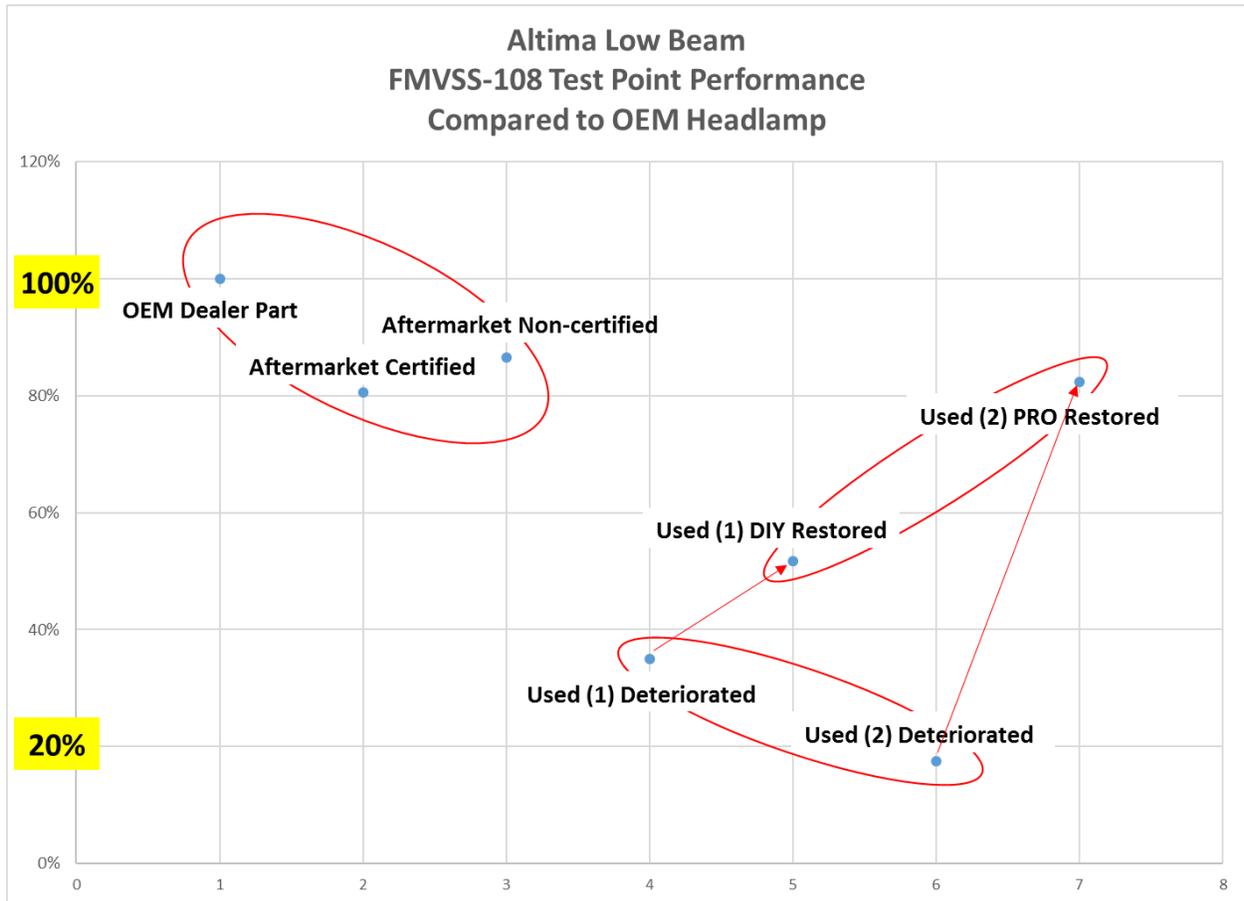


Figure 13: Nissan Altima Low Beam performance compared to OEM

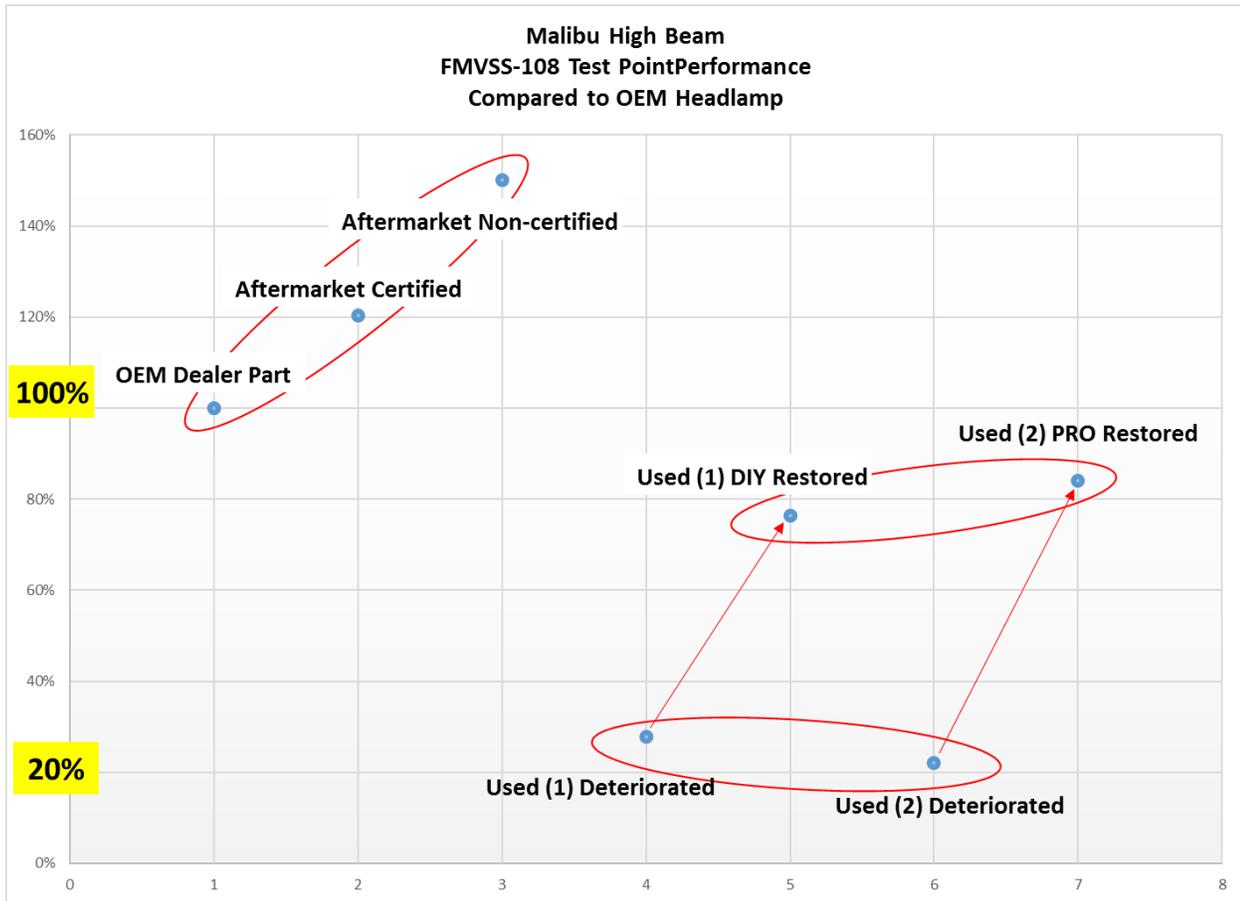


Figure 14: Chevy Malibu High Beam performance compared to OEM

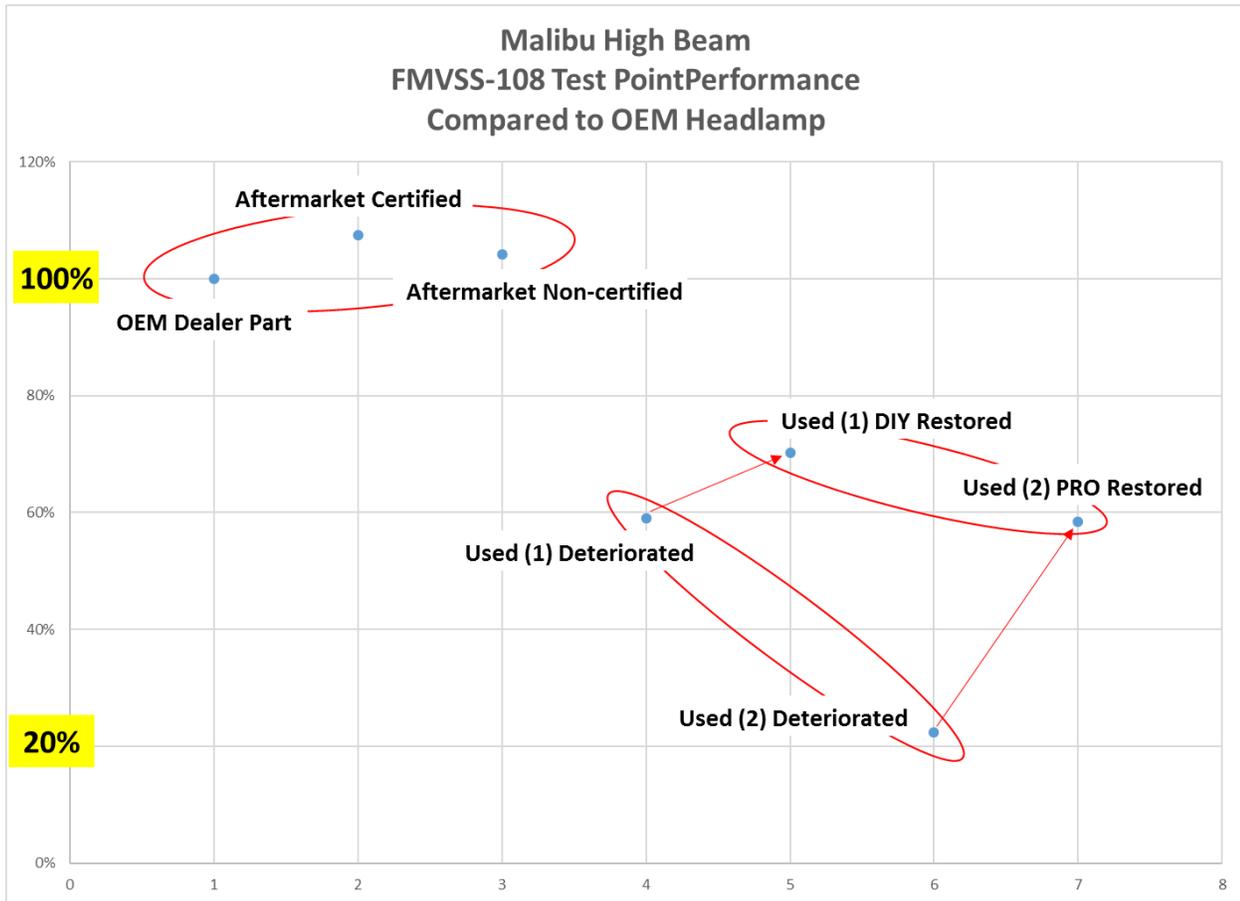


Figure 15: Chevy Malibu High Beam performance compared to OEM



The following chart summarizes headlamp forward illumination statistics for all lamps tested. Restored headlamp performance averaged 71.33 percent of the OEM reference standards¹³.

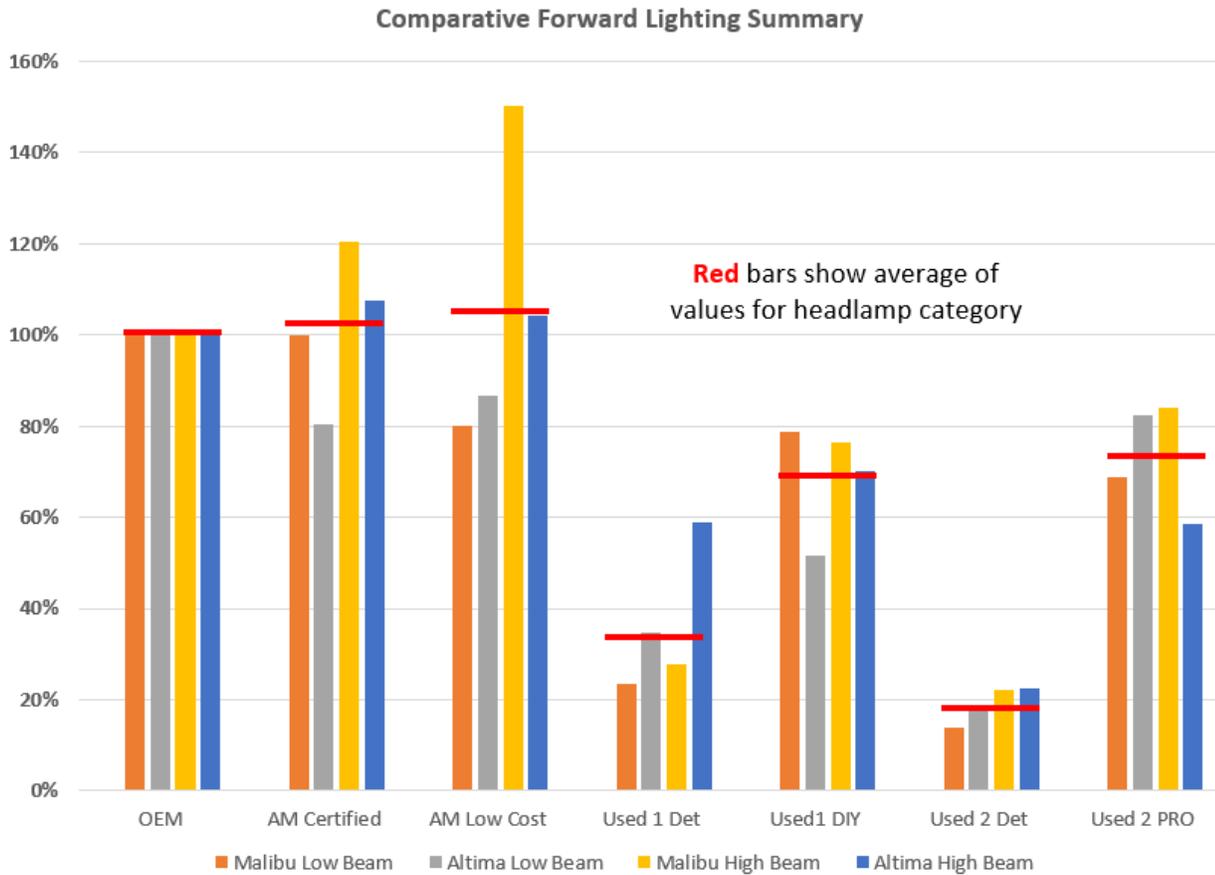


Figure 16: Comparison of light output for all headlamps

¹³ Computed by averaging performance percentage for each of the four used headlamps evaluated in both low beam and high beam operation, with light output compared to the reference standard OEM headlamp for the vehicle model.



The following example compares the forward lighting provided by a new OEM headlamp and a deteriorated lamp in low beam operation. The top image is the OEM replacement assembly. The lower birds-eye plot is a used Nissan Altima headlamp. When averaged, the forward lighting values from all four used headlamps (two Chevy Malibu and two Nissan Altima) resulted in light output of 22.43 percent in comparison to the OEM light output.

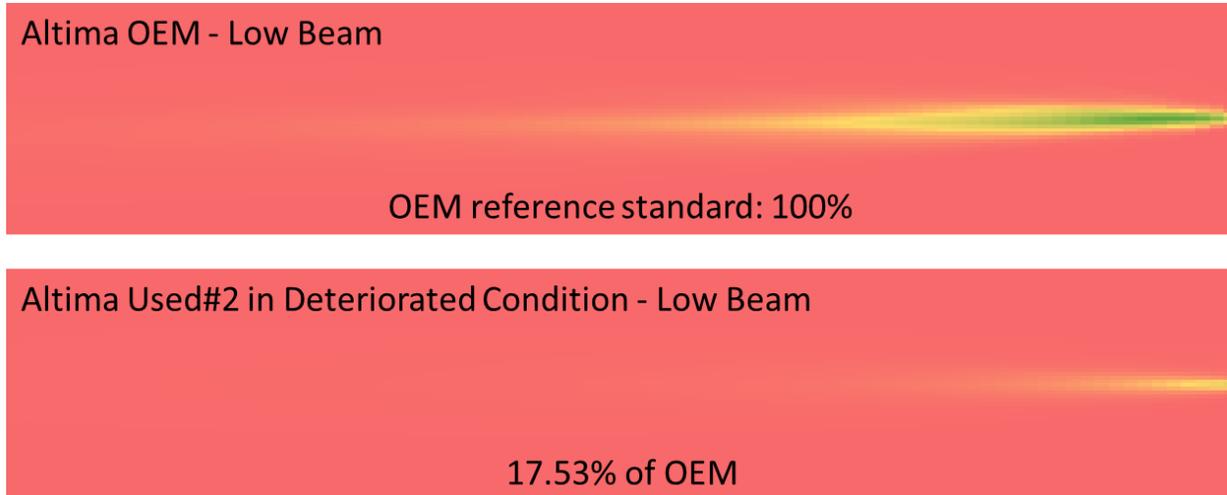


Figure 17: Comparison of Nissan Altima OEM light output vs. used



4.3.2 Quantitative Results of FMVSS-108 Test Points

Candela measurements at FMVSS-108 test points for the Chevy Malibu high beam headlights are summarized in Figure 7. Appendix C contains charts on all tested headlights (Chevy Malibu and Nissan Altima for both low beam and high beam) with data bar illustrations of the performance relative to the FMVSS-108 criteria. The total forward illumination values (where a minimum point specification is provided) are summed to create a statistic for comparison between the headlamps evaluated.

Y-axis vertical	X-axis horizontal	Point	Minimum Candela	Maximum Candela	Malibu OEM HB Dealer Part	Malibu OEM HB compared to FMVSS-108
2.00U	V	A	1,500		3,906.10	160%
1.00U	3.00L	B	5,000		7,898.00	58%
1.00U	3.00R	C	5,000		12,283.00	146%
H	12.00L	D	1,500		3,594.30	140%
H	9.00L	E	3,000		5,361.30	79%
H	6.00R	F	5,000		8,466.30	69%
H	3.00L	G	15,000		19,110.00	27%
H	V	H	40,000	75,000	42,041.00	5%
H	3.00R	I	15,000		28,397.00	89%
H	6.00R	J	5,000		12,106.00	142%
H	9.00R	K	3,000		7,038.60	135%
H	12.00R	L	1,500		4,576.70	205%
1.50D	9.00L	M	2,000		7,798.10	200%
1.50D	V	N	5,000		21,675.00	334%
1.50D	9.00R	O	2,000		6,932.10	247%
2.50D	12.00L	P	1,000		3,010.00	201%
2.50D	V	Q	2,500		10,008.00	200%
2.50D	12.00R	R	1,000		3,089.20	209%
<i>Measured performance of the OEM (dealer part) headlamp assembly is used as the reference standard.</i>					OEM	
					207,290.70	candela
					100.00%	

Figure 18: Chevy Malibu OEM High Beam Candela Measurements

The charts in this report section quantify high beam headlight performance according to FMVSS-108 test points. The specific test points and larger areas evaluated (mostly for glare producing light scatter) are different for low beam operation. Refer to Appendix B for illustrations and explanation of the test locations for both low beam and high beam headlamp operation.

The aftermarket headlamps for the Chevy Malibu passed all point specifications for high beam operation. Both aftermarket units provided more forward illumination than the OEM headlamp. This is arguably a better result than the OEM lamp on high beam performance, but low beam performance must be considered as well. Performance of all Chevy Malibu headlamps relative to FMVSS-108 high beam operation is shown below. Refer to Appendix C for quantified results for both low and high beam operation for the Chevy Malibu and Nissan Altima headlamps.



Y-axis vertical	X-axis horizontal	Point	Minimum Candela	Maximum Candela	Malibu HB Certified	Malibu HB Certified AM compared to FMVSS-108	Malibu HB Low Cost	Malibu HB Low Cost AM compared to FMVSS-108
2.00U	V	A	1,500		10,487.00	599%	15,026.00	902%
1.00U	3.00L	B	5,000		14,217.00	184%	30,802.00	516%
1.00U	3.00R	C	5,000		29,678.00	484%	24,922.00	398%
H	12.00L	D	1,500		3,615.90	141%	4,972.20	231%
H	9.00L	E	3,000		7,259.60	142%	9,230.50	208%
H	6.00R	F	5,000		10,466.00	109%	21,596.00	332%
H	3.00L	G	15,000		18,273.00	22%	63,326.00	322%
H	V	H	40,000	75,000	51,383.00	28%	40,117.00	0%
H	3.00R	I	15,000		34,496.00	130%	25,411.00	69%
H	6.00R	J	5,000		14,362.00	187%	15,256.00	205%
H	9.00R	K	3,000		8,286.90	176%	9,010.20	200%
H	12.00R	L	1,500		7,110.10	374%	4,378.30	192%
1.50D	9.00L	M	2,000		6,141.00	207%	6,749.10	237%
1.50D	V	N	5,000		16,776.00	236%	18,150.00	263%
1.50D	9.00R	O	2,000		5,450.30	173%	5,971.50	199%
2.50D	12.00L	P	1,000		1,540.60	54%	2,732.70	173%
2.50D	V	Q	2,500		7,049.80	182%	11,727.00	369%
2.50D	12.00R	R	1,000		3,021.00	303%	1,879.30	88%
					AM2 Certified		AM1 Low Cost	
					249,613.20	candela	311,256.80	candela
					120.42%		150.15%	

Figure 19: Chevy Malibu AM Certified High Beam Candela Measurements



The used headlamps for the Chevy Malibu, like those for the Nissan Altima failed FMVSS-108 point specifications in many areas. Overall, the used headlamps¹⁴ in deteriorated condition provided an average of 27.63 percent of the illumination of the reference standard OEM headlamp assembly.

