

**Compliance Test Results
of Independently Manufactured
Automotive Replacement Headlamps
To FMVSS 108
Study II
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Summary

The United States Code of Federal Regulations provides standards for the performance of automotive exterior lamps and reflective devices. The standards are described in Title 49, Part 571-Federal Motor Vehicle Safety Standards, Standard Number 108 (FMVSS 108).

Compliance with FMVSS 108 is required of both original equipment and replacement lighting components. Replacement lighting components include those manufactured under a car company's brand as well as independently produced replacement parts.

This report is the second document released in twelve months that offers a recent examination of independently produced lights and their compliance with FMVSS 108 requirements. Two of the top ten selling replacement headlamp models supplied by original equipment (OE) and independent manufacturers were evaluated for conformance to FMVSS 108. These are lights designed for use on the Ford Taurus (2000-2003) and Toyota Camry (2000-2001). Aftermarket headlamps used in this study were manufactured by TYC and DEPO, two of the leading independent automotive lighting suppliers. Although this report is limited to headlamps, FMVSS 108 also encompasses other exterior lighting components such as taillamps, stoplamps, turn signal lamps, reflex reflectors, backup lamps, and side markers.

This study indicates that a high percentage (100%) of the independently manufactured replacement headlamps included in this study failed to conform to the photometric requirements of FMVSS 108. This data was developed by testing five (5) headlamps of each model and from each manufacturer for a total of fifteen (15) headlamps. Because one of the supplier's headlamps could not achieve "in-vehicle position" in the photometric fixture, no photometric data was recorded. This prevented us from testing all 20 of the samples. This inability to achieve "in-vehicle position" immediately failed the part with regard to the photometric requirements of FMVSS 108.

Conversely, a low percentage (10%) of the original equipment replacement manufactured headlamps included in this study failed to conform to the photometric requirements of FMVSS 108. Five (5) headlamps of each model were tested, for a total of ten (10) lamps.

Summary

In addition to a high rate of nonconformance to FMVSS 108 requirements, some of the independently produced headlamps for the Taurus and Camry were found to show variations in fit when compared to the original equipment replacement headlamps. Some of the fit variations included mounting clips that fit too loosely causing the lamp to “wobble” in the vehicle, as well as areas of excessive high flush and wide gap when fit on a car. The variation in fit may indicate that the independent manufacturers are not appropriately referencing the actual vehicles during their development process.

Introduction

The United States Code of Federal Regulations provides standards for the performance of automotive exterior lamps and reflective devices. The regulatory documentation is referenced as Title 49, Part 571-Federal Motor Vehicle Safety Standards, Standard Number 108 (hereafter cited as FMVSS 108).

FMVSS 108 specifies both original equipment and replacement lighting components. The “replacement” aspect of the regulation includes components supplied by an original equipment manufacturer as well as independent sources.

This report is the second document released in 12 months, which provides insight into the current state of independent lighting as it relates to the FMVSS 108 requirements. Two (2) of the top ten selling headlamp models supplied by original equipment replacement manufacturers and independent manufacturers were evaluated for conformance to FMVSS 108, the Ford Taurus (2000-2003), and the Toyota Camry (2000-2001). The original equipment replacement headlamps were manufactured by licensed Ford and Toyota suppliers. The independently manufactured headlamps selected for this study were manufactured by TYC and DEPO, two of the leading independent automotive lighting suppliers. Although this report is limited to headlamps, FMVSS 108 also encompasses other exterior lighting components such as taillamps, stoplamps, turn signal lamps, reflex reflectors, backup lamps, and side markers.

This study indicates that 100% of the independently manufactured replacement headlamps tested failed to conform to the photometric requirements of FMVSS 108, while 10% of the original equipment replacement manufactured headlamps included in this study failed to conform to the photometric requirements of FMVSS 108.

Technical Background

FMVSS 108 includes several categories of performance requirements. However, the most prominent feature of the FMVSS 108 standard is the “photometric” performance. The photometric performance of a headlamp must meet at least three distinct requirements.

