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Rear Amber Turn Signal Lamps Confirmation Test – Example Measurements

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16. Abstract This report summarizes an effort to carry out and evaluate a draft test procedure for confirming amber rear turn signal lamp color. The procedure adapts existing test procedures from Federal Motor Vehicle Safety Standard (FMVSS) No. 108, Lamps, reflective devices, and associated equipment, to accommodate testing the lamps as installed on the vehicle. The draft laboratory test procedure consists of measuring the color of the emitted light using a colorimeter and an adaptation of the tristimulus method and chromaticity coordinates as described in FMVSS No. 108. Four vehicles were subjected to the draft test procedure. Two vehicles were confirmed to have amber rear turn signal lamps, one was confirmed to be red, and the fourth was determined to be a color other than amber or red. Overall, the test procedure was found to be easy to carry out and effective in determining turn signal lamp color.			
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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

A 2009 National Highway Traffic Safety Administration report [1] summarized an analysis of the effect of rear turn signal color as a means to reduce the frequency of passenger vehicles crashes. Specifically, an answer was sought as to whether amber or red turn signals were more effective at preventing rear-end crashes in which the lead vehicle was engaged in a maneuver where a turn signal was assumed to be engaged – turning, changing lanes, merging, or parking. The study used State data and a "switch pair" method that considered only vehicles having turn signals that switched signal color, either from red to amber or amber to red across model years. The analysis concluded that amber rear turn signals show a 5.3 percent effectiveness in reducing involvement in two-vehicle crashes where a lead vehicle is rear-ended in the act of turning left, turning right, merging into traffic, changing lanes, or entering/leaving a parking space. The advantage of amber rear turn signal color was shown to be statistically significant.

This report documents testing performed to evaluate a test procedure to confirm the existence of amber rear turn signal lamps. The test is intended to be applicable to passenger vehicles with gross vehicle weight ratings (GVWR) under 10,000 pounds. The test procedure adapts existing test procedures from FMVSS No. 108, Lamps, reflective devices, and associated equipment, to accommodate testing the lamps as installed on the vehicle.

The test procedure involves using the tristimulus method to determine the color of a vehicle's rear turn signal lamps. This method measures the light emitted by the rear turn signal as measured by photoelectric receivers with spectral responses that approximate International Commission on Illumination (CIE) standard spectral tristimulus values. The details of this procedure are specified in FMVSS No. 108, paragraph S14.4.1.4. [2]. The results of this test demonstrate broad differences between red and amber, but cannot be used to determine compliance with FMVSS No. 108. NHTSA cannot, outside the context of an actual compliance proceeding, make a determination of whether particular vehicles fail to comply with a FMVSS.

2.0 METHOD

The test method evaluated consists of measuring the color of the light emitted by the rear turn signals of a production light vehicle. Measurements are made using a colorimeter and an adaptation of the tristimulus method and chromaticity coordinates as described in FMVSS No. 108 [2]. A summary of the test procedure is provided below.

2.1 Photographic Documentation

Still, color photographs were taken of each vehicle tested including the following views.

- Vehicle exterior, driver's side
- Vehicle exterior, oblique passenger's side/rear view
- Rear turn signal or combination lamp, close-up
- Rear turn signal, illuminated
- Dealer's window sticker
- Manufacturer's label
- Tire placard

2.2 Test Vehicle Preparation

Per the draft test procedure, each vehicle was prepared for testing by ensuring that the vehicle's hood, trunk, and all doors were closed and the rear turn signal lamp lenses were wiped clean.

2.3 Equipment

Measurements were made using a Konica-Minolta CL-200A chroma meter.

2.4 Measurement Procedure

For this effort, measurements were made indoors in a temperature-controlled laboratory setting. Overhead lighting was turned off during measurements to achieve an ambient illumination level of less than 0.20 lux. Rear turn signal color was measured two to three times for each vehicle. Individual measurements for a particular vehicle were taken on separate days. Vehicle turn signal lamps were tested for color in accordance with tristimulus method outlined below.

2.4.1 Tristimulus Method Procedure

Per the draft test procedure, the tristimulus method was used to determine the color of a vehicle's rear turn signal lamps. This method measures the light emitted by the rear turn signal as measured by photoelectric receivers with spectral responses that approximate CIE standard spectral tristimulus values. The details of this procedure are specified in FMVSS No. 108, paragraph S14.4.1.4. To determine the color of the vehicle's rear turn signal the general test procedure in FMVSS No. 108, paragraph S14.4, was followed:

> With the vehicle placed in park and the vehicular hazard warning signal operating unit engaged so that both rear turn signals flash, the color of light from the rear turn signal device must be measured by photoelectric receivers with spectral responses that approximate CIE standard spectral tristimulus values.

