Compliance Test Results

of Independently Manufactured

Automotive Replacement Headlamps

to FMVSS 108

Study I

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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 documents a recent examination of independently produced lights and their compliance with FMVSS 108 requirements. Two of the top ten selling headlamp models supplied by independent manufacturers were evaluated for conformance to FMVSS 108. These are lights designed to be used on the Pontiac Grand Am (1999-2003), and Ford Taurus (1996-1998). The 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.

A high percentage (82%) 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 ten headlamps of each model and from each manufacturer for a total of 40 headlamps.

In addition to a high rate of nonconformance to FMVSS 108 requirements, the independently produced headlamps for the Grand Am and Taurus were found to show variations in fit when compared to the original equipment replacement headlamps. The independently manufactured lamps exhibited excessive gaps or did not mate with the adjacent vehicle components in the same manner as the original parts on the car. The variation in vehicle 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 provides insight into the current state of aftermarket lighting as it relates to the FMVSS 108 requirements. Two (2) of the top ten selling headlamp models supplied by independent manufacturers were evaluated for conformance to FMVSS 108, the Pontiac Grand Am (1999-2003), and the Ford Taurus (1996-1998). The 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 at least 82% of the independently manufactured replacement headlamps tested 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 dual filament headlamp (i.e. a headlamp that utilizes a "bulb" that encapsulates both a high beam and low beam filament) 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.

Headlamps may be equipped with a Vehicle Headlamp Aiming Device (VHAD) that must be utilized for the photometric test. The 1996-1998 Ford Taurus headlamp features a VHAD in the form of a "bubble level" attached to the lamp structure. Lamps equipped with a bubble level should be preset so that when the lamp is in the correct aiming position the bubble reads at the "0" position on the level. When the headlamp is installed on a test fixture for photometric evaluations, the headlamp mechanical adjustors are used to position the lamp to the correct vertical aim orientation as indicated by the level.

An alternative to the VHAD concept is an aiming technique referenced as "external aiming." The external aiming technique employs the use of "aiming pads." Aiming pads are protrusions on the exterior of the lenses that are accompanied with dimensional instructions that dictate the orientation of a mechanical aiming device. The 1999-2003 Pontiac Grand Am headlamp incorporates the use of aiming pad protrusions on the exterior of the lens.

Headlamps also have the option of specifying aiming using a procedure referenced as Visual Optical Left (VOL) or Visual Optical Right (VOR). Visual Optical aiming is performed by positioning the beam horizontally and vertically on a target surface in the photometric laboratory based on the characteristics of its illuminated pattern.

Headlamp Test Samples:

The headlamp models selected for this study included a left hand (LH) 1999-2003 Pontiac Grand Am, and a right hand (RH) 1996-1998 Ford Taurus. These models were assumed to be representative of two (2) of the top ten selling lighting products supplied by independent manufacturers, and therefore represent a significant quantity of lamps produced for the market. A minimum of ten (10) headlamps manufactured by both TYC and DEPO were purchased for each vehicle model (i.e. a minimum of 40 samples). The headlamps were purchased through the same distribution network that a collision repair shop would utilize to procure replacement parts produced by independent manufacturers. Photometric testing was performed on ten (10) headlamps for each model and from each manufacturer. The lot numbers of the test headlamps are provided in Table 1.

Test Sample	LH Grand Am		RH Taurus	
	TYC	DEPO	TYC	DEPO
A	07160208	12080112	10050107	12080022
B	11190213	12080112	10050107	12080022
C	11190213	12070353	10050107	12080022
D	11190213	12080112	10050107	12080022
E	11190213	12080112	10050107	12080022
F	11190213	12080112	10050107	12110210
G	11190213	12080112	10050107	12110210
H	11190213	12080112	10050107	12110210
I	11190213	12080112	10050107	12110210
J	11190213	12080112	10050107	12110210

Table 1. Lot Number Identification of Headlamp Test Samples

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 DEPO Taurus where the test samples were evenly divided between two 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 1. and Figure 2. provide views of a Grand Am and Taurus headlamp mounted in the respective vehicles.

Figure 1. 1999 Pontiac Grand Am exhibiting a LH Headlamp.