- 1.) Photometric testing consists of the measurement of light intensity at defined test points in a beam pattern. FMVSS 108 provides the beam pattern test point locations and the associated light intensity requirements at the respective locations.
- 2.) The photometric requirements for the headlamp beam pattern must be satisfied when the lamp is aimed in accordance with the aiming device or aiming features of the lamp.
- 3.) After the low beam has met the requirements of 1.) and 2.) above, the high beam must pass with the lamp in the same position. No additional aiming can be performed to bring the high beam into conformance. The low beam pattern is tested initially.

FMVSS 108 provides aiming instructions and criteria for the range of acceptable aiming devices incorporated into automotive headlamps. Both of the lights included in this study are aimed using a procedure referenced as Visual Optical Left (VOL) or Visual Optical Right (VOR). In order to eliminate any visual subjectivity, Visual Optical aiming is performed by a computer, which positions the beam horizontally and vertically on a target surface in the photometric laboratory based on the characteristics of its illuminated pattern. Both the Ford Taurus and Toyota Camry in this study employ the use of VOR aim. Since lamps are aimed based on their beam pattern characteristics, it is possible for a beam pattern to fail intensity requirements that are needed in order to position it accurately. As a result, a headlamp may be photometrically non-conformant in the aiming stage of the testing.

Technical Background

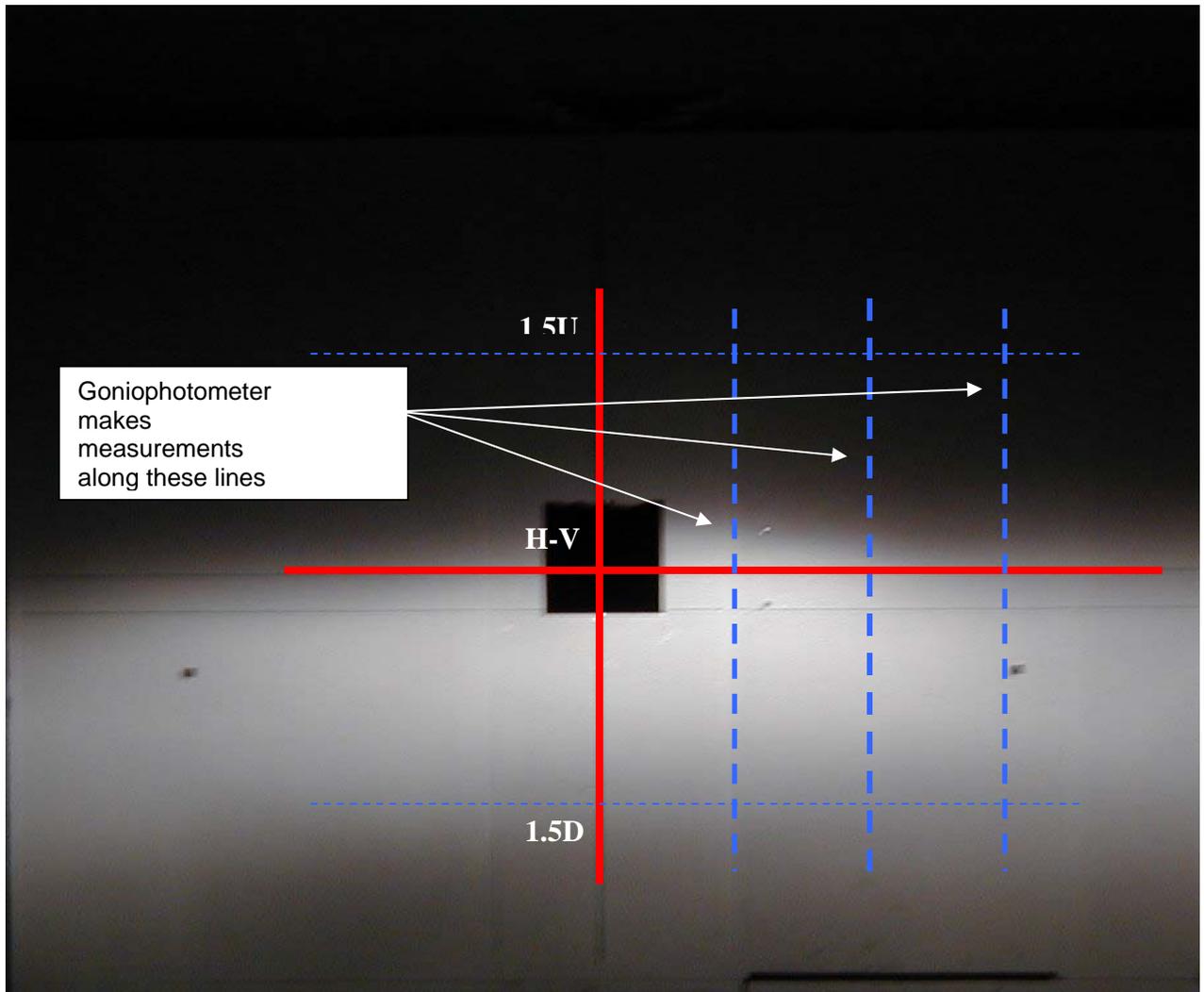


Figure 1. Representation of the VOR aiming grid laid over a headlamp beam pattern. Proper vertical aim of the headlamp is carried out by the goniophotometer.

Test Procedure

Headlamp Test Samples:

The headlamp models selected for this study included a left hand (LH) 2000-2003 Ford Taurus, and a left hand (LH) 2000-2001 Toyota Camry. These models were found to be two of the top ten selling vehicles in the United States and therefore represent a significant quantity of lamps produced for the market. Five (5) headlamps manufactured by the original equipment replacement manufacturer, TYC and DEPO were purchased for each vehicle model (30 total samples). The headlamps were purchased through the same distribution network that a collision repair shop would utilize to procure replacement parts produced by both original equipment replacement and independent manufacturers. Photometric testing was performed on five (5) headlamps for each model and from each manufacturer, with the exception of the DEPO Ford Taurus headlamp, which could not be mounted to the photometric fixture based upon OEM in-vehicle position mounting point data. The lot numbers of the test headlamps are provided in Table 1.