2.4.2 Tristimulus Method Performance Requirements

The color of light as expressed by the chromaticity coordinates according to the CIE 1931 Standard Colorimetric System, described in the CIE 1931 Chromaticity Diagram (and FMVSS No. 108 Figure 1) must fall within the following boundaries.

Red

y = 0.33 (yellow boundary)

y = 0.98 – x (purple boundary)

Yellow (Amber)

y= 0.39 (red boundary)

y = x – 0.12 (green boundary)

y = 0.79 – 0.67x (white boundary)

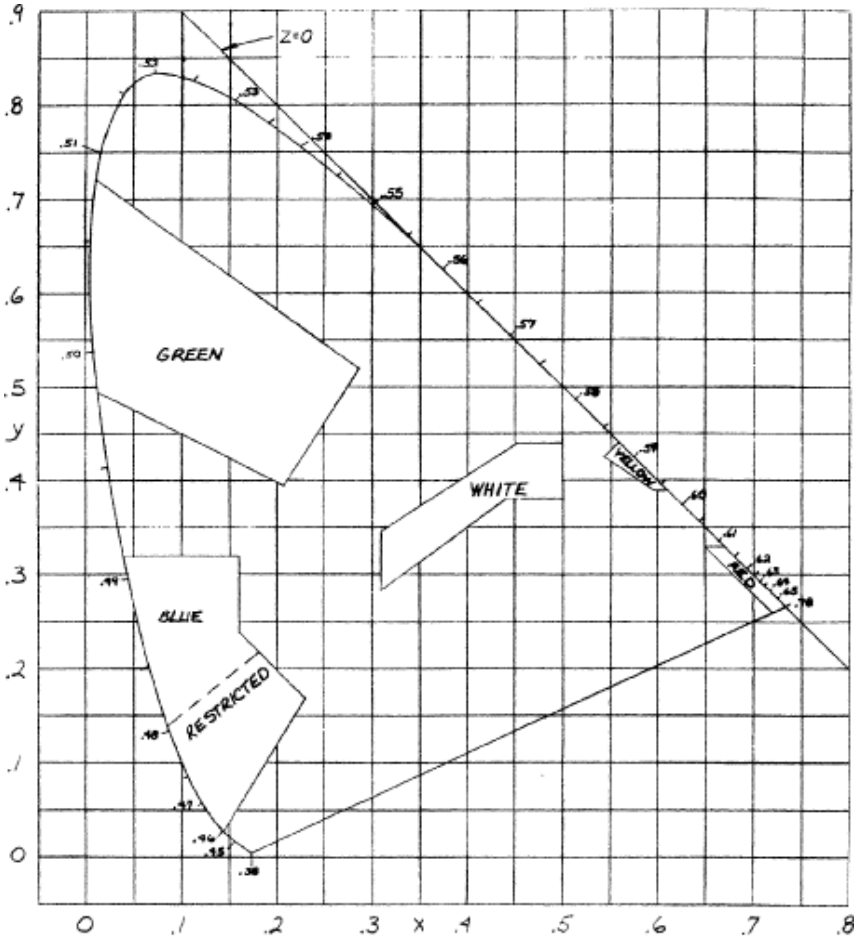

Figure 1. FMVSS No. 108 Figure 1 Chromaticity Diagram

3.0 RESULTS

The following sections presents the rear turn signal color measurement results for the stated vehicles. All vehicles measured had colored turn signal bulbs with clear lenses. No vehicles having amber-colored rear turn signal lenses were tested.

Vehicles examined in this effort are listed in Table 1.

Table 1. Vehicles Examined

Vehicle Model Info	Mileage	Light Source Type
2012 Mercedes S400 Hybrid	<500	LEDs
2016 Nissan Rogue	<100	Bulb
2015 Subaru Legacy	2,064	Bulb
2016 Chevrolet Malibu	<100	LEDs

3.1 2012 Mercedes S400 Hybrid

3.1.1 Vehicle Photos

Still, color photographs of the measured 2012 Mercedes S400 Hybrid are presented in the Figures 2 to 5. Photos of the vehicle's window sticker, manufacturing label, and tire placard are shown in Figures 6 to 8.