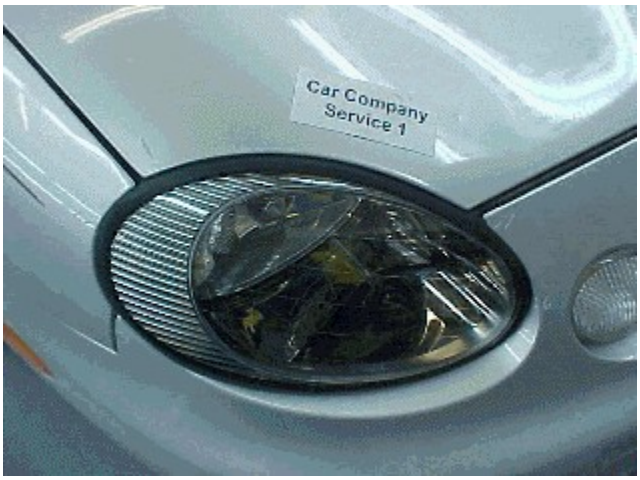

Figure 2. 1997 Ford Taurus exhibiting a RH Headlamp.

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 3. illustrates the 1999-2003 LH Grand Am headlamp photometric fixture drawing, and Figure 4. shows the completed fixture with a mounted headlamp.

Figure 5. illustrates the 1996-1998 RH Taurus headlamp photometric fixture drawing, and Figure 6. shows the completed fixture with a mounted headlamp.

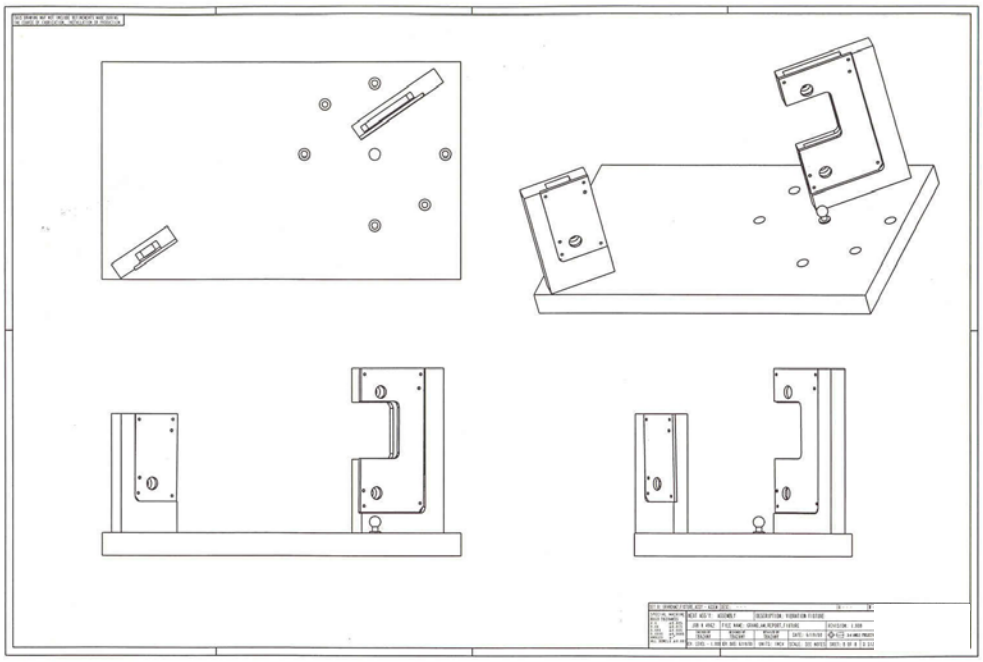

Figure 3. 1999-2003 LH Grand Am CAD generated photometric fixture assembly drawing.

Figure 4. 1999-2003 LH Grand Am headlamp mounted on the photometric test fixture.