Test Sample	LH Ford Taurus (2000-2003)			LH Toyota Camry (2000-2001)		
	OE	DEPO*	TYC	OE	DEPO	TYC
A	082703	13010027	04030308	00913	130030003	08120309
B	082703	13010027	04030308	01313	130030003	01180308
C	073103	13010027	04030308	16613	130030003	08120309
D	082703	13010027	04030308	02113	130030003	08120309
E	082703	13010027	04030308	16613	130030003	08120309

* DEPO lot numbers for reference only. Parts did not undergo photometric testing because they did not fit into the fixture based upon OEM in-vehicle position mounting point data.

Table 1. Lot Number Identification of Headlamp Test Samples

Test Procedure

The majority of the test samples for a given model and manufacturer were derived from the same manufacturing lot. The exception to this was the OE Toyota Camry where the test samples were divided between four different lots, and the TYC Toyota Camry which included 2 different lots.

Photometric Test Fixtures:

Compliance with FMVSS 108 requires the lamps to be oriented in an “in-vehicle” position. In order to fulfill this requirement, photometric test fixtures were constructed based on dimensional data procured from vehicles.

Figure 2. and Figure 3. provides views of a 2003 Ford Taurus and 2001 Toyota Camry headlamp mounted in the respective vehicles.



Figure 2. 2003 Ford Taurus exhibiting a LH Headlamp.

Test Procedure



Figure 3. 2001 Toyota Camry exhibiting a LH Headlamp.

Vehicle headlamp mounting locations were measured using a Coordinate Measurement Machine (CMM). The “in-vehicle” position photometric fixtures were developed from the vehicle measurements using 3-D computer aided design (CAD) software.

Figure 4. illustrates the 2000-2003 LH Ford Taurus headlamp photometric fixture drawing, and Figure 5. shows the completed fixture with a mounted headlamp.

Figure 6. illustrates the 2000-2001 LH Toyota Camry headlamp photometric fixture drawing, and Figure 7. shows the completed fixture with a mounted headlamp.

Test Procedure



Figure 5. 2000-2003 LH Ford Taurus headlamp mounted on the photometric test fixture.

Test Procedure



Figure 7. 2000-2001 LH Toyota Camry headlamp mounted on the photometric test fixture.

Test Procedure

Bulbs:

Not every headlamp that was purchased for this report came equipped with a bulb for the headlamp functions. The Ford Taurus headlamps manufactured by TYC were missing all bulbs and wiring harnesses. The OE and DEPO parts both had 9007 headlamp bulbs, turn signal/side marker bulbs and associated wiring harnesses. All three manufacturers supplied necessary bulbs on the Toyota Camry headlamps, which utilized 9006 bulbs for the low beam function and 9005 bulbs for the high beam function. Specifications for 9007, 9006, and 9005 bulbs are cited in SAE (Society of Automotive Engineers) standards.