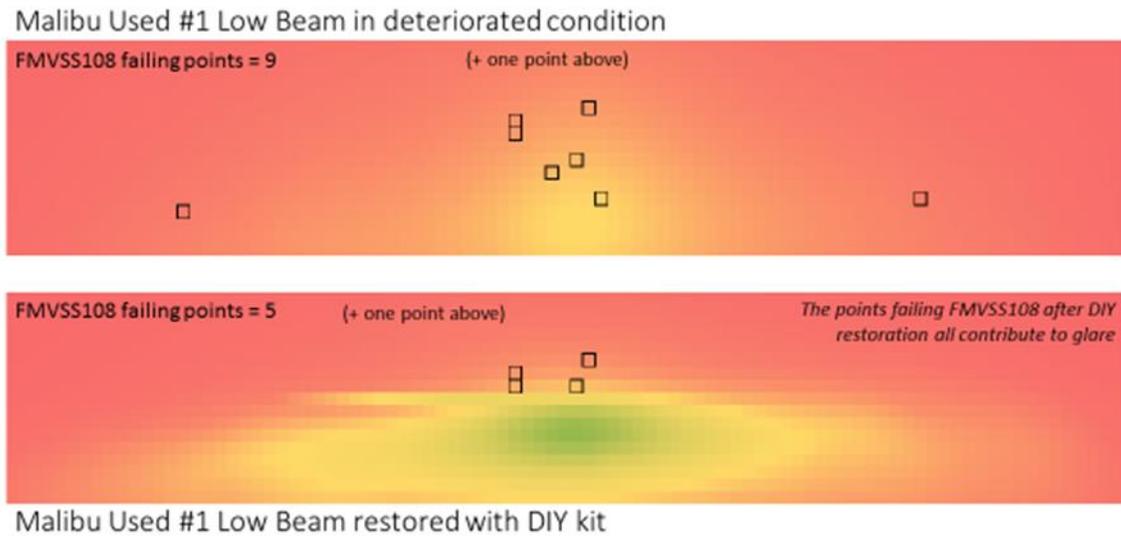
After restoration, the DIY process resulted in an average of 69.2 percent compared to the baseline of the OEM headlamp output (low beam and high beam). The professional restoration process resulted in 73.4 percent of the OEM performance. However, there were failure points when the restored headlamps were tested. The example in figure 20 shows the performance of the two used high beam headlamps for the Nissan Altima. Performance in deteriorated condition is compared to restored headlamps for both DIY and professional processes.

Malibu HB Used #1 Deteriorated	Malibu HB Used#1 Deteriorated compared to FMVSS-108	Malibu HB Used #1 DIY Restored	Malibu HB Used#1 DIY Restored compared to FMVSS-108	Malibu HB Used #2 Deteriorated	Malibu HB Used#2 Deteriorated compared to FMVSS-108	Malibu HB Used #2 PRO Restored	Malibu HB Used#2 PRO Restored compared to FMVSS-108
3,590.40	139.38%	5,749.40	283.29%	1,759.80	17.32%	4,340.90	189.39%
3,317.60	-33.65%	9,321.30	86.43%	2,089.70	-58.21%	7,161.30	43.23%
4,140.30	-17.19%	10,633.00	112.66%	2,480.10	-50.40%	9,594.90	91.90%
1,227.70	-18.15%	3,046.50	103.10%	965.65	-35.62%	2,785.90	85.73%
1,739.10	-42.03%	4,903.70	63.46%	1,304.00	-56.53%	4,368.00	45.60%
2,549.80	-49.00%	7,883.10	57.66%	1,885.70	-62.29%	7,055.40	41.11%
3,971.80	-73.52%	16,581.00	10.54%	2,894.50	-80.70%	16,653.00	11.02%
5,721.70	-85.70%	26,743.00	-33.14%	3,956.30	-90.11%	32,769.00	-18.08%
4,861.30	-67.59%	16,915.00	12.77%	3,550.50	-76.33%	19,121.00	27.47%
3,081.00	-38.38%	8,459.40	69.19%	2,405.70	-51.89%	9,225.30	84.51%
1,964.80	-34.51%	4,947.60	64.92%	1,646.10	-45.13%	5,709.80	90.33%
1,313.50	-12.43%	2,996.70	99.78%	1,156.90	-22.87%	3,433.20	128.88%
2,035.80	-1.79%	5,670.70	18.54%	1,727.80	-13.61%	6,422.80	221.14%
6,678.70	33.57%	15,841.00	216.12%	6,094.90	21.90%	22,934.00	358.68%
2,063.00	-3.15%	4,535.30	66.75%	2,142.30	7.12%	5,827.00	191.35%
1,413.40	41.34%	3,147.20	214.12%	1,287.40	28.74%	3,111.90	211.19%
6,598.00	163.92%	8,791.00	251.6%	6,971.80	178.87%	11,489.00	359.56%
1,335.60	33.56%	2,041.40	104.14%	1,506.30	50.63%	2,372.00	137.20%
Used1 Deteriorated		Used1 DIY Restoration		Used 2 Deteriorated		Used 2 PRO Restoration	
57,603.50 candela		158,206.30 candela		45,825.45 candela		174,374.40 candela	
27.79%		76.32%		22.11%		84.12%	

Figure 20: Chevy Malibu Used (1) High Beam Candela Measurements

In the example shown in figure 21, several test points that failed to meet minimum light output levels were corrected by the headlamp restoration process. Failure points shown for the restored headlamp are above the horizontal level and are associated areas of the headlamp beam that produce glare. After restoration, the headlamp produced too much light in the indicated test points. Refer to Appendix B for failure locations on all tested lamps (Chevy Malibu and Nissan Altima, low beam and high beam).

¹⁴ Eight data points: two left-side headlamps for each of the Chevy Malibu and Nissan Altima, each evaluated separately for low beam and high beam operation.



10

Figure 21: Comparison of deteriorated and restored light intensity failure points

4.3.3 Cost of Replacement or Restoration

The cost of replacement headlamp assemblies varies greatly based on the vehicle year, make and model. The mechanical complexity and associated cost to install a headlamp assembly also varies. Using the two test vehicles in this research, the Chevy Malibu headlamps can be replaced for a labor charge of 1.0 hours while the Nissan Altima requires 1.8 hours labor due to the requirement of removing and re-installing the front bumper cover. Because headlights are often damaged in relatively minor collisions, there is a competitive environment for replacement parts. The replacement parts, OEM and aftermarket were purchased for the prices indicated below. The following chart is intended to be illustrative of the comparison costs from restoration, DIY or professional, to replacing the headlight assemblies with new parts, either aftermarket or OEM.

In each case, the headlamp aim should be checked and adjusted as necessary. A minor adjustment to headlamp aim can avoid needless glare to oncoming or preceding traffic, as well as optimizing the amount of light illuminating the roadway for night driving. Labor for a repair shop to aim headlights is typically 1/2 hour, or \$48, using the national average labor rate figure. Refer to Appendix D for additional detail in price calculations. The amount charged for professional headlamp restoration services varies, but typically includes a one-half to three-quarter hour labor charge and an amount for supplies used in the process.



2007 Chevy Malibu		Total w/o Re-Aiming
OEM Dealer Part (qty = 2)		
Purchase from and installation by dealership		\$427.29
Purchase locally and DIY installation		\$331.29
Aftermarket Certified Part (qty = 2)		
Purchase from and installation by service provider ⁵		\$259.92
Purchase online and DIY installation		\$131.41
Aftermarket Low Cost Part (qty = 2)		
Purchase from and installation by service provider		\$243.13
Purchase online and DIY installation		\$120.71
Professional Restoration (both headlights)		
Professional Restoration (<i>estimated</i>)		\$77.00
Do-It-Yourself Restoration (both headlights)		
DIY Restoration		\$21.39

¹ Assume dealership will price match online OEM part cost

² 7% sales tax used in calculations; assume no tax on labor

² \$13.50 per headlamp used in calculations

³ Sourced from an industry standard labor guide

⁴ National average labor rate as determined by AAA research

⁵ Typical parts mark-up percentage: 57%

Figure 22: Chevy Malibu restore/replace cost estimates



2007 Nissan Altima		Total w/o Re-Aiming
OEM Dealer Part (qty = 2)		
Purchase from and installation by dealership		\$466.54
Purchase locally and DIY installation		\$370.54
Aftermarket Certified Part (qty = 2)		
Purchase from and installation by service provider ⁵		\$270.00
Purchase online and DIY installation		\$137.83
Aftermarket Low Cost Part (qty = 2)		
Purchase online and DIY installation		\$190.92
Purchase from and installation by service provider		\$104.41
Professional Restoration (both headlights)		
Professional Restoration (<i>estimated</i>)		\$77.00
Do-It-Yourself Restoration (both headlights)		
DIY Restoration		\$21.39

¹ Assume dealership will price match online OEM part cost

² 7% sales tax used in calculations; assume no tax on labor

² \$13.50 per headlamp used in calculations

³ Sourced from an industry standard labor guide

⁴ National average labor rate as determined by AAA research

⁵ Typical parts mark-up percentage: 57%

Figure 23: Nissan Altima restore/replace cost estimates

4.4 Summary Findings

- New OEM headlamps performed best, considering light output as well as compliance with FMVSS-108 test criteria. The new OEM Nissan Altima headlamp did have one failure point¹⁵.
- Aftermarket headlamps performed well, but did not comply with all test points. In particular, aftermarket headlamps did not meet FMVSS-108 specification for cutoff and failed to meet all requirements for intensity. Failure to meet specification for cutoff is interpreted to mean the headlamp is more likely to produce glare to oncoming and/or preceding traffic.
 - Certified aftermarket headlamps performed slightly better in terms of compliance than the low-cost alternative, most notably on low beam, although the total number of failure points was identical.
 - Both aftermarket alternatives out-performed the restored headlamps.

¹⁵ Measured 14,679 of required 15,000 candela at point H (horizontal) 3R (degrees to right).



- Restored headlamps performed significantly better than in their deteriorated condition. All restored headlamps came much closer to meeting performance criteria in terms of light output. However, each restored headlamp continued to have non-compliance failures. This is a significant improvement in forward lighting performance, but falls short of the level of performance provided by either aftermarket unit or the OEM replacement part.
 - In the limited sample size tested, both professional and DIY restoration processes substantially improved light output. The DIY process resulted in an average of 69.2 percent compared to the baseline of the OEM headlamp output (low beam and high beam). The professional restoration process resulted in 73.4 percent of the OEM performance
 - After restoration by either DIY or professional methods, failure points were largely in regions of the low beam test associated with producing glare to oncoming or preceding traffic



5 Summary Recommendations

- Vehicle lenses that are yellowed or cloudy may be producing less than 30 percent of the light output as compared to new headlamp lenses. To improve visibility for nighttime driving, replace the headlights with OEM or aftermarket units or have them restored (professionally or DIY) as soon as they start showing signs of aging.
- The cost to restore or replace headlights varies. AAA recommends considering personal budget and length of vehicle ownership when deciding which option is best. Regardless of the approach selected, make sure headlamps are properly re-aimed to maximize forward lighting performance and minimize glare to oncoming and preceding motorists.
- While test results provided a hierarchy of performance, it is clear that any method chosen to address deteriorated headlamp lenses results in a big improvement in nighttime driving safety.

8 Appendix A: Headlamp Images



Figure 24: Malibu OEM



Figure 25: Altima OEM



Figure

Malibu Aftermarket Certified

26:



Figure
Malibu

Aftermarket Non-certified

27:



Figure 28: Altima Aftermarket Certified



Figure 29: Altima Aftermarket Non-certified



Figure 30: Malibu Used 1 – Deteriorated



Figure 31: Malibu Used 1 DIY Restoration



Figure 32: Malibu Used 2 Deteriorated



Figure 33: Malibu Used 2 Professional Restoration



Figure 34: Altima Used 1 Deteriorated



Figure 35: Altima Used 1 DIY Restored



Figure 36: Altima Used 2 Deteriorated



Figure 37: Altima Used 2 Professional Restoration



9 Appendix B: Images of ISO scans with FMVSS 108 failure locations

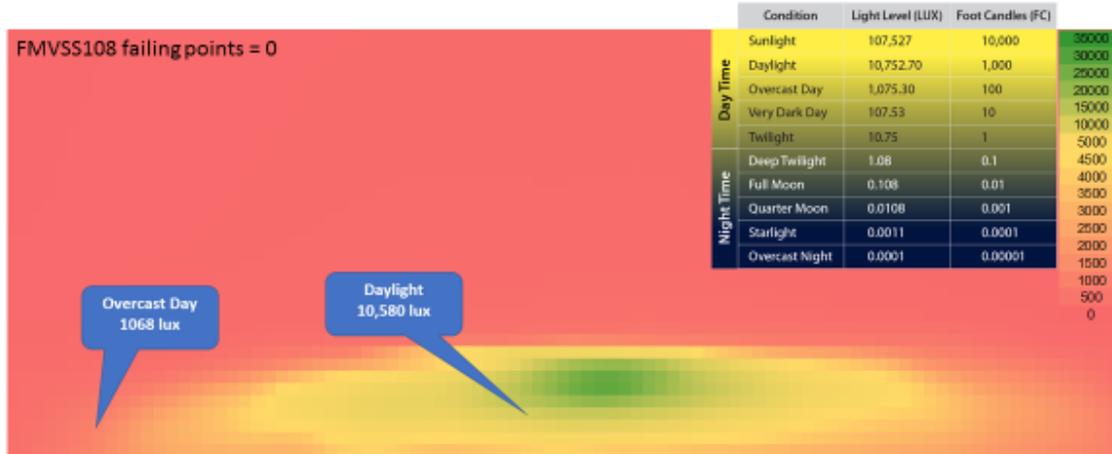
9.1 Low Beam (2007 Malibu)

Malibu Original Equipment (new) Low Beam >> Showing Full ISO Scan



1

Malibu Original Equipment (new) Low Beam

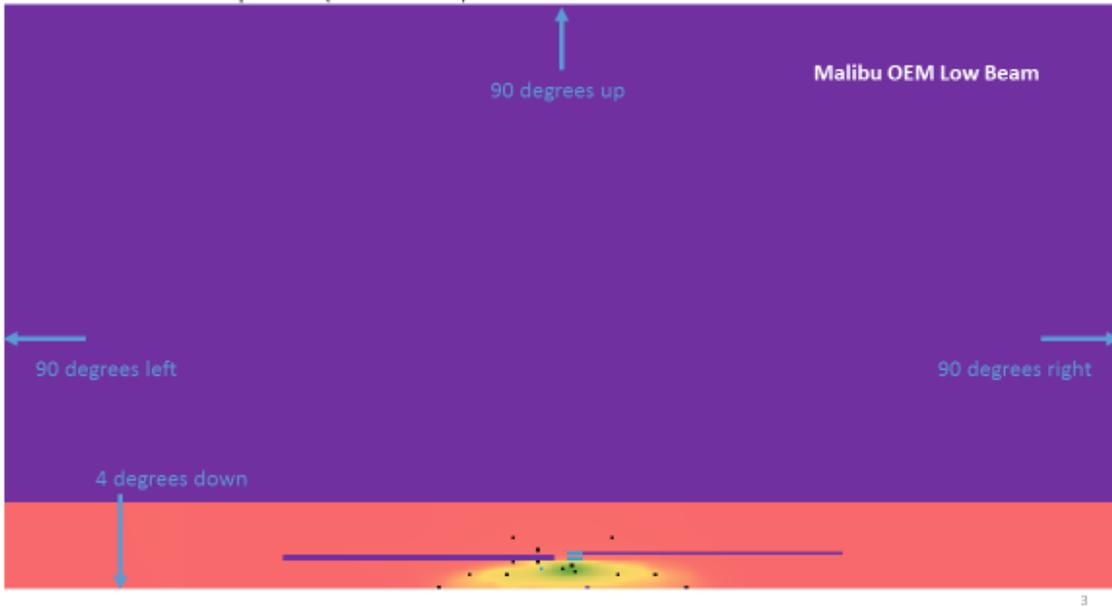


The full ISO scan is 68,229 data points. This image is zoomed to show 3,185 points of the full scan (4.7%). Each "cell" has a value in lux (the amount of light that falls on a surface), measured at a distance of 64 feet. The brightest green is the highest lux value. The highest value on this scan 27,875.8 lux. For comparison, sunlight is rated at 107,527 lux.

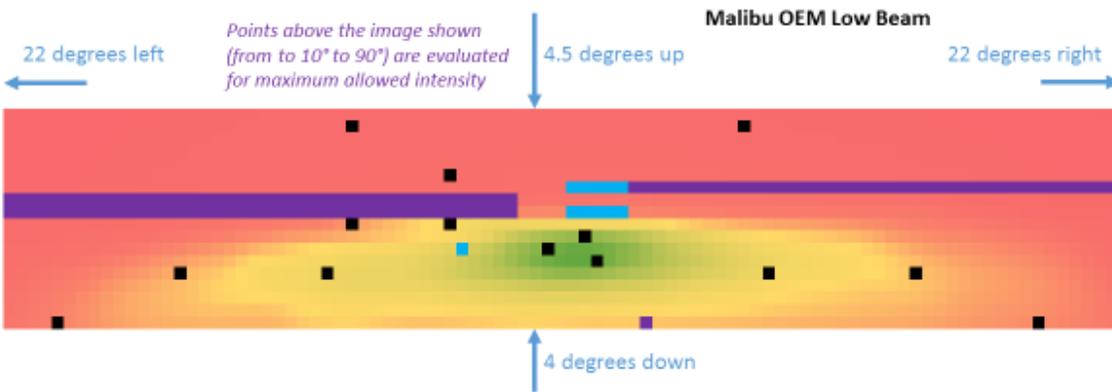
2



FMVSS-108 test points (Low Beam) overlaid on full ISO scan



FMVSS-108 test points (Low Beam) overlaid on zoomed ISO scan



Purple shaded points/areas have a maximum allowed intensity

Black shaded points/areas have a minimum allowed intensity

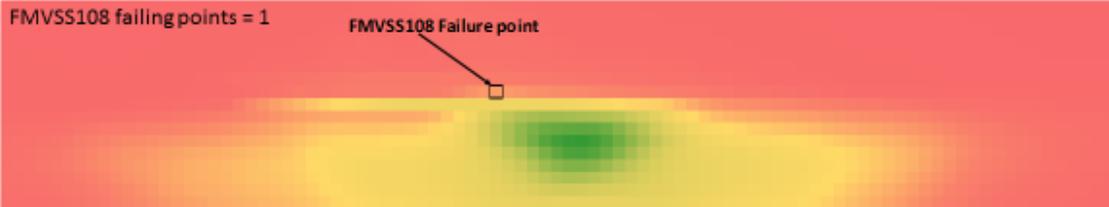
Light blue shaded points/areas have both a minimum and maximum

The full ISO scan is 68,229 data points. This image is zoomed to show 1,547 points of the full scan (2.3%)

4



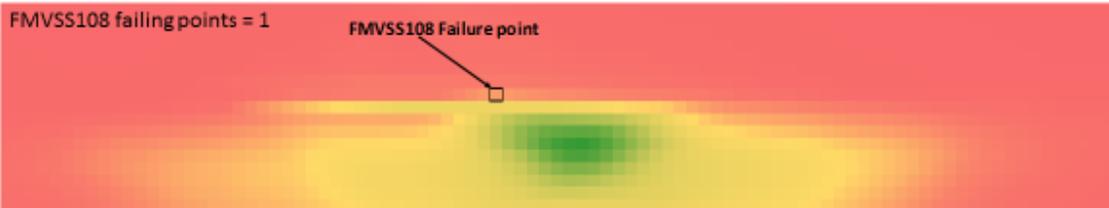
Malibu Aftermarket #1 (low cost part) Low Beam



Malibu Original Equipment (new) Low Beam

5

Malibu Aftermarket #1 (low cost part) Low Beam

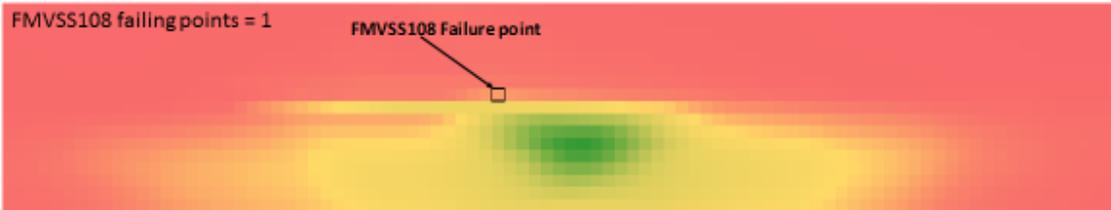


Malibu Original Equipment (new) Low Beam

5



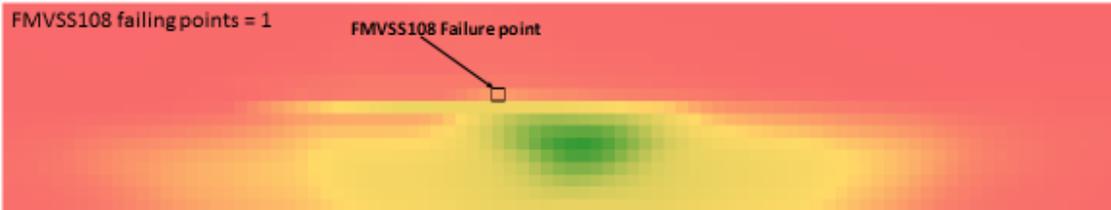
Malibu Aftermarket #1 (low cost part) Low Beam