Figure 2. 2012 Mercedes S400 Hybrid - Driver's Side

Figure 3. 2012 Mercedes S400 Hybrid - Oblique Passenger's Side/Rear View

Figure 4. 2012 Mercedes S400 Hybrid - Rear Combination Lamp, Close-up

Figure 5. 2012 Mercedes S400 Hybrid - Rear Turn Signal Illuminated, Close-up

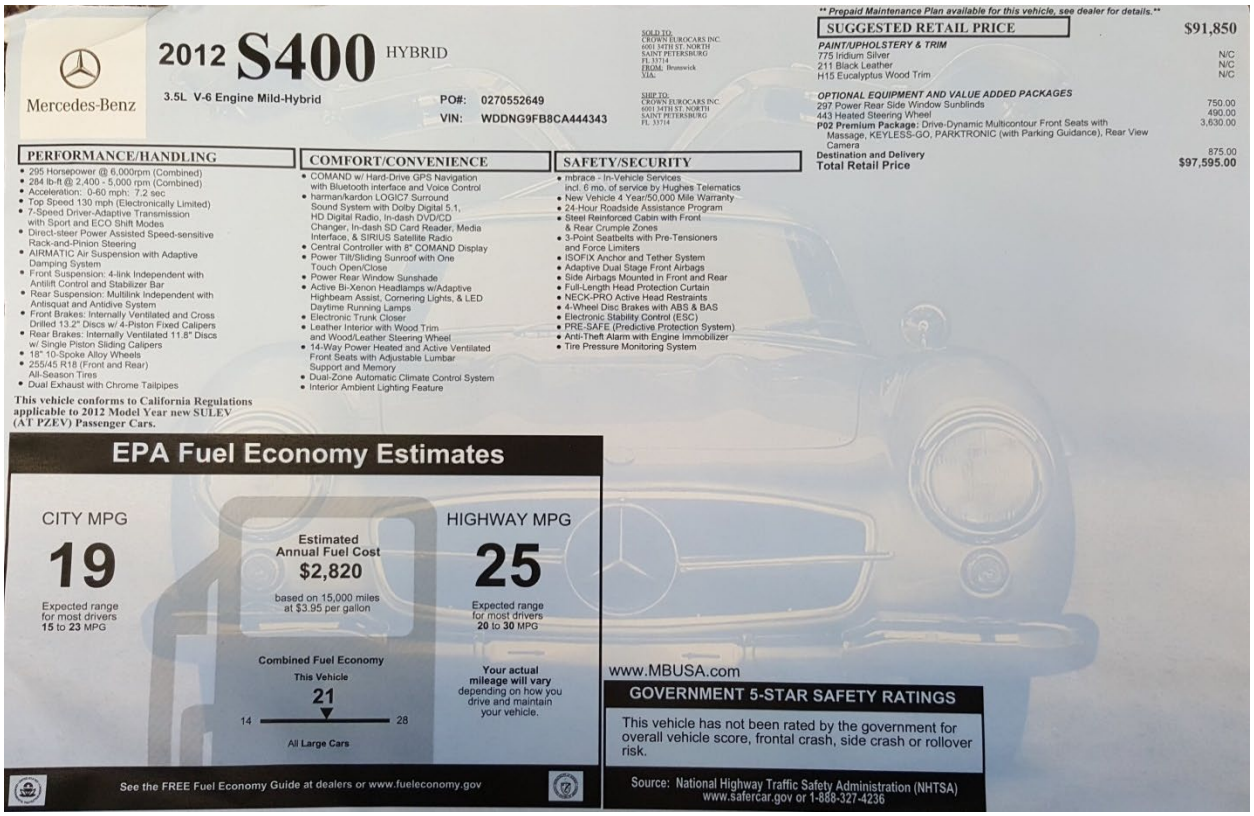

Figure 6. 2012 Mercedes S400 Hybrid - Window Sticker

Figure 7. 2012 Mercedes S400 Hybrid - Manufacturer's Label

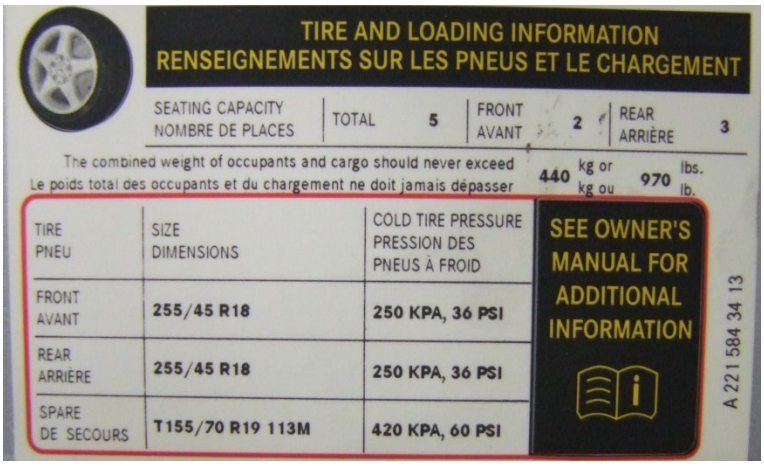

Figure 8. 2012 Mercedes S400 Hybrid - Tire Placard

3.1.2 Turn Signal Color Measurement Results

Rear turn signal color measurements and an average value for the 2012 Mercedes S400 Hybrid are provided in Table 2.