According to the National Highway Traffic Safety Administration (NHTSA), headlamps must meet the FMVSS 108 requirements using “production” bulbs. Since the TYC Ford Taurus model was sold without bulbs and other hardware, five (5) 9007 bulbs were purchased through a licensed Ford Dealership Parts Department and used during the photometric testing. Specific information regarding the bulbs used for the photometric tests in this report is presented in Tables 2a and 2b.

Test Procedure

Test Sample		LH Ford Taurus (2000-2003)		
		OE	DEPO*	TYC
A	Description	Sylvania 9007/HB5	Philips 9007/HB5	Sylvania 9007/HB5
	Lot ID	Aug 12 03	F228	Apr 12 02
B	Description	Sylvania 9007/HB5	Philips 9007/HB5	Sylvania 9007/HB5
	Lot ID	Aug 12 03	F221	May 09 02
C	Description	Sylvania 9007/HB5	Philips 9007/HB5	Sylvania 9007/HB5
	Lot ID	Jul 21 03	F227	May 02 03
D	Description	Sylvania 9007/HB5	Philips 9007/HB5	Sylvania 9007/HB5
	Lot ID	Aug 12 03	F226	May 02 03
E	Description	Sylvania 9007/HB5	Philips 9007/HB5	Sylvania 9007/HB5
	Lot ID	Aug 12 03	F227	May 02 03

* DEPO bulb lot numbers for reference only. Parts did not undergo photometric testing because they did not fit into the fixture based upon OEM in-vehicle position mounting point data.

Table 2a. Description of Bulbs Utilized on 2000-2003 Ford Taurus for Photometric Tests

Test Procedure

Test Sample		LH Toyota Camry (2000-2001) Low Beam			LH Toyota Camry (2000-2001) High Beam		
		OE	DEPO	TYC	OE	DEPO	TYC
A	Description	Sylvania 9006/HB4	Philips 9006/HB4	Philips 9006/HB4	Sylvania 9005/HB3	Philips 9005/HB3	Philips 9005/HB3
	Lot ID	A0703	K211	25C3	M3002	B319	F303
B	Description	Sylvania 9006/HB4	Philips 9006/HB4	Philips 9006/HB4	Sylvania 9005/HB3	Philips 9005/HB3	Philips 9005/HB3
	Lot ID	B0803	K211	H224	A2903	B319	K217
C	Description	Sylvania 9006/HB4	Philips 9006/HB4	Philips 9006/HB4	Sylvania 9005/HB3	Philips 9005/HB3	Philips 9005/HB3
	Lot ID	E1703	K211	25C3	E3003	B319	F303
D	Description	Sylvania 9006/HB4	Philips 9006/HB4	Philips 9006/HB4	Sylvania 9005/HB3	Philips 9005/HB3	Philips 9005/HB3
	Lot ID	E1703	K211	25C3	E3003	B319	F303
E	Description	Sylvania 9006/HB4	Philips 9006/HB4	Philips 9006/HB4	Sylvania 9005/HB3	Philips 9005/HB3	Philips 9005/HB3
	Lot ID	E1703	K211	25C3	E3003	B319	F303

Table 2b. Description of Bulbs Utilized on 2000-2001 Toyota Camry for Photometric Tests

Test Procedure

Instrumentation and Test Process:

The photometric testing was performed in accordance with FMVSS 108 and the associated SAE standards using a Hoffman goniophotometer (Figure 8). The headlamp samples were mounted on the photometric fixture and then attached to the goniometer. The filament of the bulb was aligned with the axis of the goniometer and the photometric sensor using a laser system incorporated in the goniometer/photometer set-up. The lamp was then aimed at the photometric sensor using the VOR aiming method detailed in the Technical Background section of this report.