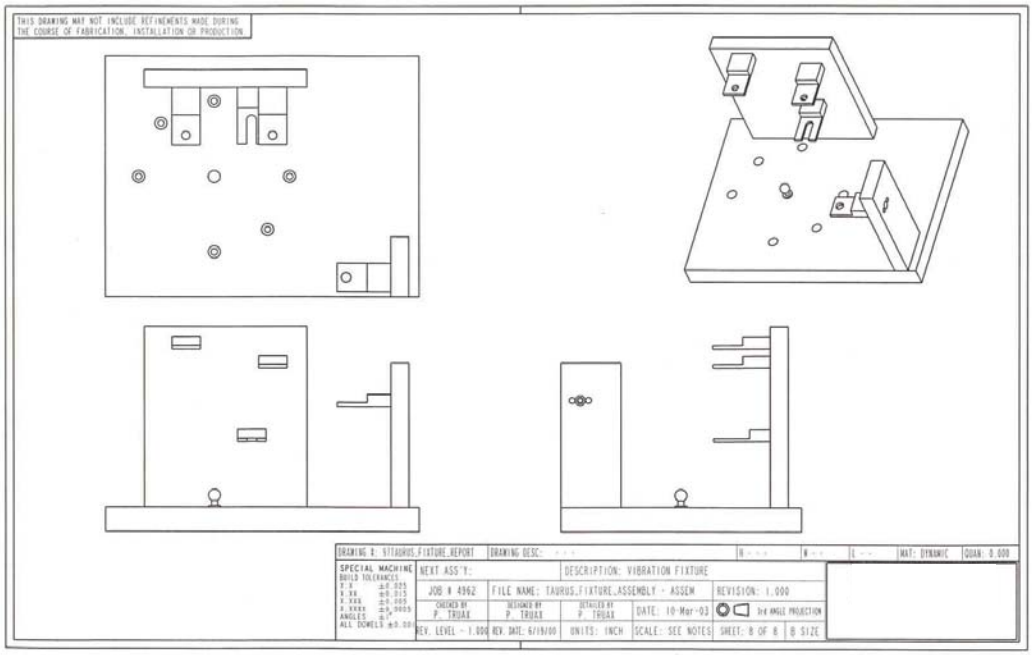

Figure 5. 1996-1998 RH Taurus CAD generated photometric fixture assembly drawing.

Figure 6. 1996-1998 RH Taurus headlamp mounted on the photometric test fixture.

Bulbs:

Each headlamp purchased for this report came equipped with a bulb for the headlamp functions. The Grand Am and Taurus headlamps both use a single bulb with a dual filament for the high and low beams that is referenced as a "9007" bulb. The specifications for a 9007 bulb are cited in SAE (Society of Automotive Engineers) standards. The 9007 bulbs provided with the aftermarket lamps were from suppliers that are known to provide bulbs for the original equipment. The TYC headlamps were equipped with 9007 bulbs from Sylvania, and DEPO headlamps were equipped with 9007 bulbs from Philips.

According to the National Highway Traffic Safety Administration (NHTSA), headlamps must meet the FMVSS 108 requirements using "production" bulbs. Since the purpose of this study was to test the aftermarket lamps for variation rather than the bulbs, one bulb was randomly selected from one of the test parts for each model and consistently used throughout the test program.

Specific information regarding the bulbs used for the photometric tests in this report is presented in Table 2.

Model	Bulb Manufacturer	Bulb Manufacturer Description	Lot Number
Grand Am	Sylvania	HB5/9007 DOT 12V	Dec 12 01
Taurus	Philips	L1 07 HB5/9007 DOT 12V	F105

Table 2. Description of Bulbs Utilized for Photometric Tests

Instrumentation and Test Process:

The photometric testing was performed in accordance with FMVSS 108 and the associated SAE standards using a Lichtmesstechnik LMT GO-H 1300 goniometer-photometric sensor (Figure 7). 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. The lamp was then aimed at the photometric sensor using the aiming method appropriate for the lamp.