Malibu Original Equipment (new) Low Beam

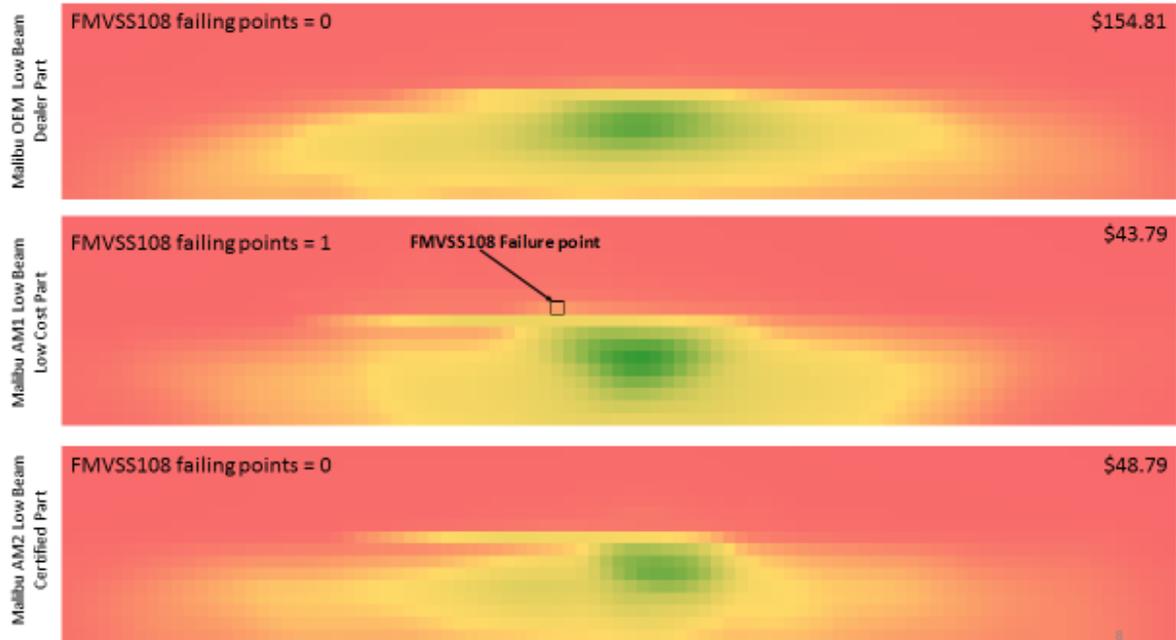
7

Malibu Aftermarket #1 (low cost part) Low Beam

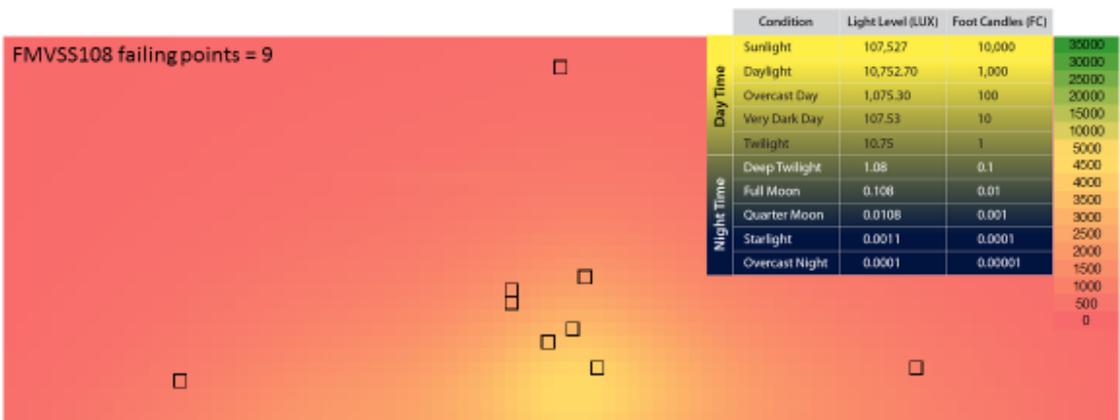


Malibu Original Equipment (new) Low Beam

7



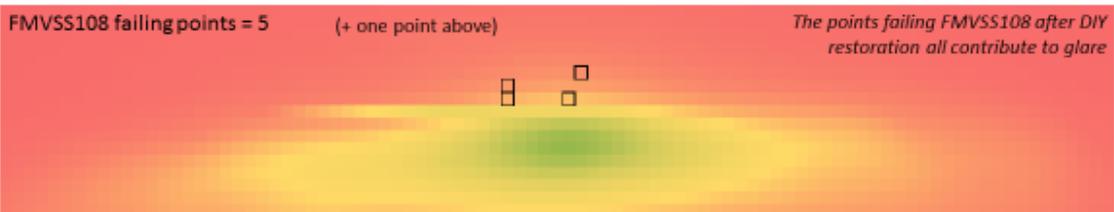
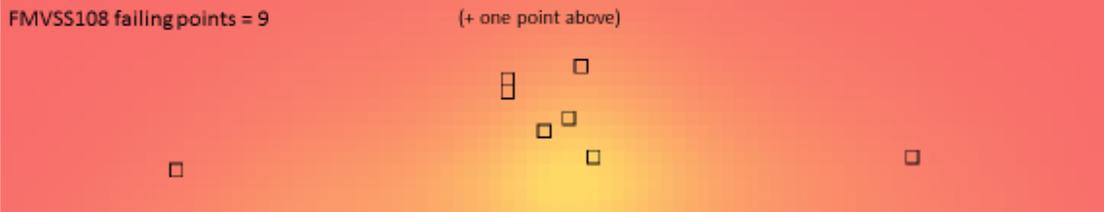
Malibu Used #1 Low Beam in deteriorated condition



The full ISO scan is 68,229 data points.
 This image is zoomed to show 2,821 points of the full scan (4.1%).
 The highest value on this scan is 4654.1 lux.

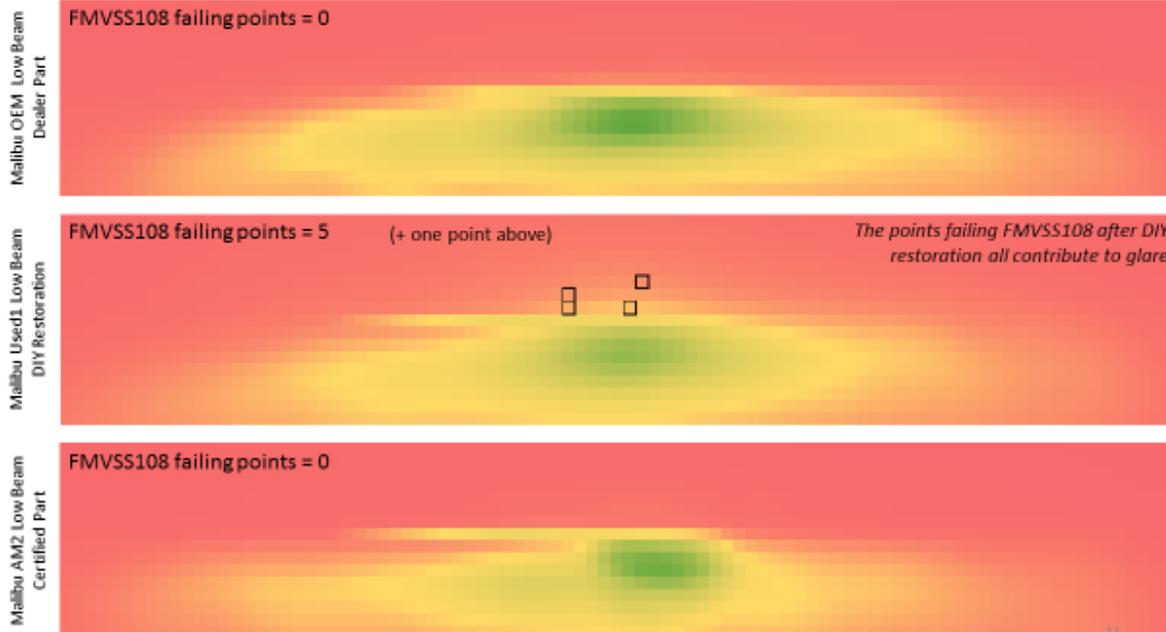


Malibu Used #1 Low Beam in deteriorated condition



Malibu Used #1 Low Beam restored with DIY kit

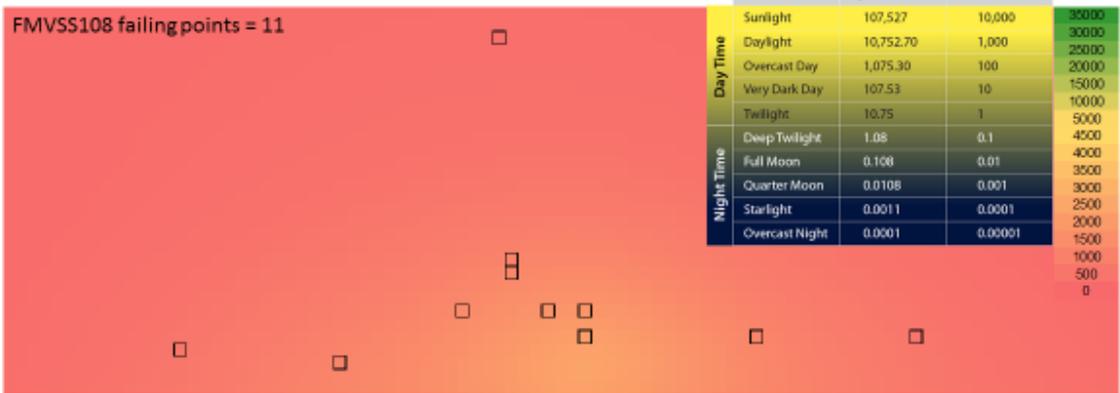
10



11



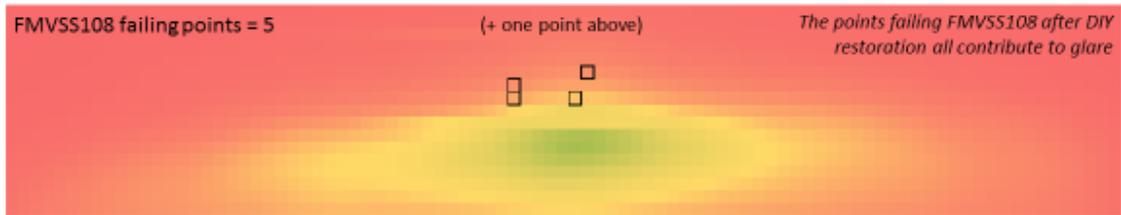
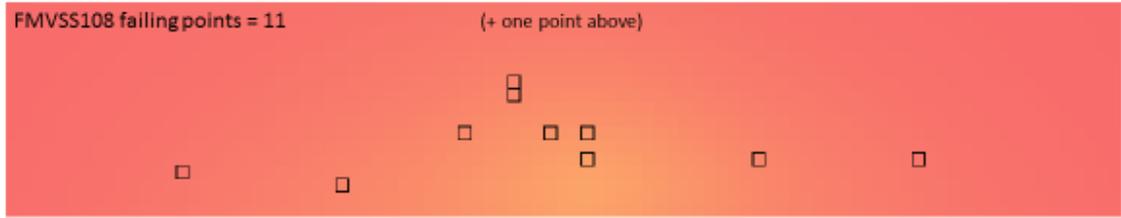
Malibu Used #2 Low Beam in deteriorated condition



The full ISO scan is 68,229 data points.
 This image is zoomed to show 3,185 points of the full scan (4.6%).
 The highest value on this scan is 2376.7 lux.

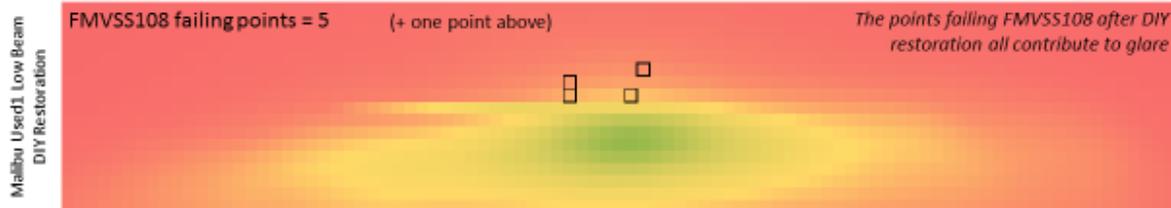
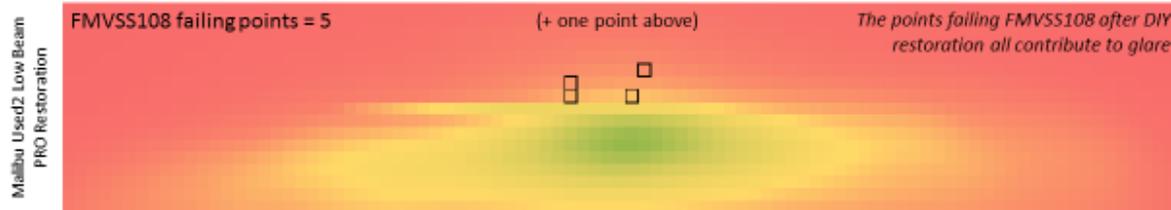
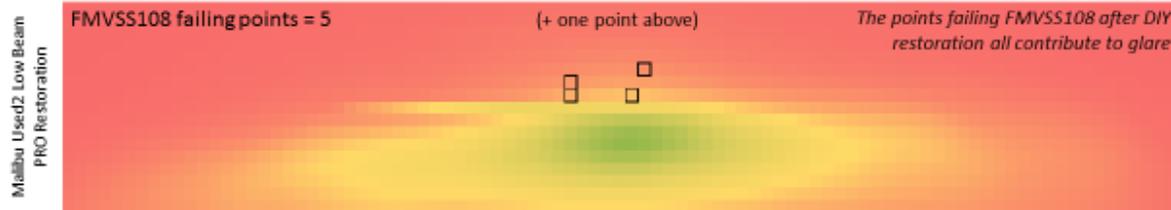
12

Malibu Used #2 Low Beam in deteriorated condition



Malibu Used #2 Low Beam after PRO restoration

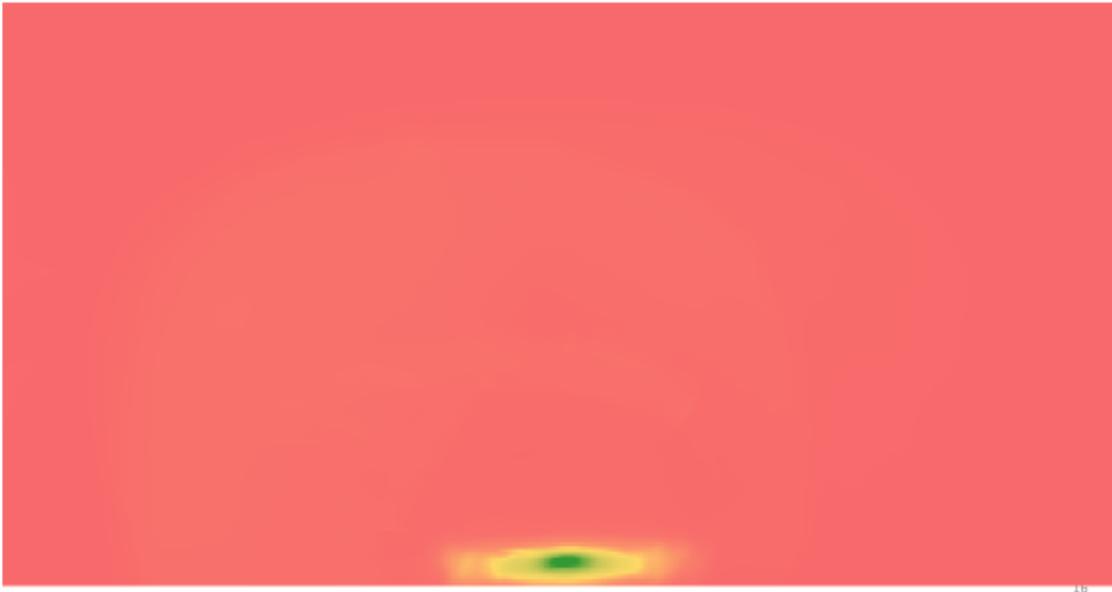
13



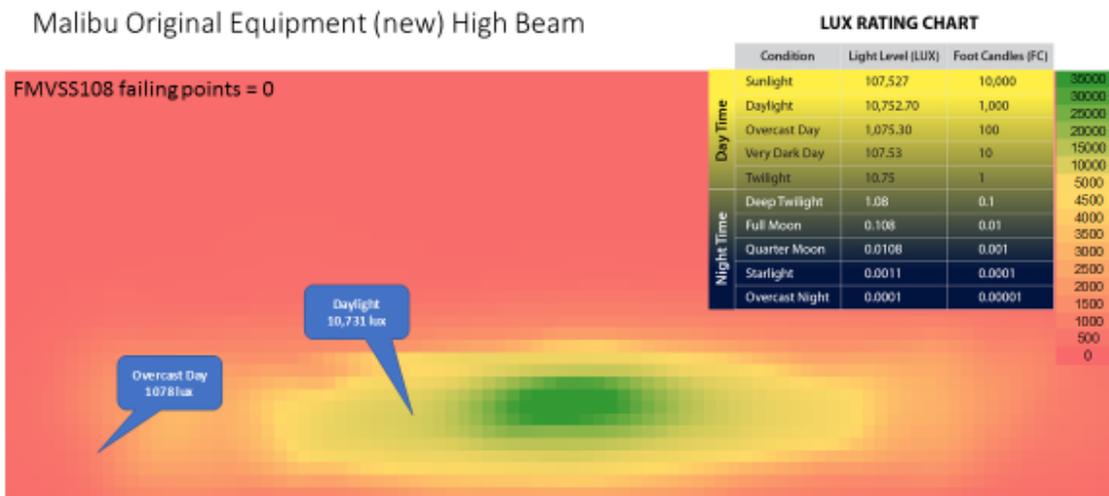


9.2 High Beam (2007 Malibu)

Malibu Original Equipment (new) High Beam >> Showing Full ISO Scan



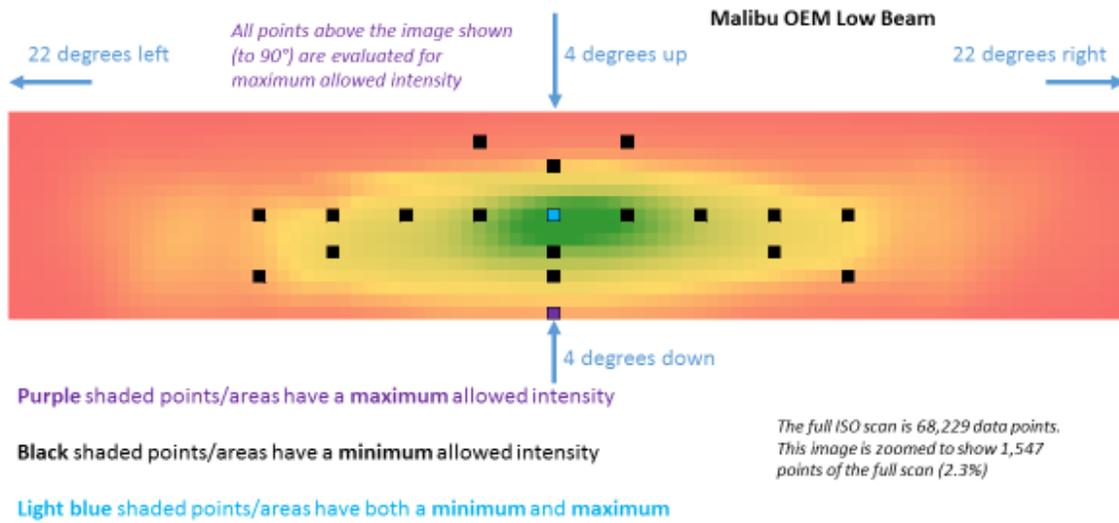
Malibu Original Equipment (new) High Beam



The full ISO scan is 68,229 data points. This image is zoomed to show 3,185 points of the full scan (4.7%). Each "cell" has a value in lux (the amount of light that falls on a surface), measured at a distance of 64 feet. The brightest green is the highest lux value. The highest value on this scan 43,289.2 lux. For comparison, sunlight is rated at 107,527 lux.