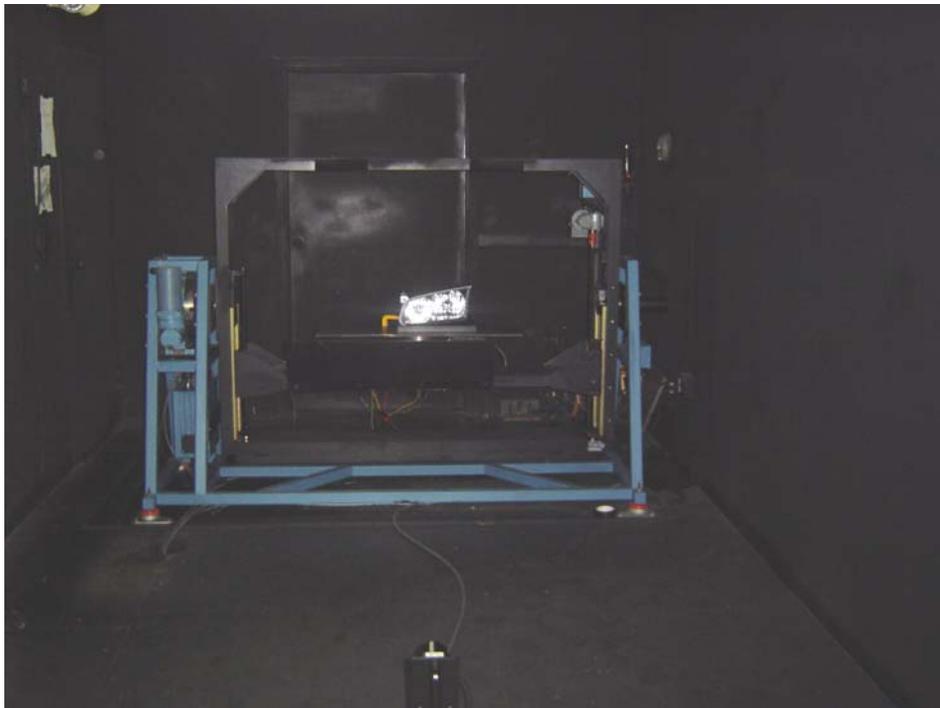


Figure 8. Photometric laboratory instrumentation with a headlamp mounted on the goniometer table. The photometric sensor is located 100 feet from the center of the headlamp's bulb filament at the opposite end of the tunnel.

Test Procedure

Once a headlamp was aimed the bulb was energized and allowed to warm up and stabilize prior to the initiation of the photometric test. The low beam was tested first, followed by the high beam. The test pattern and light intensity criteria used for the headlamps was in accordance with FMVSS 108.

Figure 9. and Figure 10. illustrate the Ford Taurus and Toyota Camry headlamps respectively mounted to the goniometer table.



Figure 9. 2000-2003 LH Ford Taurus headlamp mounted to the goniometer table.

Test Procedure



Figure 10. 2000-2001 LH Toyota Camry headlamp mounted to the goniometer table.

Test Results

Photometric Test Results:

Fixture Fit of Headlamp Models:

The DEPO Ford Taurus independently manufactured lamps exhibited excessive gaps, or did not mate with the mounting points in the same manner as the original equipment replacements. The variation in fixture fit may indicate that DEPO is not appropriately referencing the actual vehicles during their development process.

Test Sample	LH Ford Taurus (2000-2003) ¹			LH Toyota Camry (2000-2001) ²		
	OE	DEPO ³	TYC	OE	DEPO	TYC
A	Pass	Fail	Fail	Pass	Fail	Fail
B	Pass	Fail	Fail	Pass	Fail	Fail
C	Fail	Fail	Fail	Pass	Fail	Fail
D	Pass	Fail	Fail	Pass	Fail	Fail
E	Pass	Fail	Fail	Pass	Fail	Fail
% Failed	20%	100%	100%	0%	100%	100%

Table 3. Results of Photometric Tests

¹Ford Taurus models were tested to FMVSS 108, Figure 27-2.

²Toyota Camry models were tested to FMVSS 108, Figure 17-2.

³DEPO Ford Taurus lamp did not fit the photometric fixture based upon OEM in-vehicle position mounting point data. Unlike the OE part which fit the photometric fixture, the DEPO part could not achieve “in-vehicle position” on the same fixture. This inability to achieve “in-vehicle position” immediately failed the part with regard to photometrics.

Note: At the time that they were purchased, the TYC headlamps had been certified to the Manufacturers’ Qualification and Validation Program (MQVP).