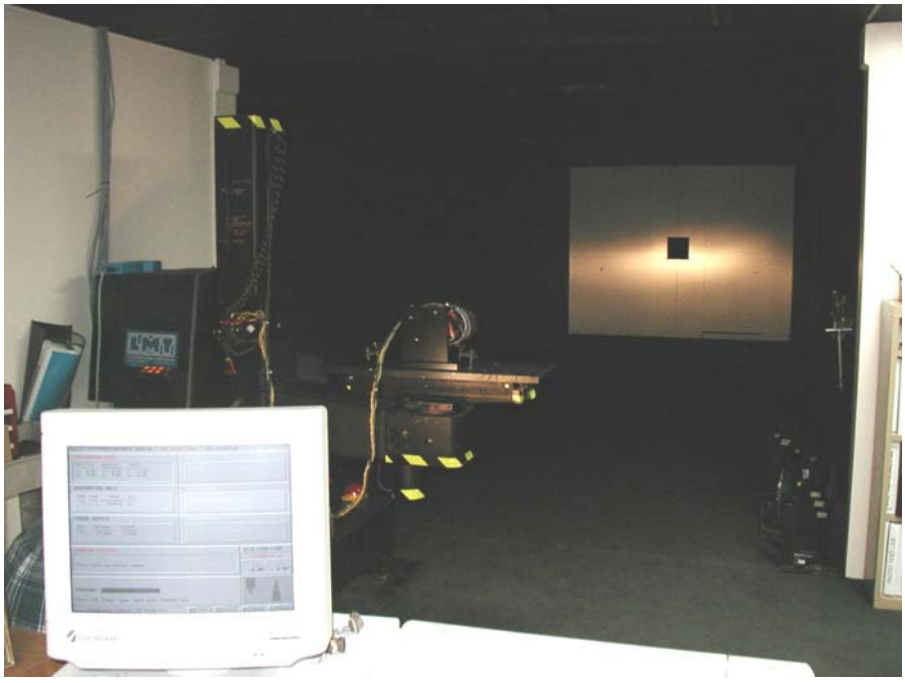

Figure 7. Photometric laboratory instrumentation with a headlamp mounted on the goniometer table. The photometric sensor is located behind the white wall on which the beam pattern is projected.

The Pontiac Grand Am headlamp incorporates “aiming pads” as a reference for a mechanical aiming device (Figure 8). The aiming pads dictate the aiming locations in the vertical and horizontal axis.

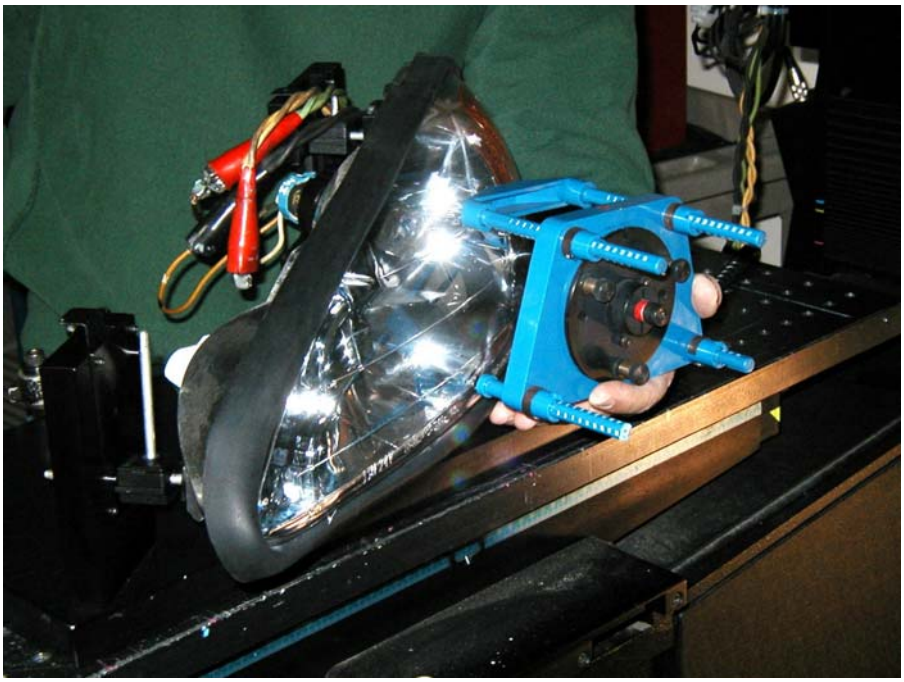

Figure 8. Grand Am headlamp with the mechanical aiming device in use. The legs of the device rest on three aiming pads located on the exterior of the lens.

The Ford Taurus employs a bubble level located at the top rear center of the lamp (Figure 9). This bubble level functions as a vertical orientation VHAD. This level is affixed to a portion of the plastic reflector inside the lamp that moves as the vertical aiming screw is turned.