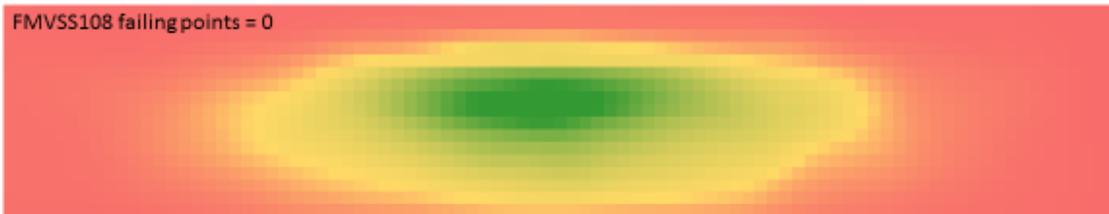
FMVSS-108 test points (High Beam) overlaid on zoomed ISO scan



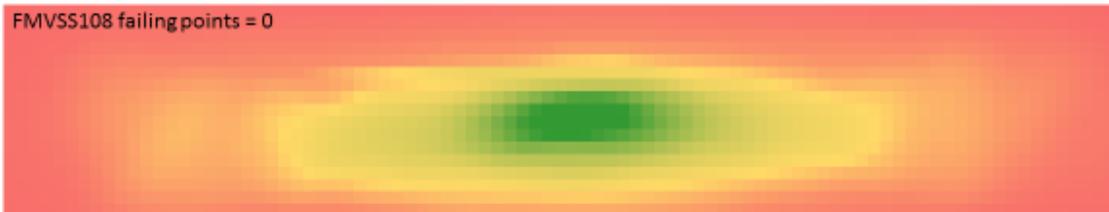
18

Malibu Aftermarket #1 (low cost part) High Beam

FMVSS108 failing points = 0



FMVSS108 failing points = 0



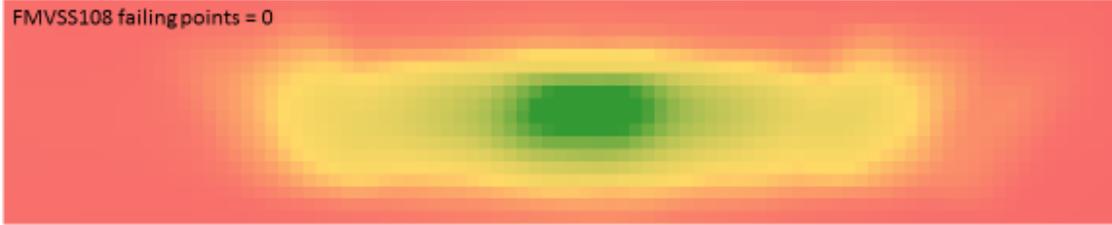
Malibu Original Equipment (new) High Beam

19

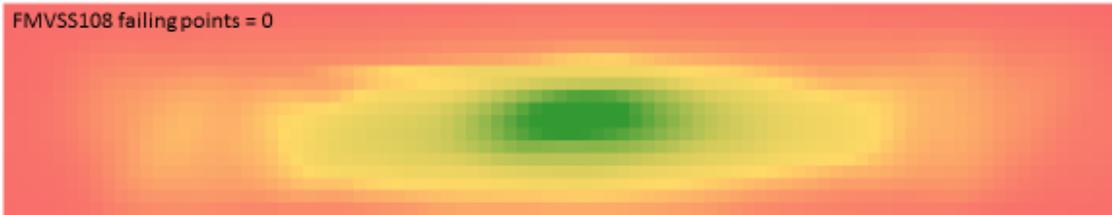


Malibu Aftermarket #2 (certified part) High Beam

FMVSS108 failing points = 0

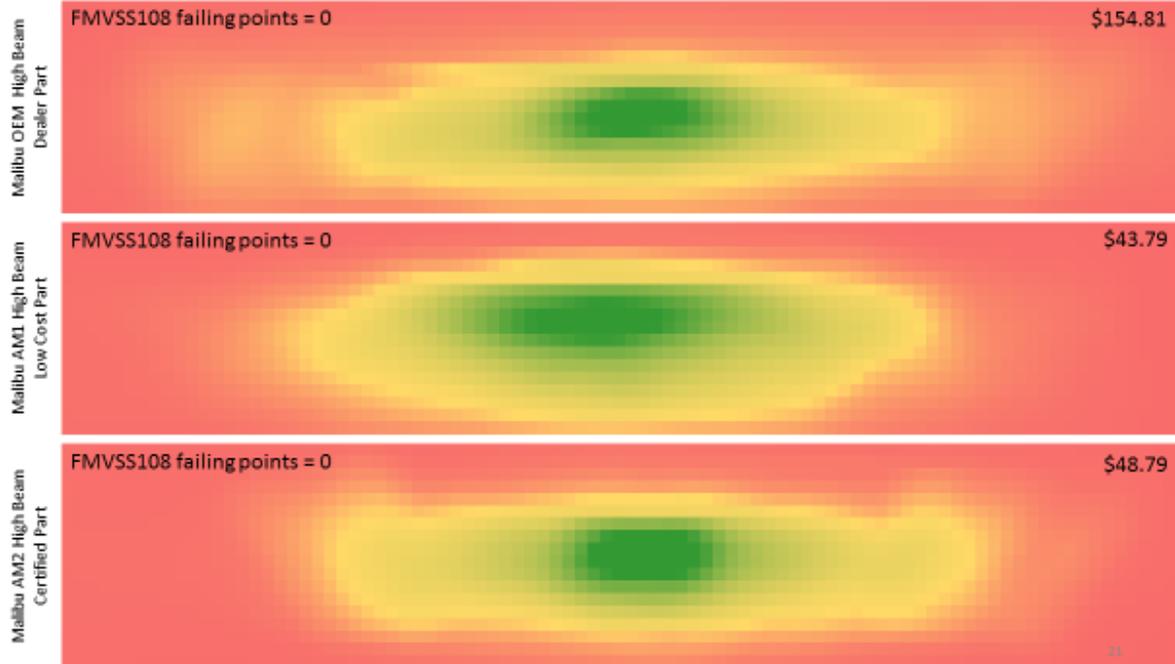


FMVSS108 failing points = 0



Malibu Original Equipment (new) High Beam

20

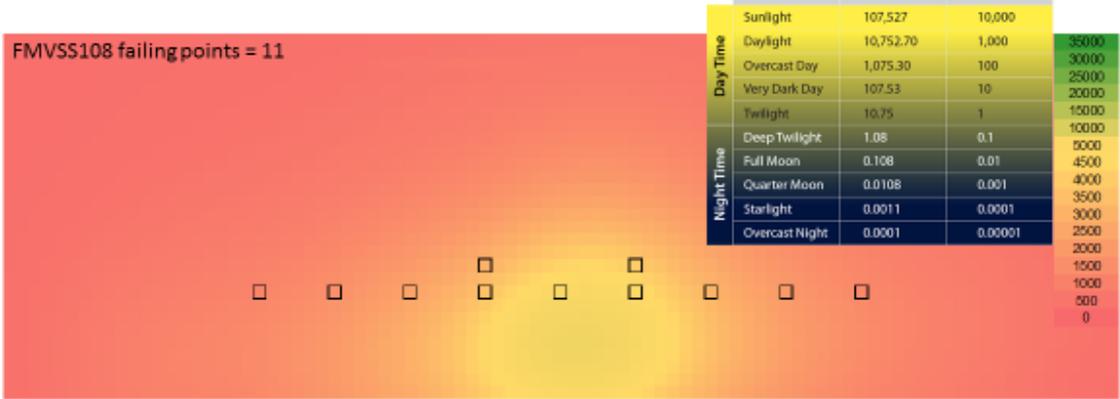


21



Malibu Used #1 ISO High Beam

FMVSS108 failing points = 11

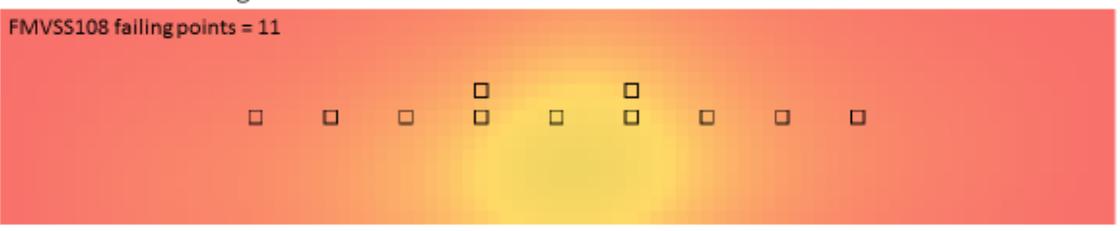


The full ISO scan is 68,229 data points.
 This image is zoomed to show 2,581 points of the full scan (3.8%).
 The highest value on this scan is 43,289.2 lux.

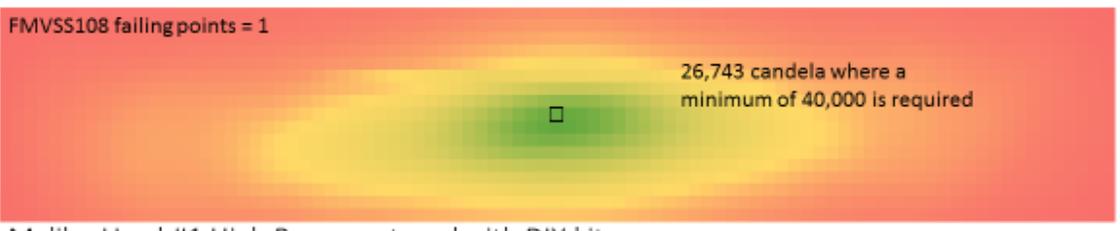
22

Malibu Used #1 High Beam in deteriorated condition

FMVSS108 failing points = 11

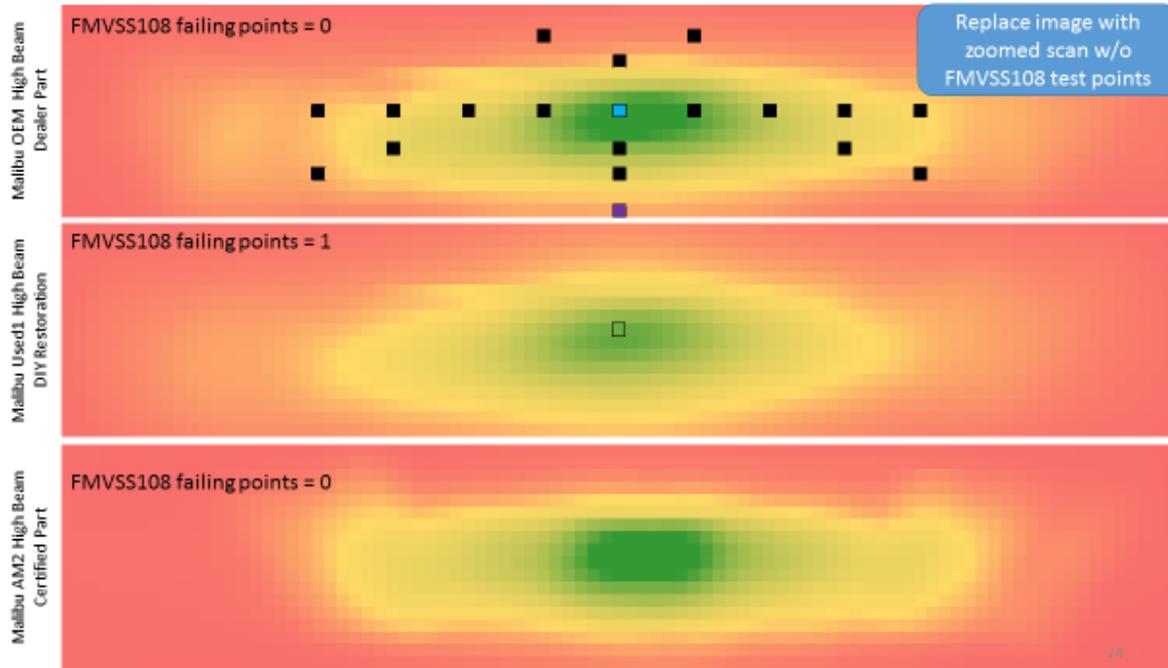


FMVSS108 failing points = 1

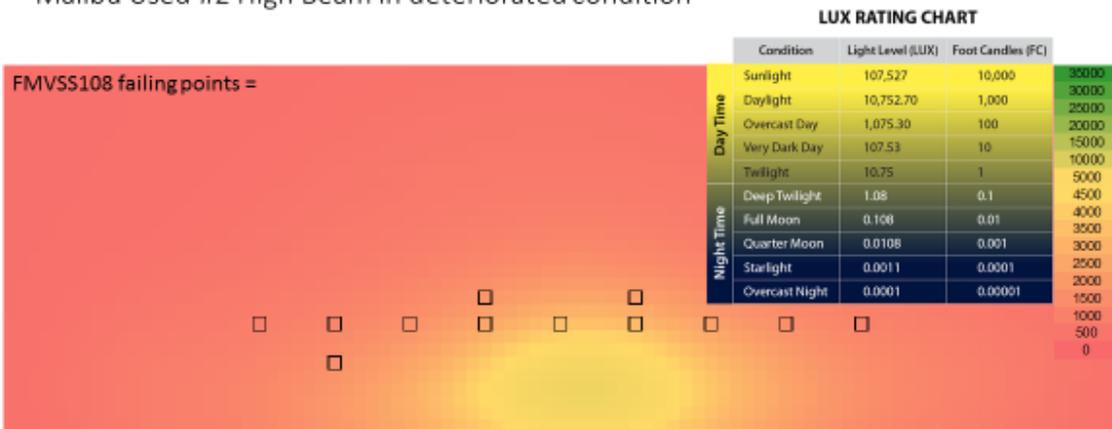


Malibu Used #1 High Beam restored with DIY kit

23



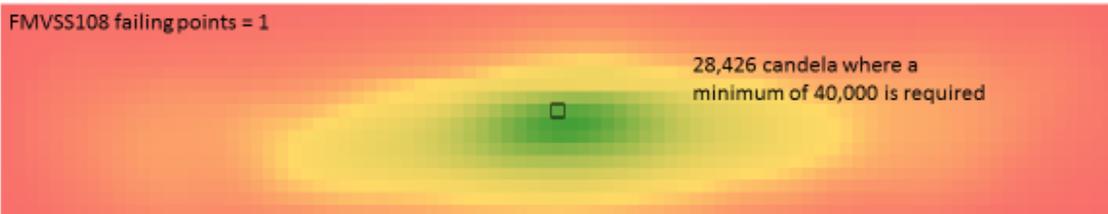
Malibu Used #2 High Beam in deteriorated condition



The full ISO scan is 68,229 data points.
 This image is zoomed to show 2,581 points of the full scan (3.8%).
 The highest value on this scan is 6,951.0 lux.

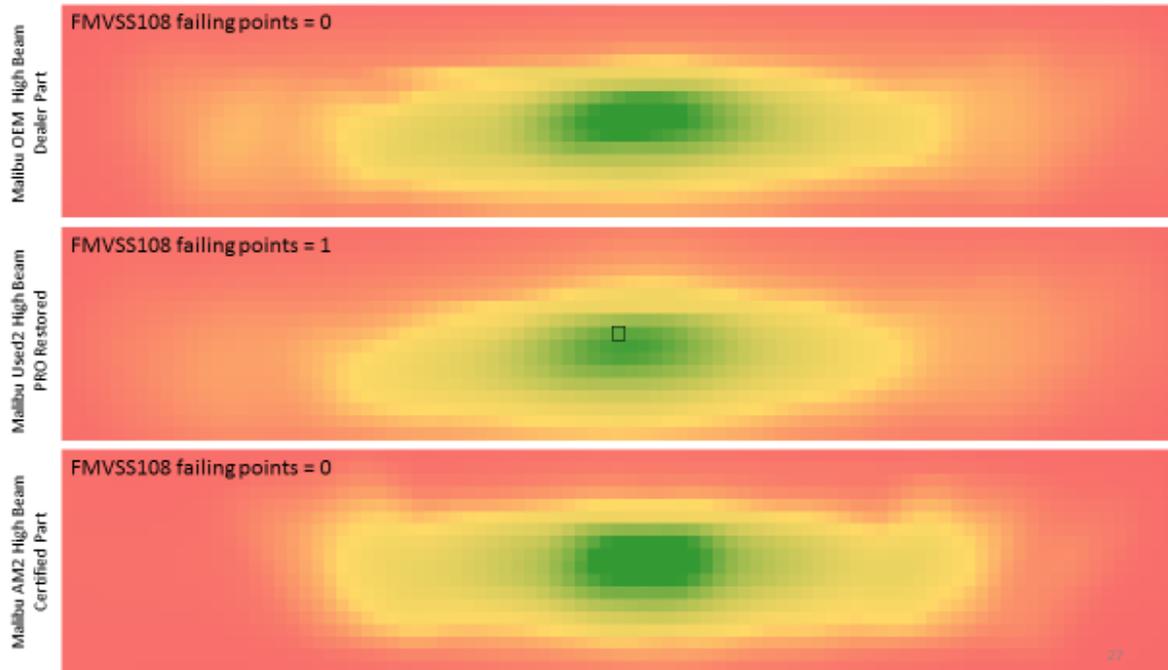


Malibu Used #2 High Beam in deteriorated condition

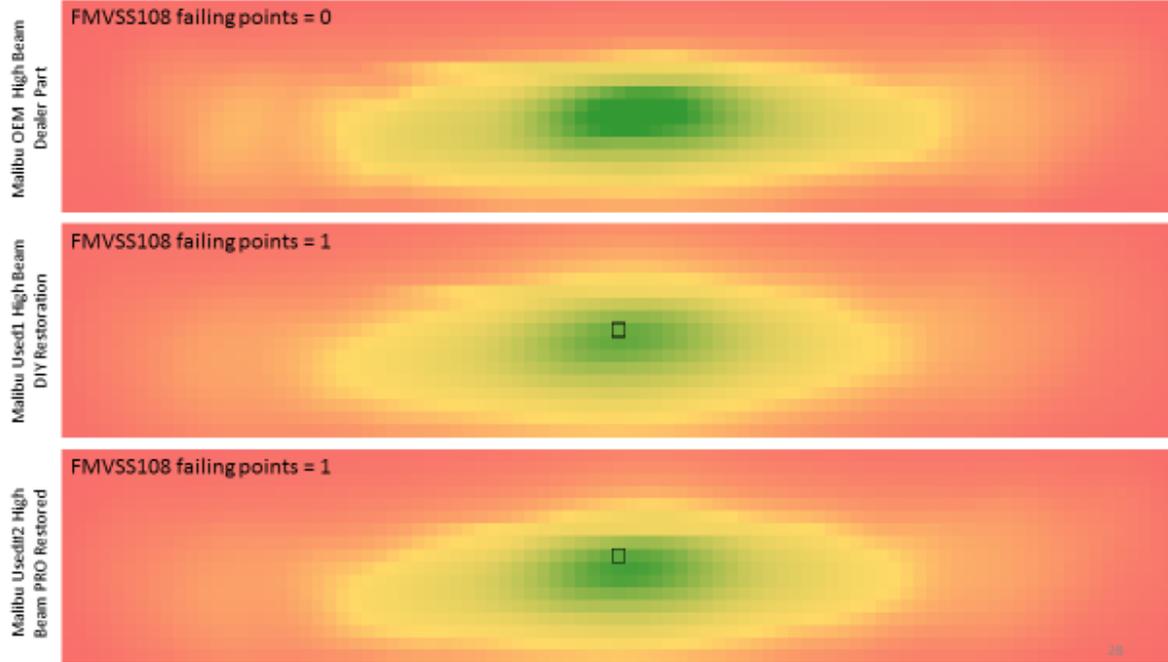


Malibu Used #2 High Beam after PRO restoration

26



27



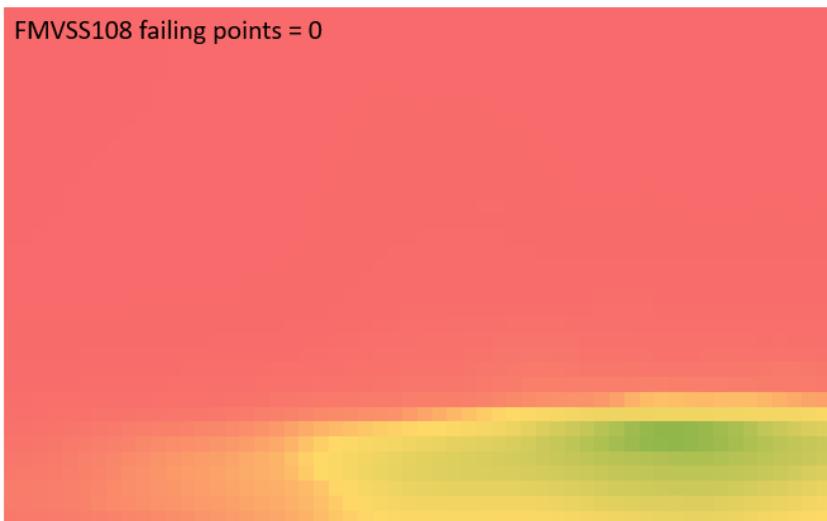


9.3 Low Beam (2007 Altima)

Altima Original Equipment (new) Low Beam >> Showing Full ISO Scan



Altima Original Equipment (new) Low Beam



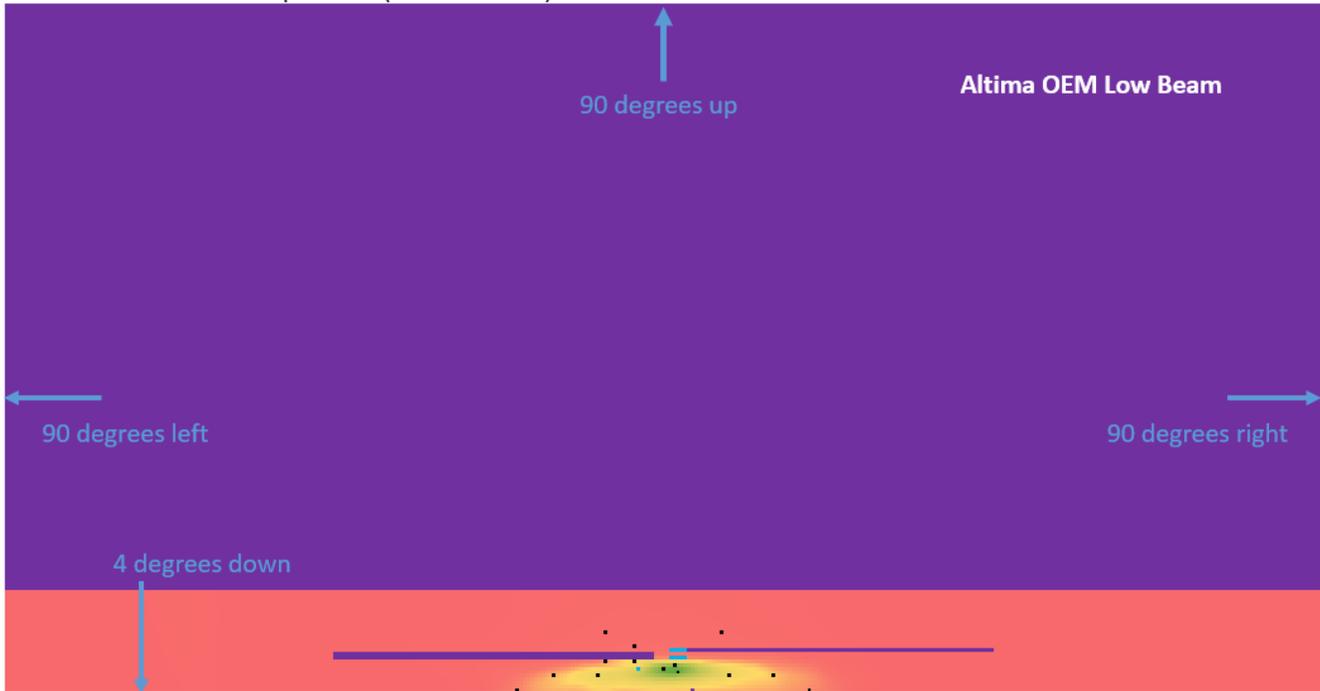
LUX RATING CHART

	Condition	Light Level (LUX)	Foot Candles (FC)	
Day Time	Sunlight	107,527	10,000	35000
	Daylight	10,752.70	1,000	30000
	Overcast Day	1,075.30	100	25000
	Very Dark Day	107.53	10	20000
	Twilight	10.75	1	15000
Night Time	Deep Twilight	1.08	0.1	10000
	Full Moon	0.108	0.01	5000
	Quarter Moon	0.0108	0.001	4500
	Starlight	0.0011	0.0001	4000
	Overcast Night	0.0001	0.00001	3500
				3000
			2500	
			2000	
			1500	
			1000	
			500	
			0	