Test Results

Table 3. indicates that 100% of the independently manufactured headlamps tested failed to conform to the FMVSS 108 photometric requirements. Meanwhile, only 10% of the original equipment manufactured headlamps tested failed to conform to the FMVSS 108 photometric requirements. It is important to remember that once a lamp fails during the aim portion of the test, the lamp has officially failed FMVSS 108 photometric requirements. For purposes of comparing photometric qualities of each lamp with respect to the test points called out in Figures 17-2 and 27-2 of FMVSS 108, each lamp's low beam and high beam was tested as well.

The photometric results indicate widespread photometric nonconformance to FMVSS 108 by the independently manufactured replacement headlamps. There are indications that the structural "optics" of some of the independent parts may have the capability of meeting the FMVSS 108 photometric requirements once the chosen method of aim coincides with the proper optics. This may imply that the independent manufacturers do not fully comprehend the requirements of FMVSS 108, or they are disregarding the requirements.

Test Results

Beam Patterns of the Independent Replacement Headlamps:

In addition to the 100% failure rate from the photometric test, the visual appearance of the independent headlamp beam patterns varied from the original equipment replacement lamps. This was illustrated by comparing the low beam patterns of the original equipment replacement lamps to independent replacement headlamps that did not meet the FMVSS 108 photometric requirements.

Figures 11., and 12. provide digital photographic comparisons between the Ford Taurus original equipment manufacturer (OEM) replacement, TYC, and DEPO low beam patterns when aimed in accordance with FMVSS 108.

Figures 13., 14., and 15. provide digital photographic comparisons between the Toyota Camry original equipment manufacturer (OEM) replacement, TYC, and DEPO low beam patterns when aimed in accordance with FMVSS 108.

Test Results



Figure 11. A Ford Taurus original equipment manufacturer (OEM) replacement low beam when aimed using the VOR method.

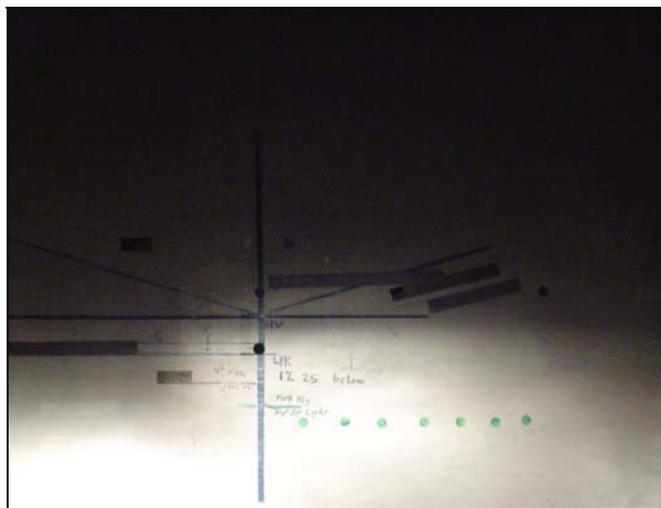


Figure 12. A TYC Ford Taurus low beam when aimed using the VOR method.

Test Results

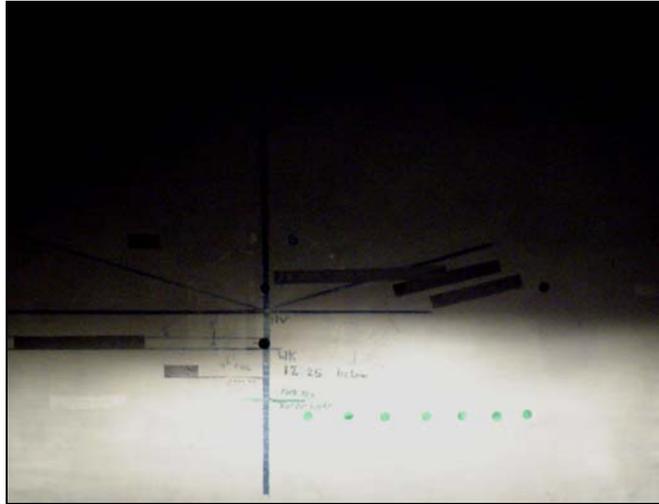


Figure 13. An original equipment manufacturer (OEM) replacement Toyota Camry low beam pattern aimed using the VOR method.