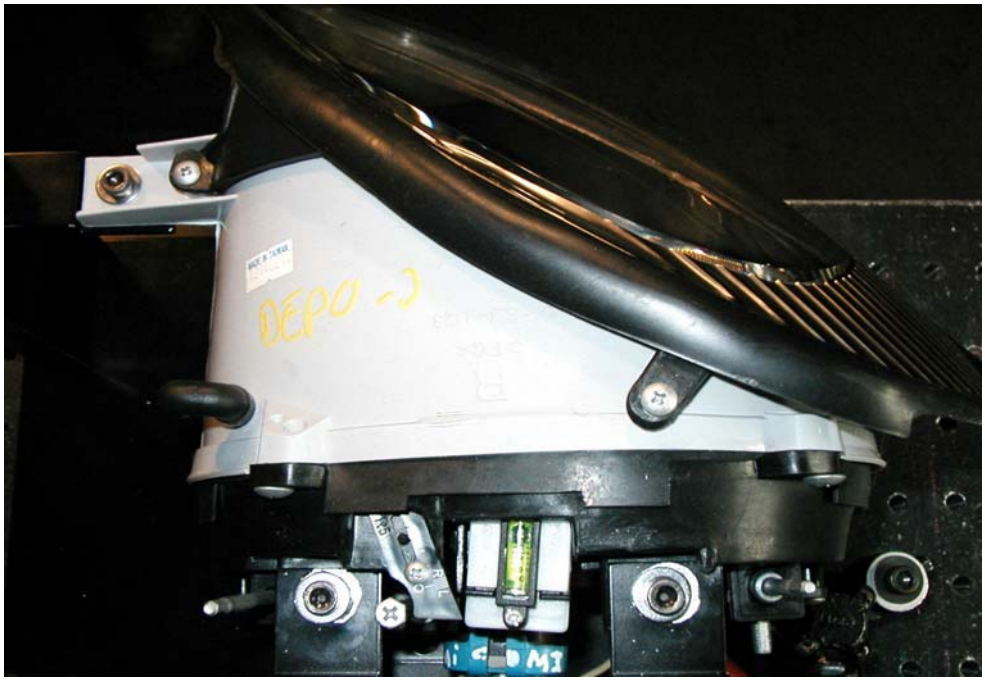

Figure 9. Top view of a DEPO manufactured Taurus headlamp. The bubble level (located near the bottom center) is a vertical VHAD used for setting the vertical aim.

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 10. and Figure 11. illustrate the Grand Am and Taurus headlamps respectively mounted to the goniometer table.

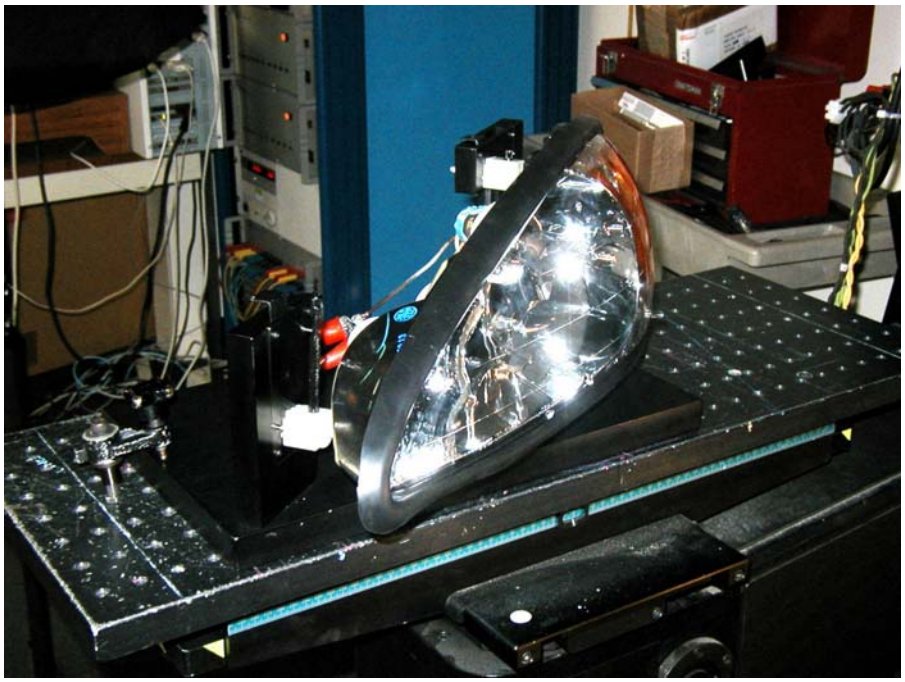

Figure 10. 1999-2003 LH Grand Am headlamp mounted to the goniometer table.