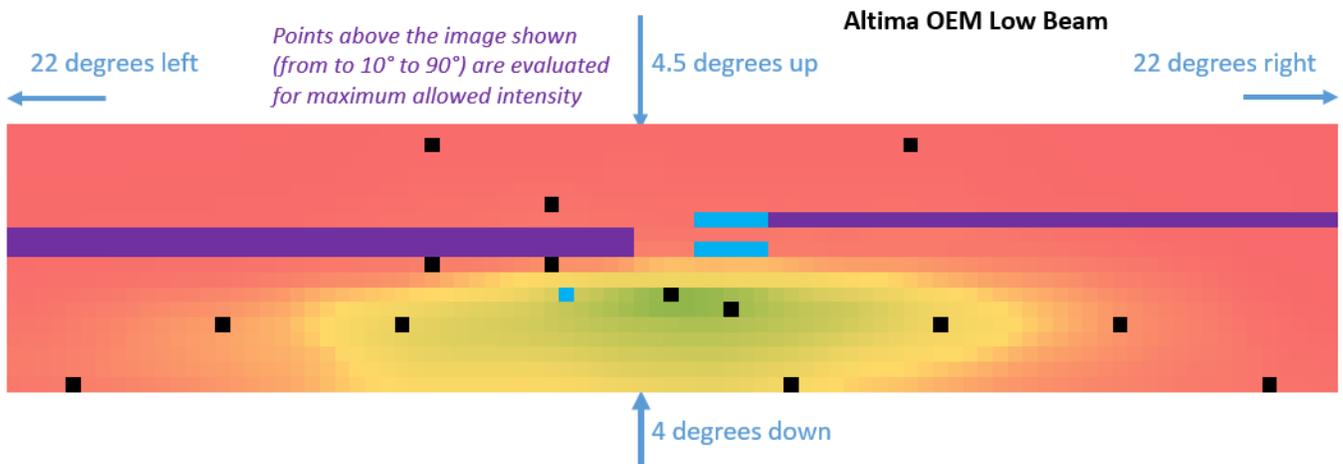
The full ISO scan is 68,229 data points. This image is zoomed to show 3,115 points of the full scan (4.6%). Each "cell" has a value in lux (the amount of light that falls on a surface), measured at a distance of 64 feet. The brightest green is the highest lux value. The highest value on this scan 27,875.8 lux. For comparison, sunlight is rated at 107,527 lux.



FMVSS-108 test points (Low Beam) overlaid on full ISO scan



FMVSS-108 test points (Low Beam) overlaid on zoomed ISO scan



Purple shaded points/areas have a **maximum** allowed intensity

Black shaded points/areas have a **minimum** allowed intensity

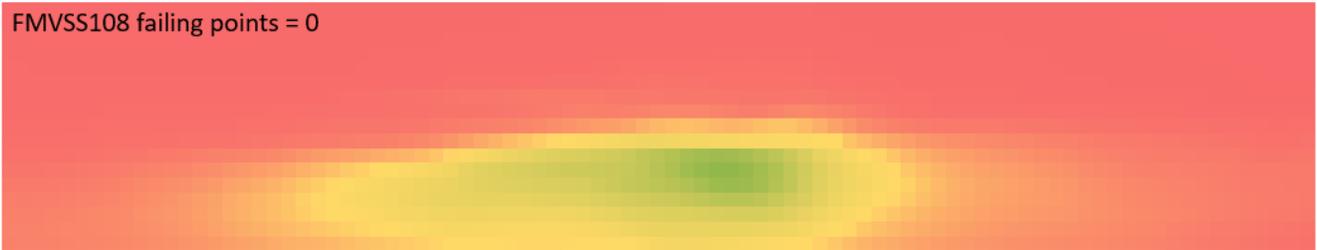
Light blue shaded points/areas have both a **minimum** and **maximum**

The full ISO scan is 68,229 data points. This image is zoomed to show 1,455 points of the full scan (2.1%)

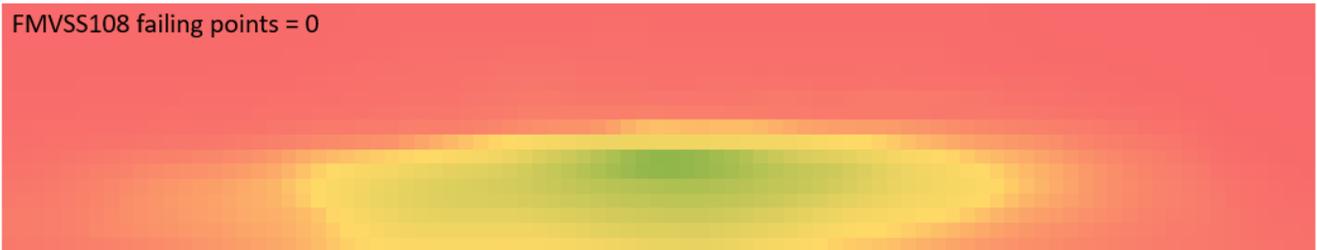


Altima Aftermarket Certified Low Beam

FMVSS108 failing points = 0



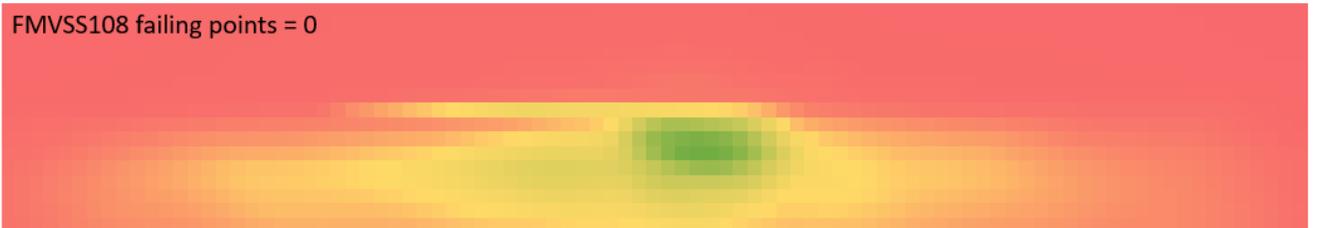
FMVSS108 failing points = 0



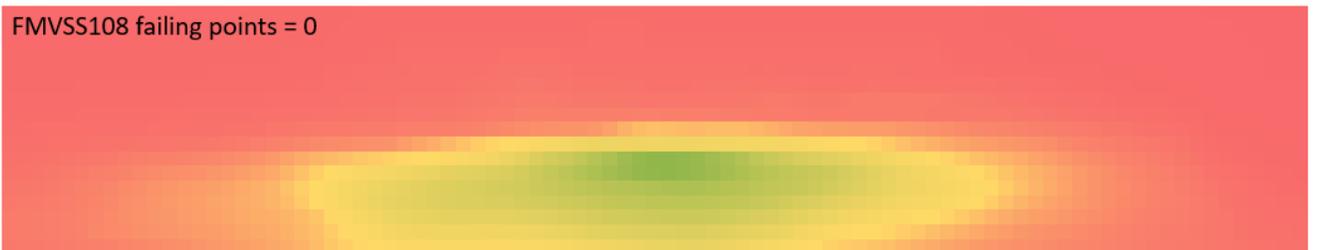
Altima Original Equipment (new) Low Beam

Altima Aftermarket Low Cost Low Beam

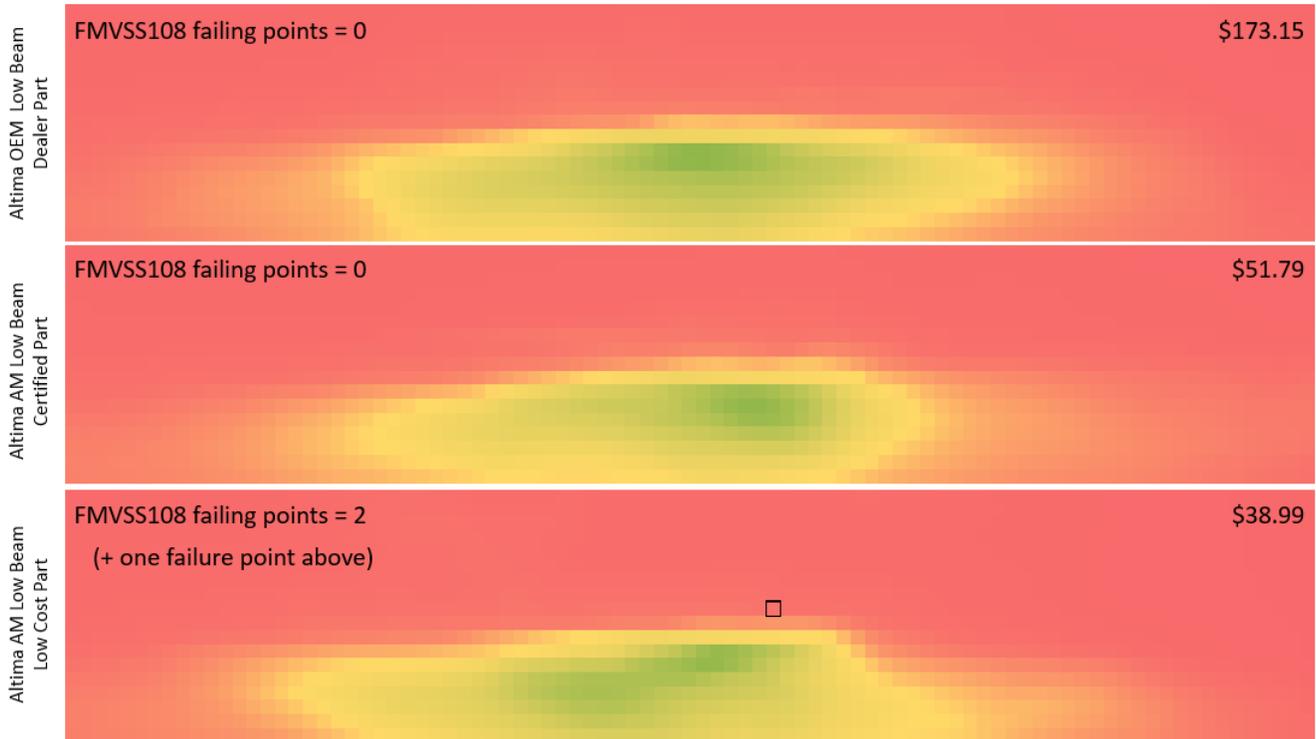
FMVSS108 failing points = 0



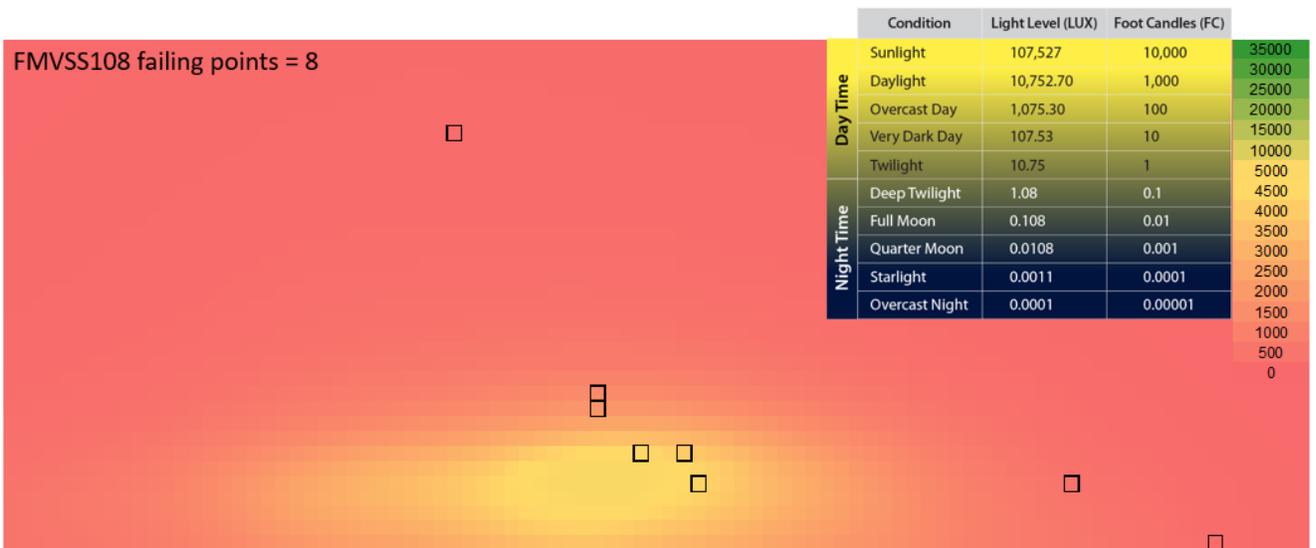
FMVSS108 failing points = 0



Altima Original Equipment (new) Low Beam



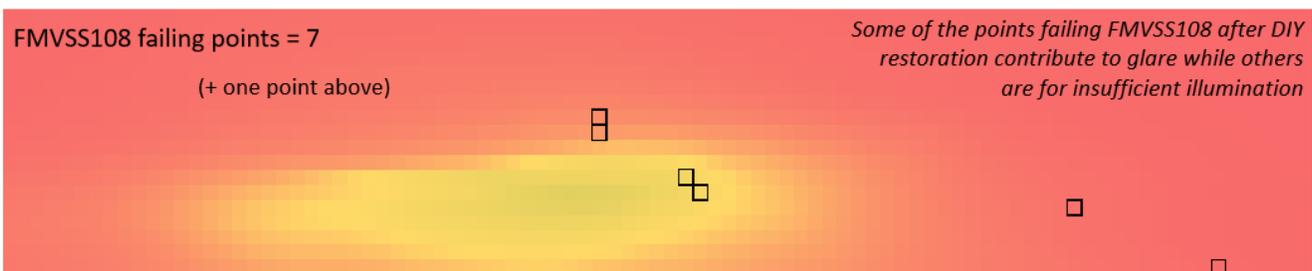
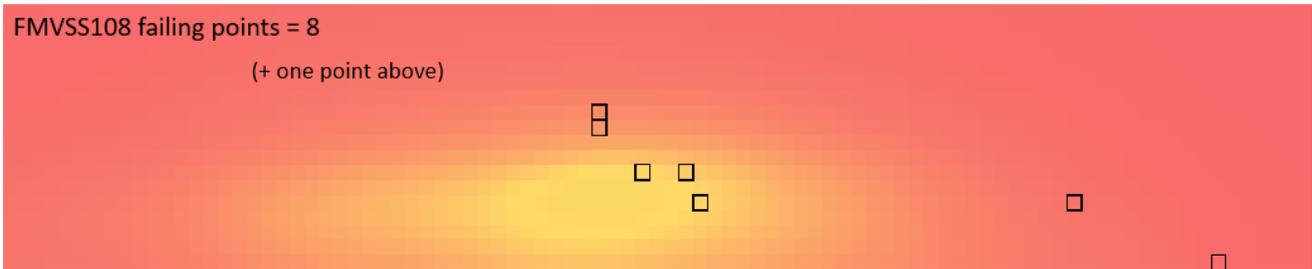
Altimax Used #1 Low Beam in deteriorated condition



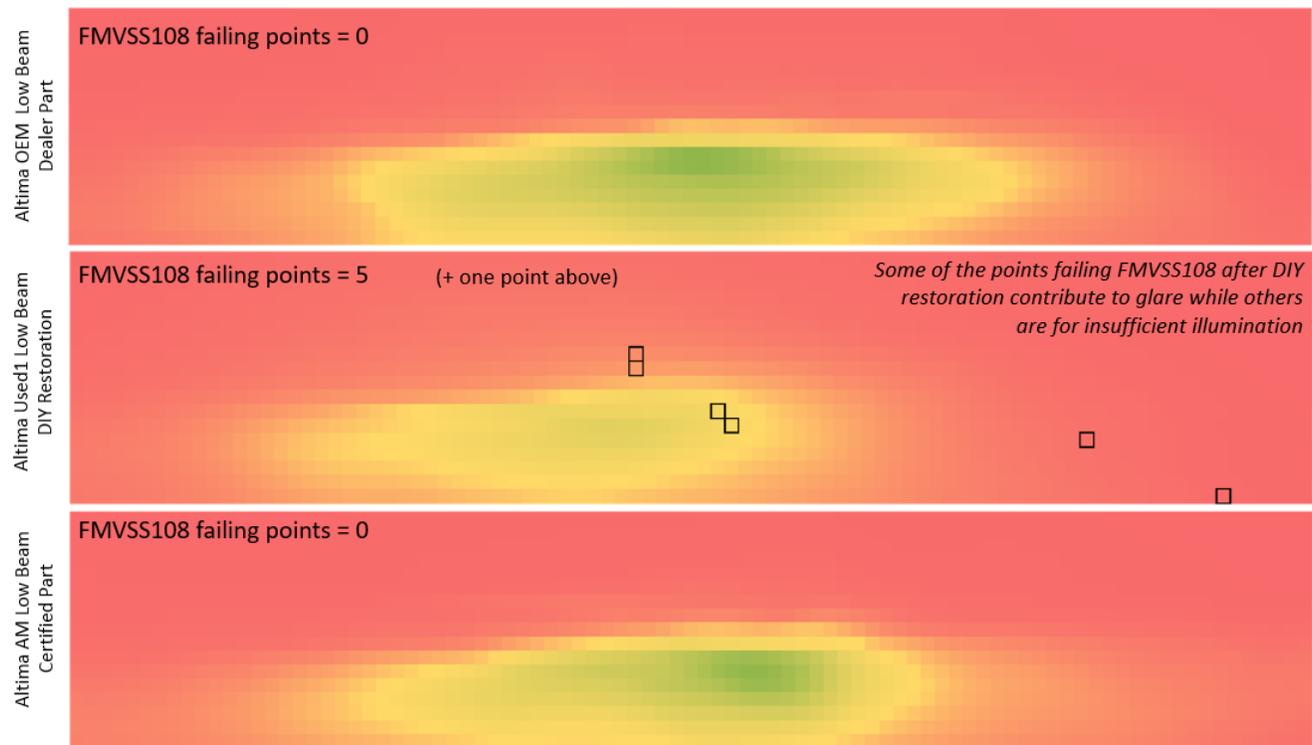
The full ISO scan is 68,229 data points.
 This image is zoomed to show 3,185 points of the full scan (4.7%).
 The highest value on this scan is 5441.0 candela.