Test Results



Figure 14. A TYC Toyota Camry low beam pattern aimed using the VOR method.



Figure 15. A DEPO Toyota Camry low beam pattern aimed using the VOR method.

Test Results

It is feasible for a range of beam patterns to fall within the FMVSS 108 requirements. However, beam patterns displayed in Figures 12., 14., and 15. do not meet the FMVSS 108 requirements when evaluated using the photometric test instrumentation.

Test Results

Humidity Test:

In addition to testing the lamps for FMVSS 108 photometric conformance, a humidity test was performed in accordance with the procedures cited in FMVSS 108. The acceptance criteria for these tests require passing physical criteria and subsequently conforming to the FMVSS 108 photometric requirements. A humidity test run to the specifications of FMVSS 108 was run on one headlamp from each model for a total of six (6) humidity samples. These samples were labeled “E.” Because the DEPO Ford Taurus lamp did not fit into the fixture based upon OEM in-vehicle position mounting point data, it did not undergo the post-exposure photometric testing.

The FMVSS 108 humidity test involves a 72-hour exposure to 38°C and a minimum of 90% relative humidity followed by an hour-long exposure to a regulated airflow. In addition, to meeting the photometric test requirement following the humidity test, the acceptance criteria also states that the inside of the headlamp shall show no evidence of delamination or moisture, fogging, or condensation visible without magnification. None of the lamps exhibited any condensation after the dry-out portion of the test. Both original equipment replacement headlamps passed photometric requirements after the humidity test, while the three of the independently manufactured headlamps failed photometric requirements after the humidity test. Test results indicate that sample “E” photometric failures on independently manufactured depended largely on faulty aim or optical construction, and not on moisture ingress due to the humidity test.

Vehicle Test Fit:

The laboratory photometric and performance test data indicates a high rate of nonconformance to FMVSS 108 requirements. In addition, some of the independently manufactured Taurus and Camry were found to show variation in the fit to the respective vehicles when compared to the OEM original equipment and the OEM original equipment replacement lamps. The independently manufactured lamps fit variations included mounting clips that fit too loosely

Humidity Test and Vehicle Test Fit

causing the lamp to “wobble” in the vehicle, as well as areas of excessive high flush and wide gap when fit on a car. The variation in vehicle fit may indicate that the independent manufacturers are not appropriately referencing the actual vehicles during the development process.

Conclusion

This study showed that 100% (20 of 20) of the independently manufactured replacement headlamps represented in this report failed to conform to the photometric requirements of FMVSS 108, while only 10% (1 of 10) of the original equipment manufactured (OEM) replacement headlamps failed to conform to the photometric requirements of FMVSS 108. This data was developed by testing five (5) headlamps from each model and from each manufacturer (i.e. a total of 25 headlamps). Five (5) headlamps failed the photometric requirements of FMVSS 108 because they could not be mounted to a photometric fixture in “in-vehicle position” based upon OEM mounting point data. This inability to achieve “in-vehicle position” would have disqualified any actual photometric test data, so the parts did not undergo further photometric testing.

In comparing the results, it is clear that photometric aim and test point failures are statistically much more frequent in the independently manufactured replacement headlamps than in the original equipment replacement headlamps that were tested in this study. The high failure rate of independently manufactured headlamps implies either: a) a misinterpretation of the designated FMVSS 108 aiming methods intended for use on each headlamp; b) disregard of the designated FMVSS 108 aiming methods on each headlamp; c) significant variation in the optical assembly of each headlamp from the original design; or d) some combination thereof.

The Ford Taurus and Toyota Camry headlamps manufactured by TYC and DEPO were selected for this study since they appeared to be “similar” to the original equipment parts and they have both been in the top 10 highest selling vehicles in the United States during their respective model years. Upon closer inspection, visual observations between the original equipment replacement lamps and the TYC and DEPO lamps reveals variations in construction features such as heat vents, aiming mechanisms, assembly methods, and quality of optical components. Variation in these construction features may be adversely affecting the fit of the headlamps to the vehicles as well as accounting for failure to the FMVSS 108 requirements.

Manufacturers were provided a copy of this report and invited to send any comments or concerns to CAPA. As of the date of submission of this report to NHTSA, comments received from manufacturers were nothing that warranted altering the conclusions of this Report.