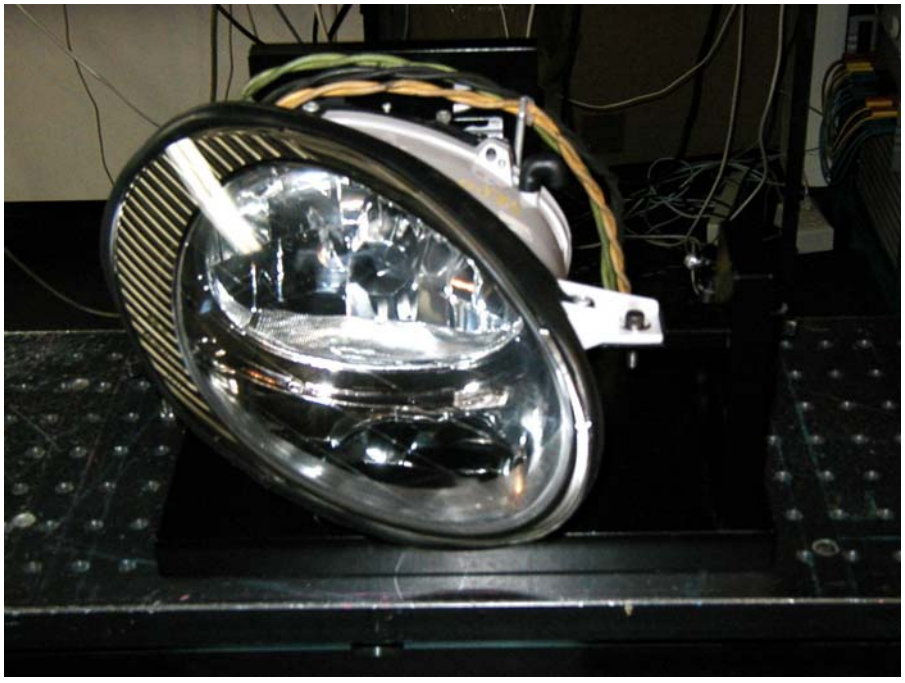

Figure 11. 1996-1998 RH Taurus headlamp mounted to the goniometer table.

Test Results

During the course of the test program, CAPA collaborated with an independent photometric test lab. This photometric laboratory provides independent testing for many of the original equipment lighting manufacturers.

Although this study was not focused on OEM original equipment replacement lamps, an OEM original equipment replacement lamp of each model was often evaluated as a reference.

Photometric Test Results:

The results of the photometric tests are presented in Table 3.

Test Sample	LH Grand Am		RH Taurus	
	TYC*	DEPO	TYC	DEPO
A	Fail	Fail	Pass	Fail
B	Fail	Fail	Fail	Fail
C	Fail	Pass	Fail	Fail
D	Fail	Pass	Fail	Fail
E	Fail	Fail	Fail	Fail
F	Fail	Pass	Fail	Fail
G	Fail	Pass	Fail	Fail
H	Fail	Pass	Fail	Fail
I	Fail	Pass	Fail	Fail
J	Fail	Fail	Fail	Fail
% Failed	100%	40%	90%	100%

*The Pontiac Grand Am headlamps have been certified to the Manufacturers' Qualification and Validation Program (MQVP) to be FMVSS 108 compliant.

Table 3. Results of the initial or "As Received" photometric tests conducted in accordance with FMVSS 108 using a production test bulb.

Test Results

Table 3. indicates that 82% of the headlamps tested failed to conform to the FMVSS 108 photometric requirements.

The photometric results indicate widespread nonconformance to FMVSS 108 regardless of manufactured "lots." The results also reveal that failures can be dispersed within a specific "lot." The distribution of parts that pass and fail within a specific lot may indicate inconsistency in the manufacturing process.

In an effort to remove the variable of the 9007 "production bulbs" as the source of the failing photometric results, an "Accurate Rated" 9007 bulb from Sylvania was used to re-test multiple samples from Table 3. An "Accurate Rated" 9007 bulb is an industry designation for a bulb that is representative of the mean characteristics of the 9007 specifications. Re-testing three (3) samples from each model and each manufacturer (a total of 12 headlamps) provided nearly identical results by yielding an 83% failure rate.

There are indications that the structural "optics" of the aftermarket parts may have the capability of meeting the FMVSS 108 photometric requirements if the aiming devices are modified and monitored for consistency. This may imply that the independent manufacturers do not fully comprehend the requirements of FMVSS 108, or they are disregarding the requirements.

Beam Patterns of the Aftermarket Replacement Headlamps:

In addition to the 82% failure rate from the photometric test, the visual appearance of the aftermarket 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 aftermarket replacement headlamps that did not meet the FMVSS 108 photometric requirements.

Figures 12., 13., and 14. provide digital photographic comparisons between the Grand Am original equipment manufacturer (OEM) replacement, TYC, and DEPO low beam patterns when aimed in accordance with FMVSS 108.