Altima Used #1 Low Beam in deteriorated condition

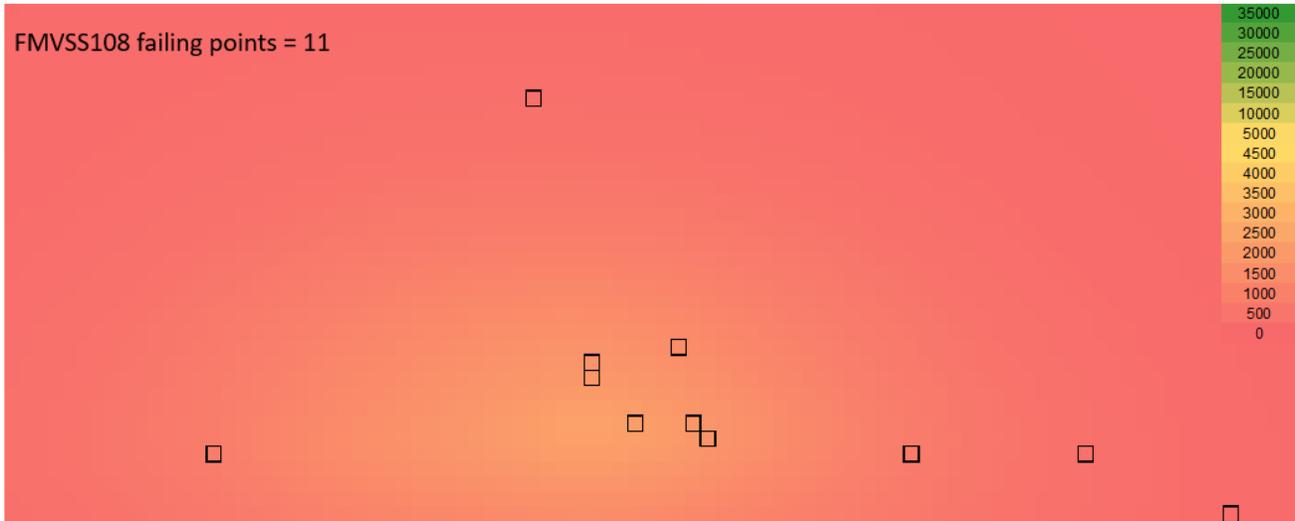


Altima Used #1 Low Beam restored with DIY kit



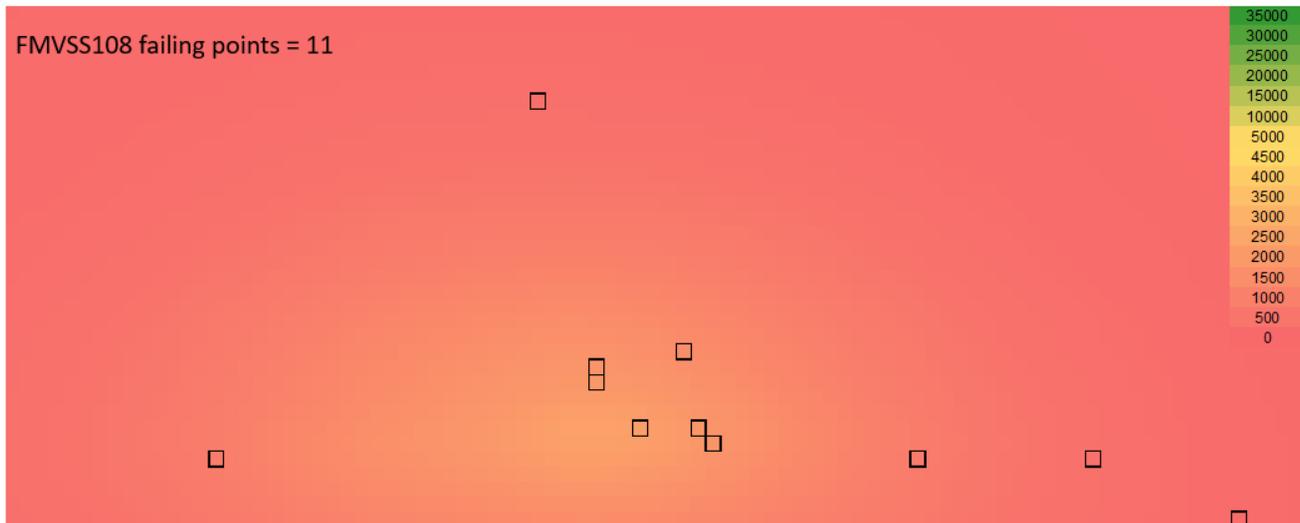


Altima Used #2 Low Beam in deteriorated condition



The full ISO scan is 68,229 data points.
This image is zoomed to show 3,115 points of the full scan (4.6%).
The highest value on this scan is 2,274.7 candela.

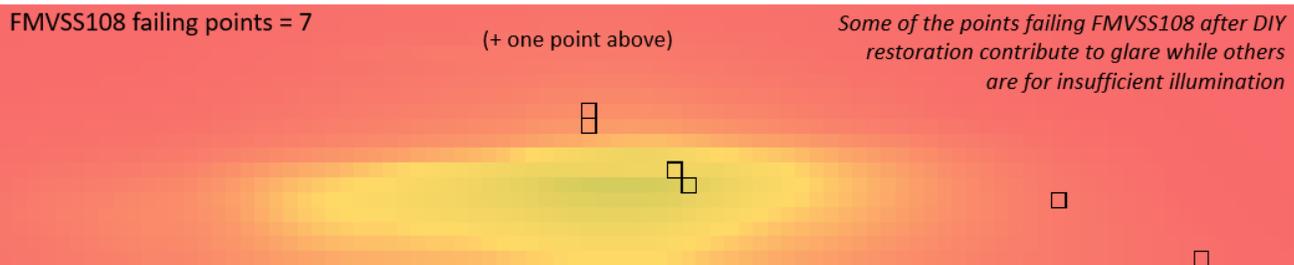
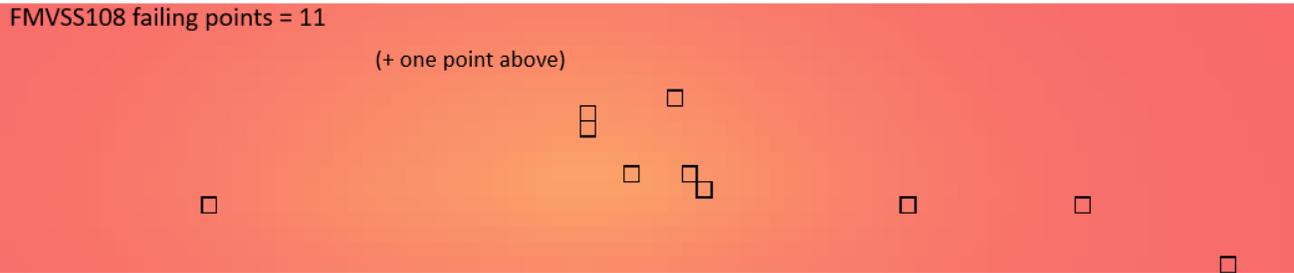
Altima Used #2 Low Beam in deteriorated condition



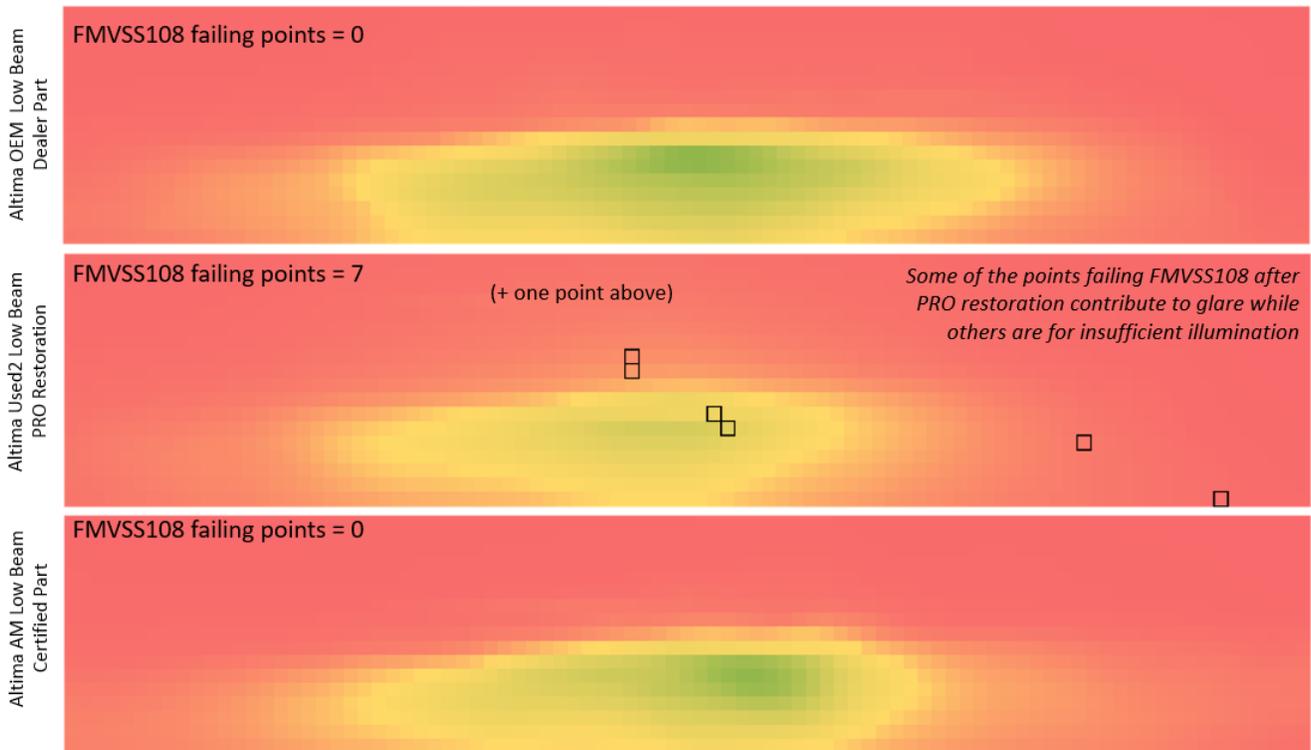
The full ISO scan is 68,229 data points.
This image is zoomed to show 3,115 points of the full scan (4.6%).
The highest value on this scan is 2,274.7 candela.

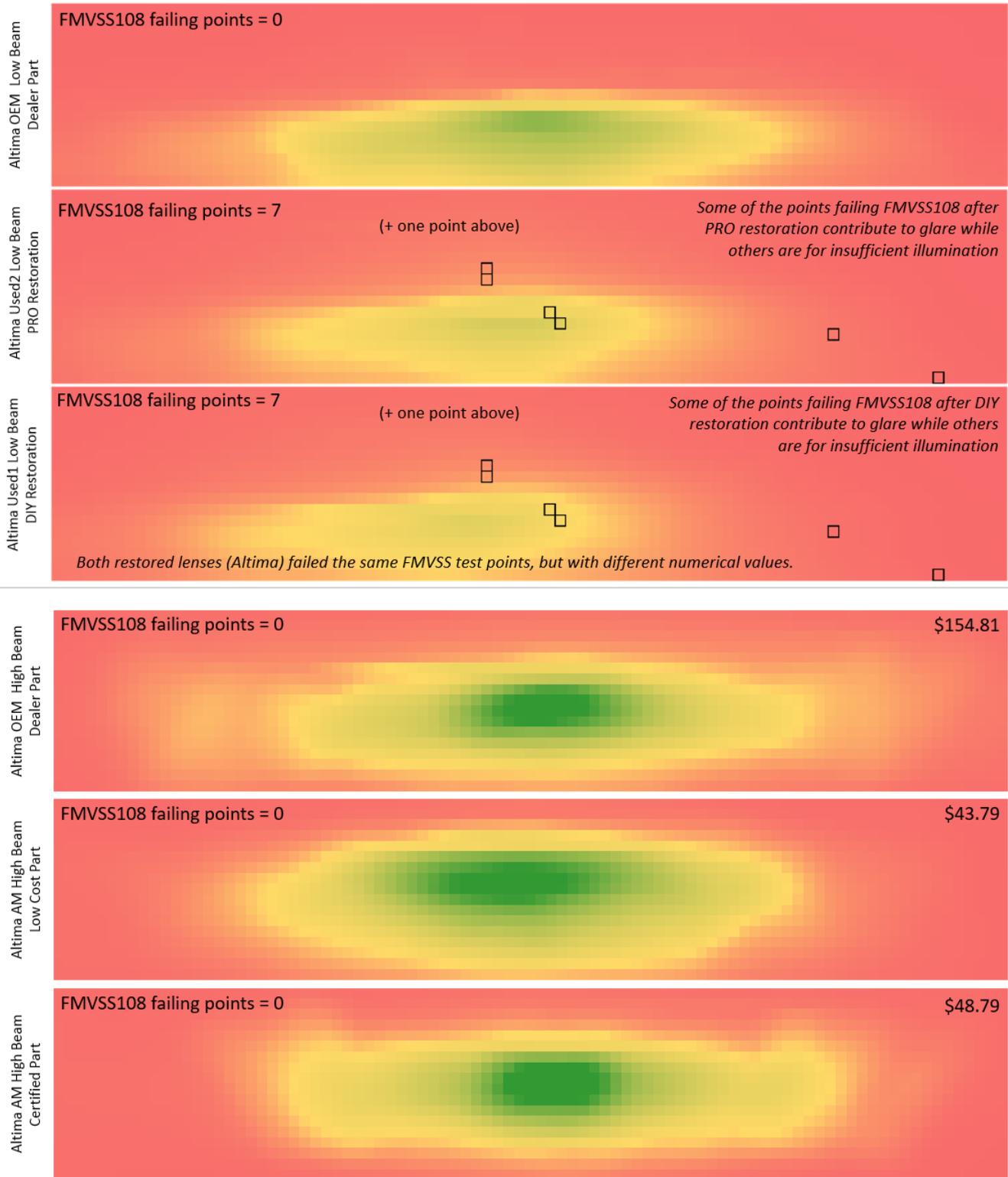


Altima Used #2 Low Beam in deteriorated condition



Altima Used #2 Low Beam after PRO restoration

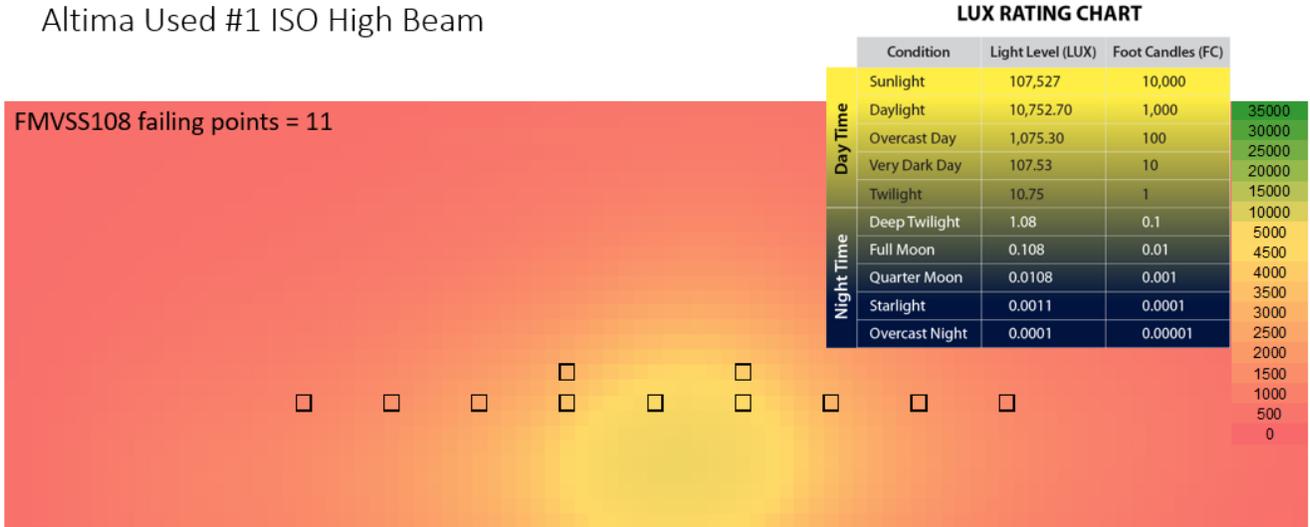






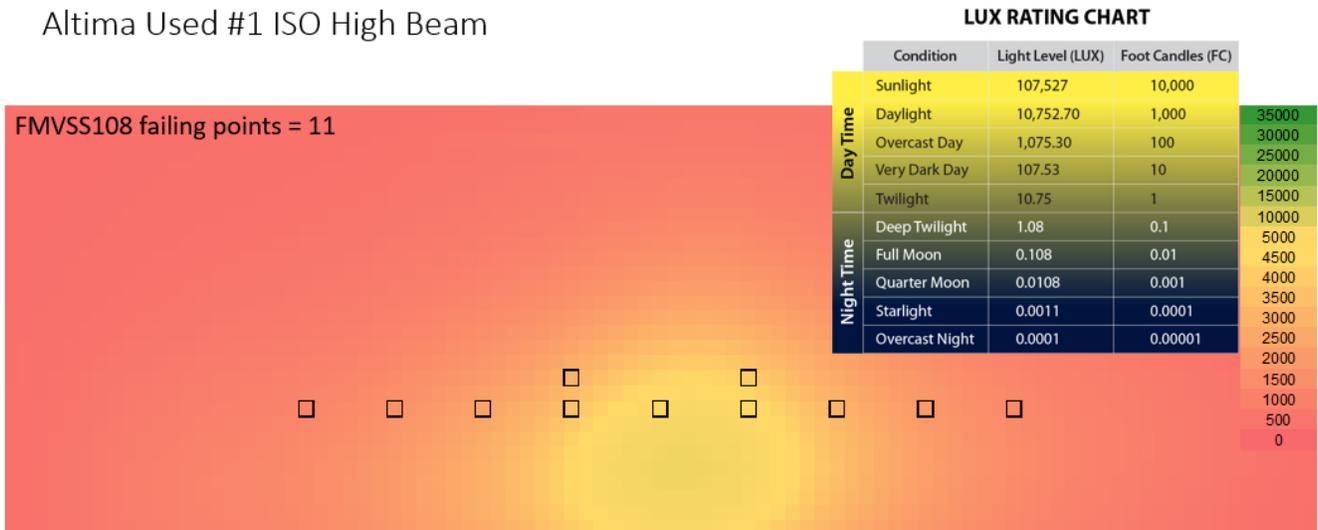
9.4 High Beam (2007 Altima)

Altima Used #1 ISO High Beam



The full ISO scan is 68,229 data points.
 This image is zoomed to show 2,581 points of the full scan (3.8%).
 The highest value on this scan is 43,289.2 lux.

Altima Used #1 ISO High Beam

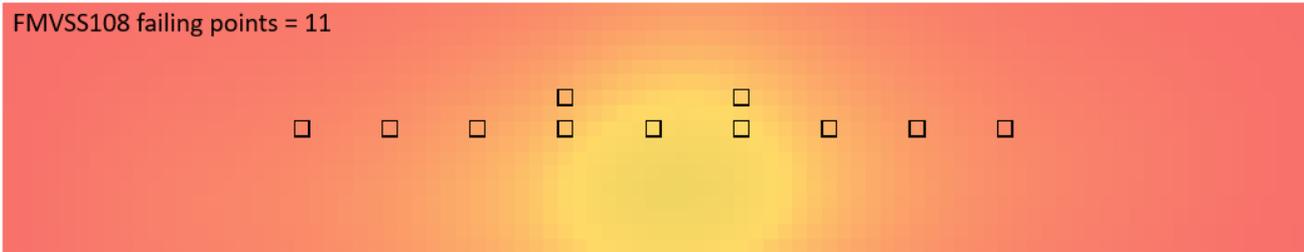


The full ISO scan is 68,229 data points.
 This image is zoomed to show 2,581 points of the full scan (3.8%).
 The highest value on this scan is 43,289.2 lux.



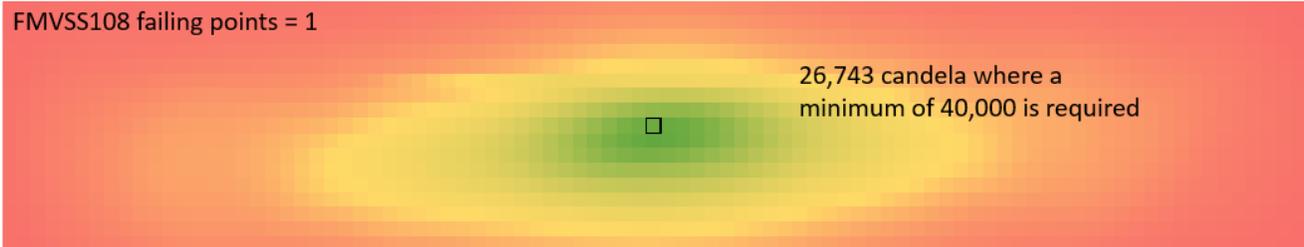
Altima Used #1 High Beam in deteriorated condition

FMVSS108 failing points = 11



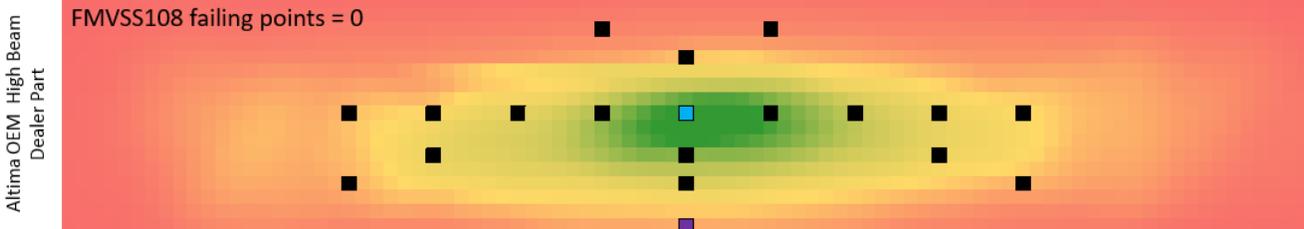
FMVSS108 failing points = 1

26,743 candela where a minimum of 40,000 is required



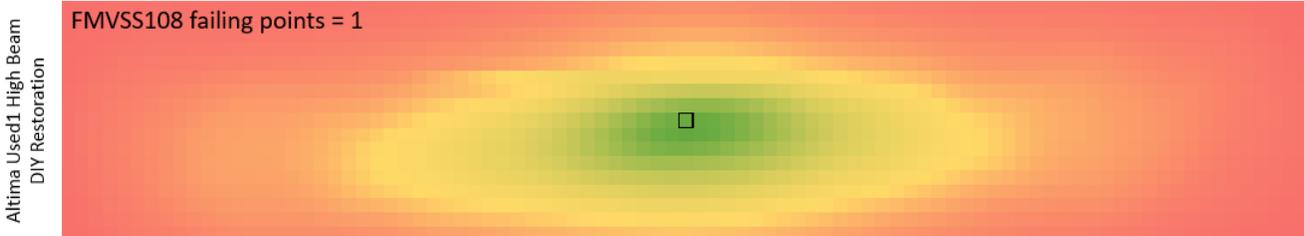
Altima Used #1 High Beam restored with DIY kit

FMVSS108 failing points = 0



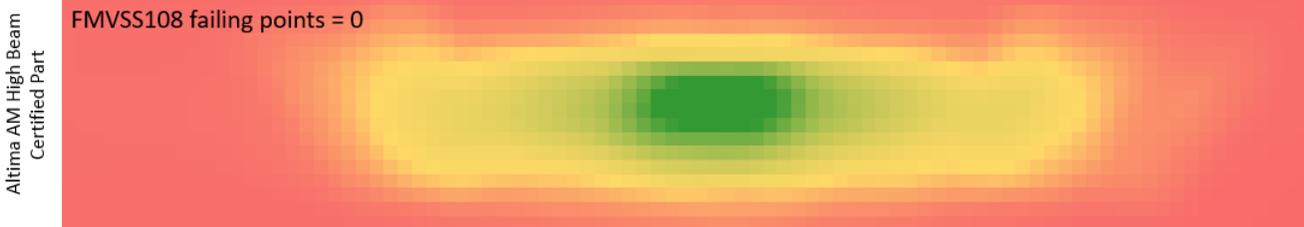
Altima OEM High Beam Dealer Part

FMVSS108 failing points = 1



Altima Used #1 High Beam DIY Restoration

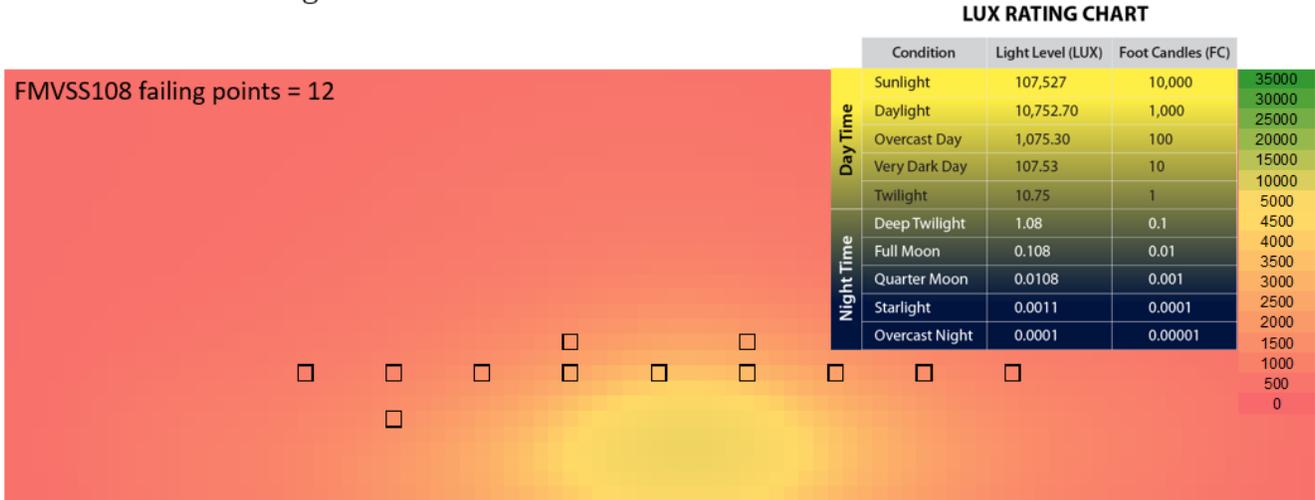
FMVSS108 failing points = 0



Altima AM High Beam Certified Part

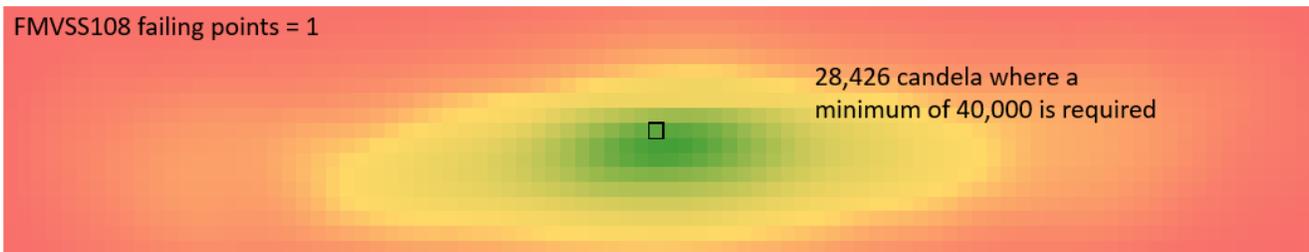
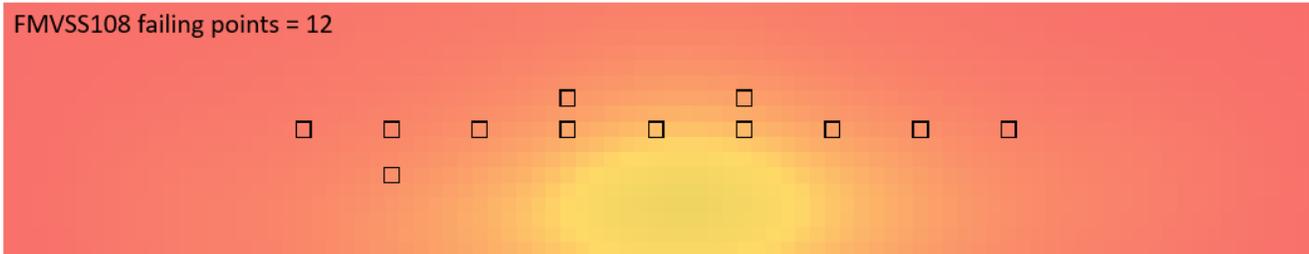


Altima Used #2 High Beam in deteriorated condition



The full ISO scan is 68,229 data points.
 This image is zoomed to show 2,581 points of the full scan (3.8%).
 The highest value on this scan is 6,951.0 lux.

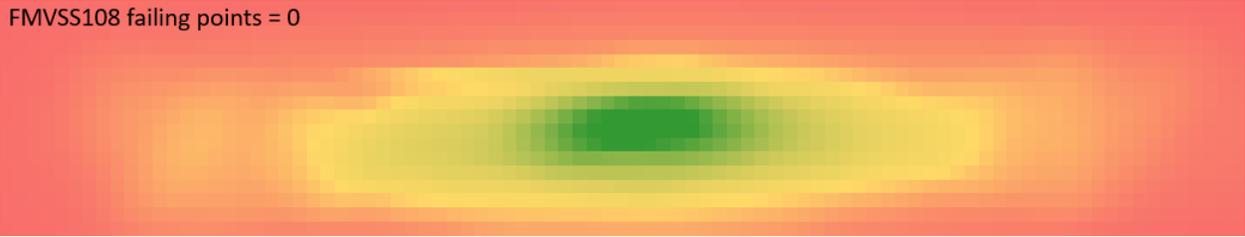
Altima Used #2 High Beam in deteriorated condition



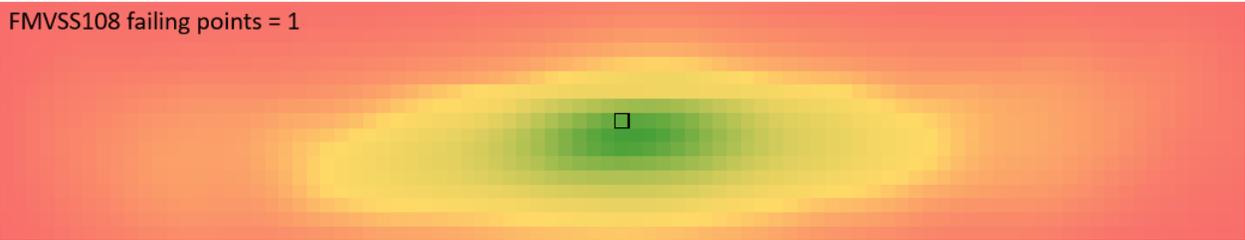
Altima Used #2 High Beam after PRO restoration



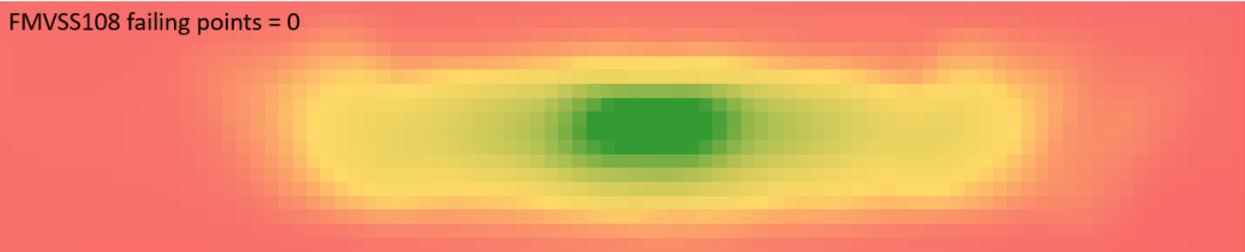
Altima OEM High Beam
Dealer Part



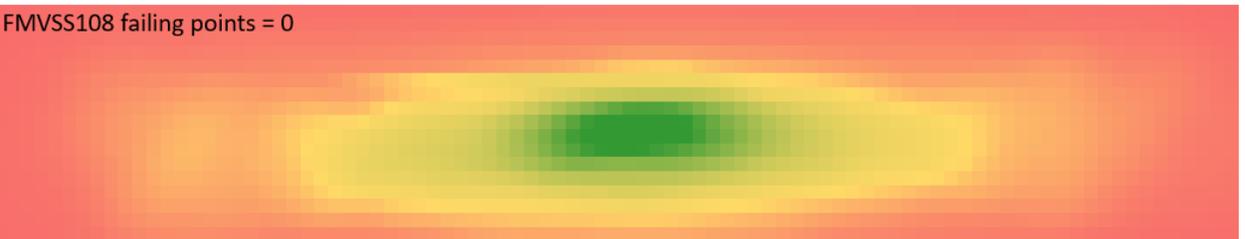
Altima Used#2 High Beam
PRO Restored



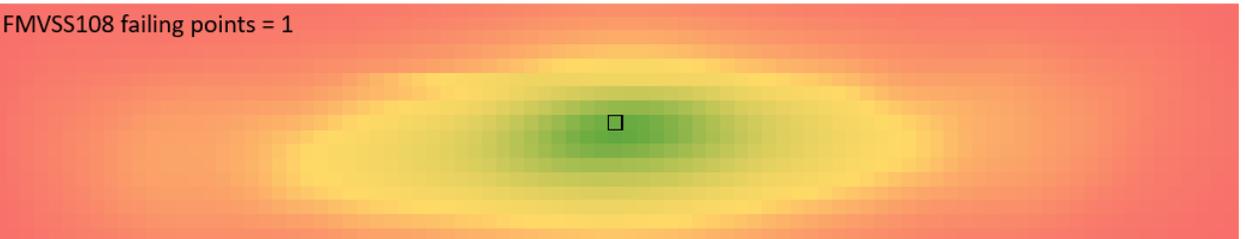
Altima AM High Beam
Certified Part



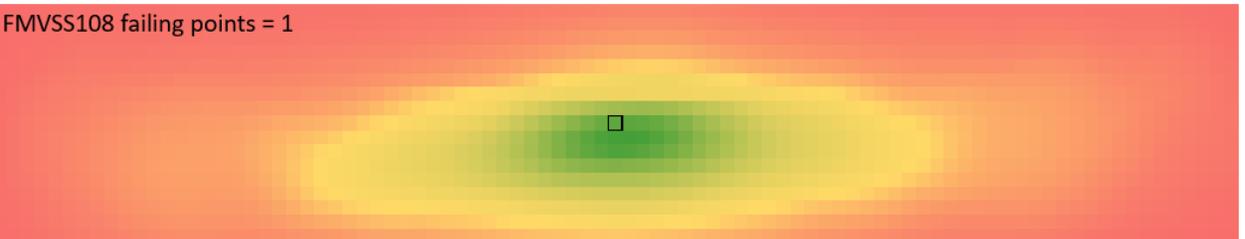
Altima OEM High Beam
Dealer Part



Altima Used#1 High Beam
DIY Restoration



Altima Used#2 High Beam
PRO Restored





Altima OEM - Low Beam

OEM reference standard: 100%

Altima AM Certified Part - Low Beam

80.57% of OEM

Altima Used after Professional Restoration - Low Beam

82.37% of OEM

Altima Used#2 in Deteriorated Condition - Low Beam

17.53% of OEM



10 Appendix C

From §3.3.3

Appendix C contains additional charts on tested headlights (Malibu and Altima, low beam and high beam) with data bar illustrations of the performance relative to the FMVSS-108 criteria. The total forward illumination values (where a minimum point specification is provided) are summed to create a statistic for comparison between the headlamps evaluated. Points with maximum criteria are not included in the charts.

10.1 Chevrolet Malibu Low Beam

Index	Y	X	Point	Min	Max	Malibu OEM LB Dealer Part	Malibu OEM LB compared to FMVSS-108
1	4.00U	8.00L	A	64.00	0	145.54	127%
2	4.00U	8.00R	B	64.00	0	136.50	113%
3	2.00U	4.00L	C	135.00	0	228.63	69%
4	H	4.00L	D	135.00	0	1847.70	1289%
5	H	8.00L	E	64.00	0	999.79	1462%
6	0.60D	1.30R	F	10000.00	0	20649.00	106%
7	0.86D	V	G	4500.00	0	22667.00	404%
8	0.86D	3.50L	H	1800.00	0	8641.20	380%
10	1.50D	2.00R	J	15000.00	0	26205.00	75%
11	2.00D	9.00L	K	1250.00	0	7046.30	464%
12	2.00D	9.00R	L	1250.00	0	6495.90	420%
13	2.00D	15.00L	M	1000.00	0	2995.40	200%
14	2.00D	15.00R	N	1000.00	0	3487.00	249%
16	4.00D	20.00L	P	300.00	0	1170.20	290%
17	4.00D	20.00R	Q	300.00	0	1392.60	364%
						OEM	
						100.00%	



Index	Y	X	Point	Min	Max	Malibu AM LB Certified Part	Malibu AM LB Certified Part	Malibu AM LB Non-certified Cost Part	Malibu AM LB Non-certified part
1	4.00U	8.00L	A	64.00	0	158.62	148%	96.39	2%
2	4.00U	8.00R	B	64.00	0	91.53	43%	70.96	2%
3	2.00U	4.00L	C	135.00	0	364.53	170%	185.20	1%
4	H	4.00L	D	135.00	0	2371.20	156%	765.85	4%
5	H	8.00L	E	64.00	0	1608.40	2413%	547.50	13%
6	0.60D	1.30R	F	10000.00	0	19262.00	93%	19045.00	0%
7	0.86D	V	G	4500.00	0	25012.00	456%	16283.00	0%
8	0.86D	3.50L	H	1800.00	0	6523.90	262%	4639.20	0%
10	1.50D	2.00R	J	15000.00	0	31821.00	112%	26251.00	0%
11	2.00D	9.00L	K	1250.00	0	4928.80	294%	4748.60	0%
12	2.00D	9.00R	L	1250.00	0	6012.80	381%	3716.00	0%
13	2.00D	15.00L	M	1000.00	0	2427.40	143%	3135.10	0%
14	2.00D	15.00R	N	1000.00	0	2776.20	178%	1827.20	0%
16	4.00D	20.00L	P	300.00	0	372.61	24%	1010.00	1%
17	4.00D	20.00R	Q	300.00	0	307.67	3%	1004.90	1%
						AM Certified	AM Low Cost		
						99.93%	80.04%		

Index	Y	X	Point	Min	Max	Malibu Used 1 Deteriorated	Malibu Used 1 Deteriorated	Malibu Used 1 DIY Restored	Malibu Used 1 DIY Restored
1	4.00U	8.00L	A	64.00	0	501.73	684%	310.54	385%
2	4.00U	8.00R	B	64.00	0	605.30	846%	332.66	420%
3	2.00U	4.00L	C	135.00	0	1083.60	703%	869.13	544%
4	H	4.00L	D	135.00	0	1693.30	154%	3024.90	214%
5	H	8.00L	E	64.00	0	1142.80	1688%	1634.60	2454%
6	0.60D	1.30R	F	10000.00	0	3604.50	-64%	15600.00	56%
7	0.86D	V	G	4500.00	0	3675.30	-18%	17557.00	290%
8	0.86D	3.50L	H	1800.00	0	2178.70	21%	7698.60	328%
10	1.50D	2.00R	J	15000.00	0	4067.40	-73%	17306.00	15%
11	2.00D	9.00L	K	1250.00	0	1592.90	27%	5374.30	330%
12	2.00D	9.00R	L	1250.00	0	1716.40	37%	4837.50	287%
13	2.00D	15.00L	M	1000.00	0	819.53	-18%	2339.60	134%
14	2.00D	15.00R	N	1000.00	0	917.03	-8%	2557.80	156%
16	4.00D	20.00L	P	300.00	0	453.60	51%	1340.00	347%
17	4.00D	20.00R	Q	300.00	0	503.30	68%	1138.00	279%
						Used 1 Det	Used1 DIY		
						23.59%	78.69%		



Index	Y	X	Point	Min	Max	Malibu Used 2 Deteriorated	Malibu Used 2 Deteriorated	Malibu Used 2 PRO Restored	Malibu Used 2 PRO Restored
1	4.00U	8.00L	A	64.00	0	416.32	551%	232.17	263%
2	4.00U	8.00R	B	64.00	0	504.56	688%	268.32	319%
3	2.00U	4.00L	C	135.00	0	752.71	458%	650.07	382%
4	H	4.00L	D	135.00	0	1098.50	114%	2507.30	1757%
5	H	8.00L	E	64.00	0	786.98	1130%	1472.40	2201%
6	0.60D	1.30R	F	10000.00	0	1734.70	-83%	13642.00	36%
7	0.86D	V	G	4500.00	0	1784.00	-60%	14893.00	231%
8	0.86D	3.50L	H	1800.00	0	1378.50	-23%	6000.60	233%
10	1.50D	2.00R	J	15000.00	0	2008.20	-87%	16441.00	10%
11	2.00D	9.00L	K	1250.00	0	1000.20	-20%	4680.00	274%
12	2.00D	9.00R	L	1250.00	0	1078.00	-14%	4612.30	269%
13	2.00D	15.00L	M	1000.00	0	548.14	-45%	1690.70	69%
14	2.00D	15.00R	N	1000.00	0	546.35	-45%	2328.50	133%
16	4.00D	20.00L	P	300.00	0	332.33	11%	1117.20	272%
17	4.00D	20.00R	Q	300.00	0	315.82	5%	1046.00	249%
						Used 2 Det		Used 2 PRO	
						13.72%		68.76%	

10.2 Chevrolet Malibu High Beam

Index	Y-axis vertical	X-axis horizontal	Point	Minimum Candela	Maximum Candela	Malibu HB OEM Dealer Part	Malibu HB OEM compared to FMVSS-108	Malibu HB Certified	Malibu HB Certified AM compared to FMVSS-108
1	2.00U	V	A	1,500		3,906.10	160%	10,487.00	599%
2	1.00U	3.00L	B	5,000		7,898.00	58%	14,217.00	184%
3	1.00U	3.00R	C	5,000		12,283.00	146%	29,678.00	44%
4	H	12.00L	D	1,500		3,594.30	140%	3,615.90	141%
5	H	9.00L	E	3,000		5,361.30	79%	7,259.60	142%
6	H	6.00R	F	5,000		8,466.30	69%	10,466.00	109%
7	H	3.00L	G	15,000		19,110.00	27%	18,273.00	22%
8	H	V	H	40,000	75,000	42,041.00	5%	51,383.00	28%
9	H	3.00R	I	15,000		28,397.00	89%	34,496.00	130%
10	H	6.00R	J	5,000		12,106.00	142%	14,362.00	187%
11	H	9.00R	K	3,000		7,038.60	135%	8,286.90	176%
12	H	12.00R	L	1,500		4,576.70	205%	7,110.10	374%
13	1.50D	9.00L	M	2,000		7,798.10	100%	6,141.00	207%
14	1.50D	V	N	5,000		21,675.00	100%	16,776.00	236%
15	1.50D	9.00R	O	2,000		6,932.10	247%	5,450.30	173%
16	2.50D	12.00L	P	1,000		3,010.00	201%	1,540.60	54%
17	2.50D	V	Q	2,500		10,008.00	100%	7,049.80	182%
18	2.50D	12.00R	R	1,000		3,089.20	209%	3,021.00	202%
						OEM		AM2 Certified	
						207,290.70	candela	249,613.20	candela
						100.00%		120.42%	



Headlamp Lens Deterioration

Index	Y-axis vertical	X-axis horizontal	Point	Minimum Candela	Maximum Candela	Malibu HB Certified	Malibu HB Certified AM compared to FMVSS-108	Malibu HB Low Cost	Malibu HB Low Cost AM compared to FMVSS-108
1	2.00U	V	A	1,500		10,487.00	699%	15,026.00	902%
2	1.00U	3.00L	B	5,000		14,217.00	184%	30,802.00	516%
3	1.00U	3.00R	C	5,000		29,678.00	481%	24,922.00	398%
4	H	12.00L	D	1,500		3,615.90	141%	4,972.20	231%
5	H	9.00L	E	3,000		7,259.60	142%	9,230.50	208%
6	H	6.00R	F	5,000		10,466.00	109%	21,596.00	332%
7	H	3.00L	G	15,000		18,273.00	22%	63,326.00	322%
8	H	V	H	40,000	75,000	51,383.00	28%	40,117.00	0%
9	H	3.00R	I	15,000		34,496.00	130%	25,411.00	69%
10	H	6.00R	J	5,000		14,362.00	187%	15,256.00	205%
11	H	9.00R	K	3,000		8,286.90	176%	9,010.20	200%
12	H	12.00R	L	1,500		7,110.10	374%	4,378.30	192%
13	1.50D	9.00L	M	2,000		6,141.00	207%	6,749.10	237%
14	1.50D	V	N	5,000		16,776.00	236%	18,150.00	263%
15	1.50D	9.00R	O	2,000		5,450.30	173%	5,971.50	199%
16	2.50D	12.00L	P	1,000		1,540.60	54%	2,732.70	173%
17	2.50D	V	Q	2,500		7,049.80	182%	11,727.00	369%
18	2.50D	12.00R	R	1,000		3,021.00	202%	1,879.30	88%
						AM2 Certified		AM1 Low Cost	
						249,613.20	candela	311,256.80	candela
						120.42%		150.15%	