Figures 15., 16., and 17. provide digital photographic comparisons between the Taurus original equipment manufacturer (OEM) replacement, TYC, and DEPO low beam patterns when aimed in accordance with FMVSS 108.

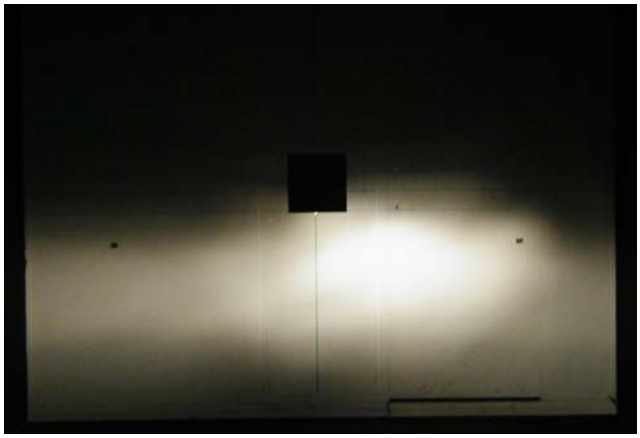

Figure 12. A Grand Am original equipment manufacturer (OEM) replacement low beam when aimed using the lens exterior aiming pads.

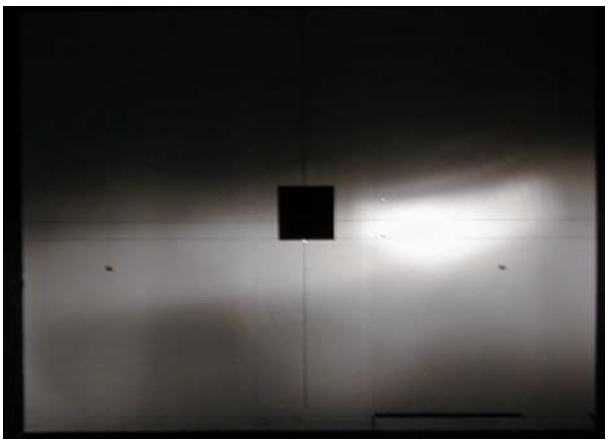

Figure 13. A TYC Grand Am low beam when aimed using the lens exterior aiming pads.

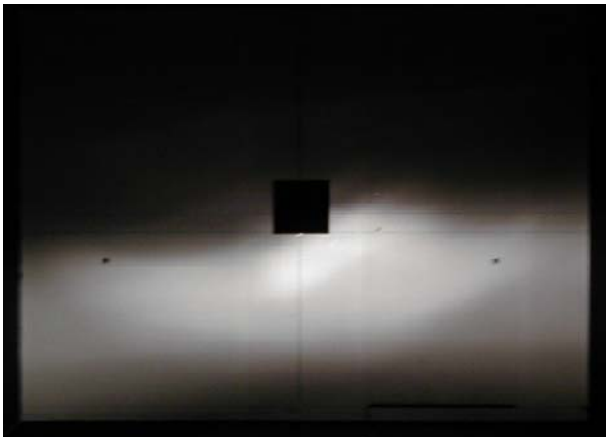

Figure 14. A DEPO Grand Am low beam when aimed using the lens exterior aiming pads.

Figure 15. A Taurus original equipment manufacturer (OEM) replacement low beam pattern aimed with the vertical VHAD.

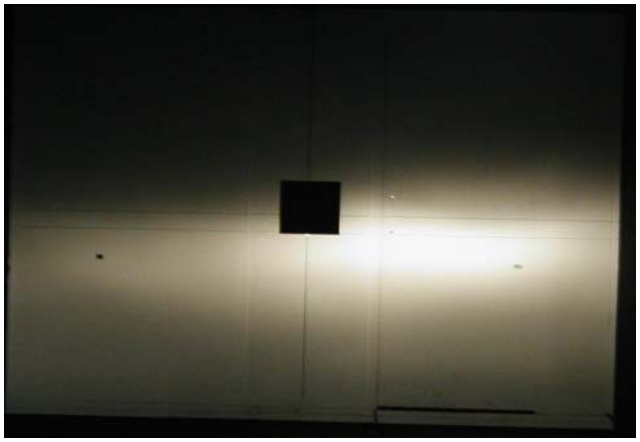

Figure 16. A TYC Taurus low beam pattern aimed with the vertical VHAD.