Index	Y-axis vertical	X-axis horizontal	Point	Minimum Candela	Maximum Candela	Malibu HB Used #1 Deteriorated	Malibu HB Used#1 Deteriorated compared to FMVSS-108	Malibu HB Used #1 DIY Restored	Malibu HB Used#1 DIY Restored compared to FMVSS-108
1	2.00U	V	A	1,500		3,590.40	139.3%	5,749.40	283.29%
2	1.00U	3.00L	B	5,000		3,317.60	-33.65%	9,321.30	86.43%
3	1.00U	3.00R	C	5,000		4,140.30	-17.19%	10,633.00	112.66%
4	H	12.00L	D	1,500		1,227.70	-18.15%	3,046.50	103.10%
5	H	9.00L	E	3,000		1,739.10	-42.03%	4,903.70	63.46%
6	H	6.00R	F	5,000		2,549.80	-49.00%	7,883.10	57.66%
7	H	3.00L	G	15,000		3,971.80	-73.62%	16,581.00	10.54%
8	H	V	H	40,000	75,000	5,721.70	-85.70%	26,743.00	-33.14%
9	H	3.00R	I	15,000		4,861.30	-67.69%	16,915.00	12.77%
10	H	6.00R	J	5,000		3,081.00	-38.30%	8,459.40	69.19%
11	H	9.00R	K	3,000		1,964.80	-34.61%	4,947.60	64.92%
12	H	12.00R	L	1,500		1,313.50	-12.43%	2,996.70	99.78%
13	1.50D	9.00L	M	2,000		2,035.80	-1.79%	5,670.70	18.54%
14	1.50D	V	N	5,000		6,678.70	33.57%	15,841.00	216.22%
15	1.50D	9.00R	O	2,000		2,063.00	3.15%	4,535.30	126.77%
16	2.50D	12.00L	P	1,000		1,413.40	41.34%	3,147.20	216.22%
17	2.50D	V	Q	2,500		6,598.00	163.92%	8,791.00	251.6%
18	2.50D	12.00R	R	1,000		1,335.60	33.56%	2,041.40	104.14%
						Used1 Deteriorated		Used1 DIY Restoration	
						57,603.50	candela	158,206.30	candela
						27.79%		76.32%	



Headlamp Lens Deterioration

Index	Y-axis vertical	X-axis horizontal	Point	Minimum Candela	Maximum Candela	Malibu HB Used #2 Deteriorated	Malibu HB Used#2 Deteriorated compared to FMVSS-108	Malibu HB Used #2 PRO Restored	Malibu HB Used#2 DIY Restored compared to FMVSS-108
1	2.00U	V	A	1,500		1,759.80	17.32%	4,340.90	189.39%
2	1.00U	3.00L	B	5,000		2,089.70	-58.21%	7,161.30	43.23%
3	1.00U	3.00R	C	5,000		2,480.10	-50.40%	9,594.90	91.90%
4	H	12.00L	D	1,500		965.65	-35.62%	2,785.90	85.73%
5	H	9.00L	E	3,000		1,304.00	-56.53%	4,368.00	45.60%
6	H	6.00R	F	5,000		1,885.70	-62.29%	7,055.40	41.11%
7	H	3.00L	G	15,000		2,894.50	-80.70%	16,653.00	11.02%
8	H	V	H	40,000	75,000	3,956.30	-90.11%	32,769.00	-18.08%
9	H	3.00R	I	15,000		3,550.50	-76.33%	19,121.00	27.47%
10	H	6.00R	J	5,000		2,405.70	-51.89%	9,225.30	84.51%
11	H	9.00R	K	3,000		1,646.10	-45.13%	5,709.80	90.33%
12	H	12.00R	L	1,500		1,156.90	-22.87%	3,433.20	128.88%
13	1.50D	9.00L	M	2,000		1,727.80	-13.61%	6,422.80	221.14%
14	1.50D	V	N	5,000		6,094.90	21.90%	22,934.00	358.68%
15	1.50D	9.00R	O	2,000		2,142.30	7.12%	5,827.00	191.35%
16	2.50D	12.00L	P	1,000		1,287.40	28.74%	3,111.90	211.19%
17	2.50D	V	Q	2,500		6,971.80	178.87%	11,489.00	359.56%
18	2.50D	12.00R	R	1,000		1,506.30	50.63%	2,372.00	137.20%
						Used 2 Deteriorated		Used 2 PRO Restoration	
						45,825.45 candela		174,374.40 candela	
						22.11%		84.12%	



10.3 Nissan Altima Low Beam

Index	Y	X	Point	Min	Max	Altima OEM LB Dealer Part	Altima OEM LB
1	4.00U	8.00L	A	64.00	0	156.84	145%
2	4.00U	8.00R	B	64.00	0	136.65	114%
3	2.00U	4.00L	C	135.00	0	428.93	218%
4	H	4.00L	D	135.00	0	1536.10	1038%
5	H	8.00L	E	64.00	0	890.24	1291%
6	0.60D	1.30R	F	10000.00	0	12465.00	25%
7	0.86D	V	G	4500.00	0	18874.00	319%
8	0.86D	3.50L	H	1800.00	0	9775.90	443%
10	1.50D	2.00R	J	15000.00	0	18382.00	23%
11	2.00D	9.00L	K	1250.00	0	7811.70	525%
12	2.00D	9.00R	L	1250.00	0	6342.40	407%
13	2.00D	15.00L	M	1000.00	0	2186.80	119%
14	2.00D	15.00R	N	1000.00	0	1614.70	61%
16	4.00D	20.00L	P	300.00	0	858.61	186%
17	4.00D	20.00R	Q	300.00	0	479.61	60%
						OEM	
						100.00%	



Headlamp Lens Deterioration

Index	Y	X	Point	Min	Max	Altima AM2 LB Certified Part	Altima AM2 LB	Altima AM1 LB Low Cost Part	Altima AM1 LB
1	4.00U	8.00L	A	64.00	0	224.11	250%	98.93	55%
2	4.00U	8.00R	B	64.00	0	180.71	182%	100.86	58%
3	2.00U	4.00L	C	135.00	0	210.04	56%	196.11	45%
4	H	4.00L	D	135.00	0	848.30	528%	1350.10	900%
5	H	8.00L	E	64.00	0	737.44	1052%	597.03	833%
6	0.60D	1.30R	F	10000.00	0	12097.00	21%	11957.00	20%
7	0.86D	V	G	4500.00	0	14605.00	225%	13225.00	194%
8	0.86D	3.50L	H	1800.00	0	5878.10	227%	8260.00	359%
10	1.50D	2.00R	J	15000.00	0	15455.00	3%	21030.00	40%
11	2.00D	9.00L	K	1250.00	0	7096.90	468%	6229.80	398%
12	2.00D	9.00R	L	1250.00	0	2799.90	124%	3443.80	176%
13	2.00D	15.00L	M	1000.00	0	3449.20	245%	2091.90	109%
14	2.00D	15.00R	N	1000.00	0	1239.50	24%	1394.10	39%
16	4.00D	20.00L	P	300.00	0	1132.90	278%	1137.80	279%
17	4.00D	20.00R	Q	300.00	0	459.53	53%	604.99	102%
						AM Certified	AM Low Cost		
						80.57%	86.54%		

Index	Y	X	Point	Min	Max	Altima Used 1 Deteriorated	Altima Used 1 Deteriorated	Altima Used 1 DIY Restored	Altima Used 1 DIY Restored
1	4.00U	8.00L	A	64.00	0	319.61	399%	421.45	559%
2	4.00U	8.00R	B	64.00	0	196.73	207%	193.34	202%
3	2.00U	4.00L	C	135.00	0	758.26	462%	852.83	532%
4	H	4.00L	D	135.00	0	2017.20	394%	2406.60	1033%
5	H	8.00L	E	64.00	0	1445.90	2158%	1587.70	2381%
6	0.60D	1.30R	F	10000.00	0	3572.50	-64%	5709.50	-43%
7	0.86D	V	G	4500.00	0	4453.20	-1%	6716.40	49%
8	0.86D	3.50L	H	1800.00	0	3790.70	111%	7026.80	290%
10	1.50D	2.00R	J	15000.00	0	4347.30	-71%	5695.50	-62%
11	2.00D	9.00L	K	1250.00	0	3114.90	149%	5378.80	330%
12	2.00D	9.00R	L	1250.00	0	1461.50	17%	1309.20	5%
13	2.00D	15.00L	M	1000.00	0	1408.60	41%	2893.20	189%
14	2.00D	15.00R	N	1000.00	0	427.74	-57%	396.91	-60%
16	4.00D	20.00L	P	300.00	0	563.70	88%	767.73	156%
17	4.00D	20.00R	Q	300.00	0	171.58	-43%	170.01	-43%
						Used 1 Det	Used1 DIY		
						34.90%	51.76%		



Index	Y	X	Point	Min	Max	Altima Used 2 Deteriorated	Altima Used 2 Deteriorated	Altima Used 2 PRO Restored	Altima Used 2 PRO Restored
1	4.00U	8.00L	A	64.00	0	416.32	551%	232.17	263%
2	4.00U	8.00R	B	64.00	0	504.56	688%	268.32	319%
3	2.00U	4.00L	C	135.00	0	752.71	458%	650.07	382%
4	H	4.00L	D	135.00	0	1098.50	714%	2507.30	1747%
5	H	8.00L	E	64.00	0	786.98	1130%	1472.40	2201%
6	0.60D	1.30R	F	10000.00	0	1734.70	-83%	13642.00	36%
7	0.86D	V	G	4500.00	0	1784.00	-60%	14893.00	231%
8	0.86D	3.50L	H	1800.00	0	1378.50	-23%	6000.60	233%
10	1.50D	2.00R	J	15000.00	0	2008.20	-87%	16441.00	10%
11	2.00D	9.00L	K	1250.00	0	1000.20	-20%	4680.00	274%
12	2.00D	9.00R	L	1250.00	0	1078.00	-14%	4612.30	269%
13	2.00D	15.00L	M	1000.00	0	548.14	-45%	1690.70	69%
14	2.00D	15.00R	N	1000.00	0	546.35	-45%	2328.50	133%
16	4.00D	20.00L	P	300.00	0	332.33	11%	1117.20	272%
17	4.00D	20.00R	Q	300.00	0	315.82	5%	1046.00	249%
						Used 2 Det		Used 2 PRO	
						17.53%		82.37%	

10.4 Nissan Altima High Beam



Index	Y	X	Point	Min	Max	Altima OEM HB Dealer Part	
1	2.00U	V	A	1500.00	0	6577.00	38%
2	1.00U	3.00L	B	5000.00	0	18436.00	269%
3	1.00U	3.00R	C	5000.00	0	9077.50	82%
4	H	12.00L	D	1500.00	0	2499.40	67%
5	H	9.00L	E	3000.00	0	5304.20	77%
6	H	6.00R	F	5000.00	0	9317.70	86%
7	H	3.00L	G	15000.00	0	31126.00	108%
9	H	3.00R	I	15000.00	0	14679.00	-2%
10	H	6.00R	J	5000.00	0	7651.30	53%
11	H	9.00R	K	3000.00	0	4976.80	66%
12	H	12.00R	L	1500.00	0	1504.80	0%
13	1.50D	9.00L	M	2000.00	0	5297.60	165%
14	1.50D	V	N	5000.00	0	24294.00	316%
15	1.50D	9.00R	O	2000.00	0	4800.20	140%
16	2.50D	12.00L	P	1000.00	0	2103.50	110%
17	2.50D	V	Q	2500.00	0	6053.80	142%
18	2.50D	12.00R	R	1000.00	0	1129.50	13%
						OEM	
						100.00%	



Index	Y	X	Point	Min	Max	Altima AM2 HB Certified Part		Altima AM1 HB Low Cost Part	
1	2.00U	V	A	1500.00	0	8427.90	40%	17551.00	167%
2	1.00U	3.00L	B	5000.00	0	17348.00	247%	28842.00	56%
3	1.00U	3.00R	C	5000.00	0	12685.00	154%	15207.00	68%
4	H	12.00L	D	1500.00	0	2989.90	99%	1900.90	-24%
5	H	9.00L	E	3000.00	0	5064.90	69%	5554.80	5%
6	H	6.00R	F	5000.00	0	7352.30	47%	10089.00	8%
7	H	3.00L	G	15000.00	0	22322.00	49%	31941.00	3%
9	H	3.00R	I	15000.00	0	19975.00	33%	15054.00	3%
10	H	6.00R	J	5000.00	0	7205.50	44%	7917.50	3%
11	H	9.00R	K	3000.00	0	4358.50	45%	4870.20	-2%
12	H	12.00R	L	1500.00	0	2117.10	41%	1717.70	14%
13	1.50D	9.00L	M	2000.00	0	5417.40	171%	4559.50	-14%
14	1.50D	V	N	5000.00	0	32228.00	54%	8259.40	-66%
15	1.50D	9.00R	O	2000.00	0	4710.40	136%	3170.00	-34%
16	2.50D	12.00L	P	1000.00	0	2203.60	120%	1086.00	-48%
17	2.50D	V	Q	2500.00	0	7505.30	200%	3697.50	-39%
18	2.50D	12.00R	R	1000.00	0	2096.70	110%	610.18	-46%
						AM Certified		AM Low Cost	
						107.40%		104.20%	

Index	Y	X	Point	Min	Max	Altima Used 1 Deteriorated		Altima Used 1 DIY Restored	
1	2.00U	V	A	1500.00	0	4900.70	227%	5372.80	258%
2	1.00U	3.00L	B	5000.00	0	8037.20	61%	11425.00	129%
3	1.00U	3.00R	C	5000.00	0	5250.30	5%	5211.00	4%
4	H	12.00L	D	1500.00	0	1986.60	32%	3009.60	101%
5	H	9.00L	E	3000.00	0	3493.50	16%	5037.00	68%
6	H	6.00R	F	5000.00	0	5783.70	16%	9397.30	88%
7	H	3.00L	G	15000.00	0	13549.00	-10%	24298.00	62%
9	H	3.00R	I	15000.00	0	7735.80	-48%	7334.40	-51%
10	H	6.00R	J	5000.00	0	4359.80	-13%	4460.40	-11%
11	H	9.00R	K	3000.00	0	2662.90	-11%	2470.80	-18%
12	H	12.00R	L	1500.00	0	1324.30	-12%	1143.30	-24%
13	1.50D	9.00L	M	2000.00	0	3608.60	80%	5180.90	159%
14	1.50D	V	N	5000.00	0	17912.00	258%	17150.00	243%
15	1.50D	9.00R	O	2000.00	0	2724.40	36%	2423.40	21%
16	2.50D	12.00L	P	1000.00	0	2057.30	106%	2766.70	177%
17	2.50D	V	Q	2500.00	0	12176.00	37%	9226.40	269%
18	2.50D	12.00R	R	1000.00	0	1397.00	40%	1098.80	10%
						Used 1 Det		Used1 DIY	
						59.06%		70.17%	



Index	Y	X	Point	Min	Max	Altima Used 2 Deteriorated		Altima Used 2 PRO Restored	
1	2.00U	V	A	1500.00	0	3307.30	120%	5552.30	270%
2	1.00U	3.00L	B	5000.00	0	4331.40	-13%	9983.50	100%
3	1.00U	3.00R	C	5000.00	0	2606.90	-48%	5739.90	15%
4	H	12.00L	D	1500.00	0	1223.90	-18%	1700.20	13%
5	H	9.00L	E	3000.00	0	1925.40	-36%	3223.90	7%
6	H	6.00R	F	5000.00	0	3052.40	-39%	5395.10	8%
7	H	3.00L	G	15000.00	0	4773.50	-68%	15484.00	3%
9	H	3.00R	I	15000.00	0	2770.40	-82%	8281.70	-45%
10	H	6.00R	J	5000.00	0	1722.30	-66%	4482.50	-10%
11	H	9.00R	K	3000.00	0	1035.00	-66%	2653.90	-12%
12	H	12.00R	L	1500.00	0	581.44	-61%	1205.60	-20%
13	1.50D	9.00L	M	2000.00	0	1767.40	-12%	2880.00	44%
14	1.50D	V	N	5000.00	0	4294.90	-14%	15590.00	212%
15	1.50D	9.00R	O	2000.00	0	975.34	-51%	2362.00	18%
16	2.50D	12.00L	P	1000.00	0	1003.30	0%	1464.90	46%
17	2.50D	V	Q	2500.00	0	2905.50	16%	7447.70	198%
18	2.50D	12.00R	R	1000.00	0	531.97	-47%	1012.20	1%
						Used 2 Det		Used 2 PRO	
						22.37%		58.43%	



11 Appendix D

2007 Chevrolet Malibu									
	Part cost online (each)	Part Cost ¹	Sales Tax ¹	Shipping ²	Labor Hours ³	Labor Rate ⁴	Labor Cost	Subtotal	Total w/o Re-Aiming
OEM Dealer Part (qty = 2)									
Purchase from and installation by dealership	\$154.81	\$309.62	\$21.67		1.0	\$96.00	\$96.00	\$427.29	\$427.29
Purchase locally and DIY installation	\$154.81	\$309.62	\$21.67					\$331.29	\$331.29
Re-aim headlights					0.5	\$96.00			<i>plus re-aim⁵</i>
Aftermarket Certified Part (qty = 2)									
Purchase from and installation by service provider ⁶	\$48.79	\$153.20	\$10.72		1.0	\$96.00	\$96.00	\$259.92	\$259.92
Purchase online and DIY installation	\$48.79	\$97.58	\$6.83	\$27.00				\$131.41	\$131.41
Re-aim headlights					0.5	\$96.00			<i>plus re-aim</i>
Aftermarket Low Cost Part (qty = 2)									
Purchase from and installation by service provider	\$43.79	\$137.50	\$0.00		1.0	\$13.50	\$13.50	\$137.50	\$137.50
Purchase online and DIY installation	\$43.79		\$0.00	\$192.00				\$192.00	\$192.00
Re-aim headlights					0.5	\$96.00			<i>plus re-aim</i>
Professional Restoration (both headlights)									
Professional Restoration					1.2	\$96.00	\$115.20	\$115.20	\$115.20
Re-aim headlights					0.5	\$96.00			<i>plus re-aim</i>
Do-it-Yourself Restoration (both headlights)									
DIY Restoration								\$21.39	\$21.39
Re-aim headlights	\$19.99	\$19.99	\$1.40		0.5	\$96.00			<i>plus re-aim</i>

¹ Assume dealership will price match online OEM part cost
² 7% sales tax used in calculations; assume no tax on labor
³ \$13.50 per headlamp used in calculations
⁴ Sourced from an industry standard labor guide
⁵ National average labor rate as determined by AAA research
⁶ Labor charge to re-aim headlights is 0.5 hours or \$48.00
⁷ Typical parts mark-up percentage: 57%

Figure 38: 2007 Malibu cost of repair detail



2007 Nissan Altima		Part cost online (each)	Part Cost ¹	Sales Tax ¹	Shipping ²	Labor Hour ³	Labor Rate ⁴	Labor Cost	Subtotal	Total w/o Re-Aiming
OEM Dealer Part (qty = 2)										
Purchase from and installation by dealership		\$173.15	\$346.30	\$24.24		1.0	\$96.00	\$96.00	\$466.54	\$466.54
Purchase locally and DIY installation		\$173.15	\$346.30	\$24.24					\$370.54	\$370.54
Re-aim headlights						0.5	\$96.00			plus re-aim ⁵
Aftermarket Certified Part (qty = 2)										
Purchase from and installation by service provider ⁵		\$51.79	\$162.62	\$11.38		1.0	\$96.00	\$96.00	\$270.00	\$270.00
Purchase online and DIY installation		\$51.79	\$103.58	\$7.25	\$27.00				\$137.83	\$137.83
Re-aim headlights						0.5	\$96.00			plus re-aim
Aftermarket Low Cost Part (qty = 2)										
Purchase online and DIY installation		\$48.79	\$153.20	\$10.72	\$27.00				\$190.92	\$190.92
Purchase from and installation by service provider		\$48.79	\$97.58	\$6.83		1.0	\$96.00	\$96.00	\$104.41	\$104.41
Re-aim headlights						0.5	\$96.00			plus re-aim
Professional Restoration (both headlights)										
Professional Restoration						1.2	\$96.00	\$115.20	\$115.20	\$115.20
Re-aim headlights						0.5	\$96.00			plus re-aim
Do-it-Yourself Restoration (both headlights)										
DIY Restoration	Local purchase	\$19.99	\$19.99	\$1.40					\$21.39	\$21.39
Re-aim headlights						0.5	\$96.00			plus re-aim

¹ Assume dealership will price match online OEM part cost
² 7% sales tax used in calculations; assume no tax on labor
³ \$13.50 per headlamp used in calculations
⁴ Sourced from an industry standard labor guide
⁵ National average labor rate as determined by AAA research
⁶ Labor charge to re-aim headlights is 0.5 hours or \$48.00
⁷ Typical parts mark-up percentage: 57%

Figure 39: 2007 Altima cost of repair detail