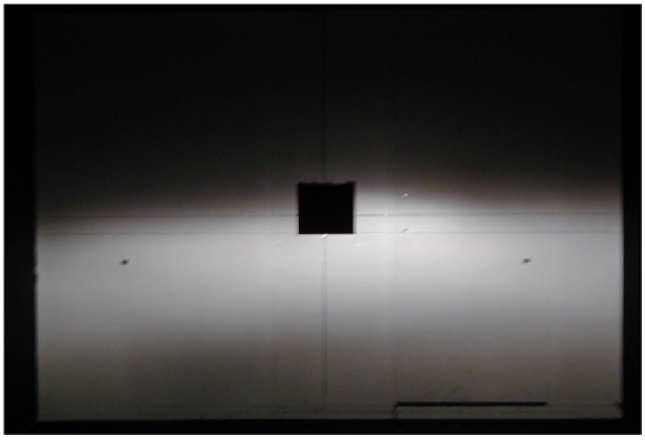

Figure 17. A DEPO Taurus low beam pattern aimed with the vertical VHAD.

It is feasible for a range of beam patterns to fall within the FMVSS 108 requirements. However, beam patterns displayed in Figures 13., 14., 16., and 17., do not meet the FMVSS 108 requirements when evaluated using the photometric test instrumentation.

Performance Tests

A temperature cycle test, chemical resistance test, and humidity test was performed on the independently manufactured headlamps 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. The high failure rate exhibited by the headlamps in the "as received" conditions as illustrated in Table 3. essentially failed the aftermarket headlamps before they were tested to the performance criteria. As a result of the high failure rate, only a select number of the performance tests were conducted to determine if the independently manufactured headlamps exhibited any overt physical or appearance failures in addition to photometric nonconformance.

Temperature Cycle Test:

During the temperature cycle test, a headlamp is exposed to ten (10) temperature cycles transitioning between 49°C and –34°C over a 60 hour period. During the exposure, the headlamp is mounted in a test fixture with the filament of the high beam energized and de-energized at select points in the temperature profile. One (1) Grand Am and one (1) Taurus headlamp manufactured by TYC and DEPO were exposed to the temperature cycle test. There was no apparent physical or appearance change at the conclusion of the test exposure.

Chemical Resistance Test:

FMVSS 108 requires that headlamp lenses must meet the photometric requirements following an exposure to common automotive fluids (tar remover, fuel, antifreeze, windshield washer solvent, and power steering fluid). One (1) Grand Am and one (1) Taurus headlamp manufactured by TYC and DEPO were used for each automotive fluid exposure. The headlamp lenses manufactured by TYC and DEPO did not appear to exhibit any change in appearance following the exposure to the specified automotive fluids. This indicates that the composition of the TYC and DEPO lens materials and coatings appears to be appropriate to meet the intent of the FMVSS 108 chemical resistance test.

Humidity Test:

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. One (1) Grand Am and one (1)

Taurus headlamp manufactured by TYC and DEPO were exposed to the humidity test. The TYC Grand Am and TYC Taurus headlamps exhibited condensation on the inside of the lenses following the test. This does not meet the FMVSS 108 requirement.

Vehicle Test Fits

The laboratory photometric and performance test data indicates a high rate of nonconformance to FMVSS 108 requirements. In addition, the independently manufactured Grand Am and Taurus headlamps 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 headlamps. The independently manufactured lamps exhibited excessive gaps, or did not mate with the adjacent vehicle components in the same manner as the original equipment or the OEM original equipment replacements. The variation in vehicle fit may indicate that the independent manufacturers are not appropriately referencing the actual vehicles during their development process.

Conclusion

At least 82% of the independently manufactured replacement headlamps represented in this report failed to conform to the photometric requirements of FMVSS 108. This data was developed by testing ten (10) headlamps from each model and from each manufacturer (i.e. a total of 40 headlamps).

The failure to meet FMVSS 108 photometric requirements may be partially based on the independent manufacturer's misinterpretation of the required aiming features on the headlamps. Aiming devices integrated into a headlamp must be properly used during the photometric tests in order to comply with FMVSS 108 requirements. The high failure rate implies either a misinterpretation or disregard of the proper use of the aiming features of the headlamps in accordance with FMVSS 108.

Grand Am and Taurus headlamps manufactured by TYC exhibited condensation inside the lamp following the FMVSS 108 humidity exposure. This fails the FMVSS 108 requirement.

The Grand Am and Taurus headlamps manufactured by TYC and DEPO were selected for this study since they appeared to be "similar" to the original equipment parts. However, 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, and assembly methods. 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.