Table 2. Summary of Rear Turn Signal Color Measurement Data for 2012 Mercedes S400

Trial	x	y
1	0.5519	0.4468
2	0.5545	0.4443
3	0.5579	0.4408
Average:	0.5548	0.4440

The following figure shows the measured values from all trials for this vehicle overlaid on the CIE 1931 Chromaticity Diagram (and FMVSS No. 108 Figure 1). All three measurement trial results were outside both the amber and red color boundaries.

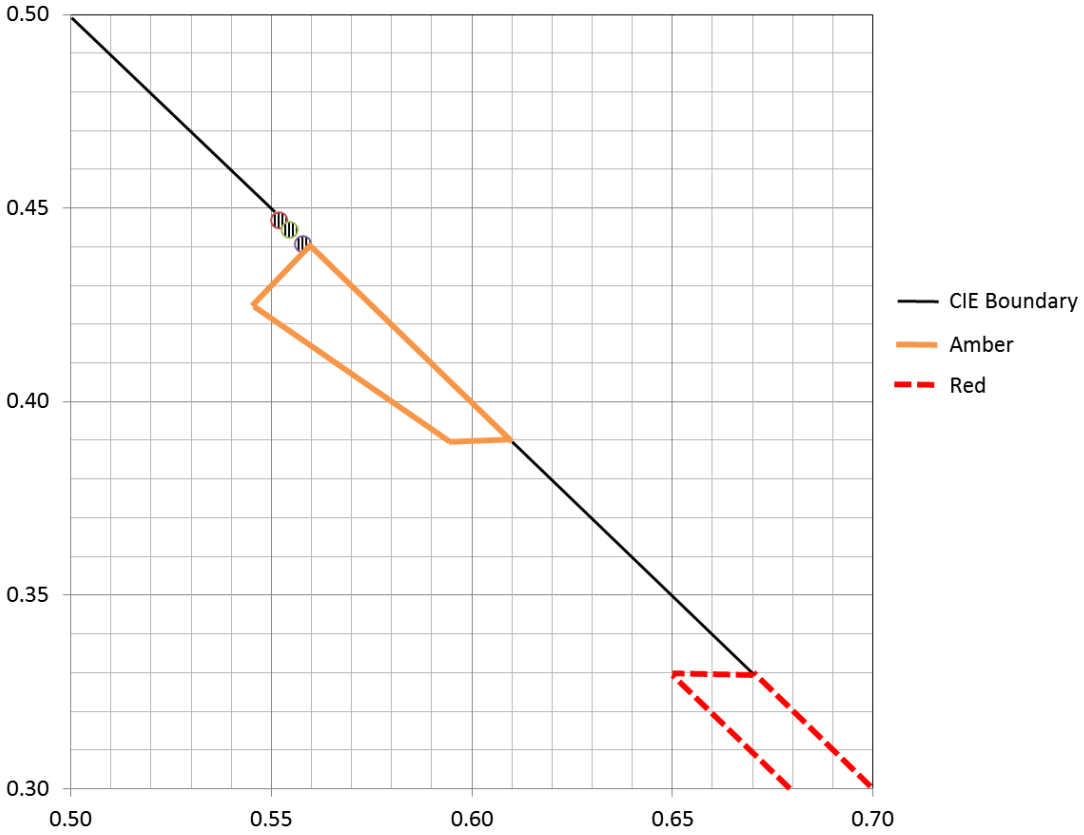

Figure 9. Plot of 3 data points for 2012 Mercedes S400 Hybrid

3.2 2016 Nissan Rogue

3.2.1 Vehicle Photos

Still, color photographs of the measured 2016 Nissan Rogue are presented in the Figures 10 to 13. Photos of the vehicle's manufacturing label, and tire placard are shown in Figures 6 to 8.

Figure 10. 2016 Nissan Rogue - Driver's Side

Figure 11. 2016 Nissan Rogue - Oblique Passenger's Side/Rear View

Figure 12. 2016 Nissan Rogue - Rear Combination Lamp, Close-up

Figure 13. 2016 Nissan Rogue - Rear Turn Signal Illuminated, Close-up

Figure 14. 2016 Nissan Rogue - Manufacturer's Label

Figure 15. 2016 Nissan Rogue - Tire Placard

3.2.2 Turn Signal Color Measurement Results

Rear turn signal color measurements and an average value for the 2016 Nissan Rogue are provided in Table 3.

Table 3. Summary of Rear Turn Signal Color Measurement Data for 2016 Nissan Rogue

Trial	x	y
1	0.5801	0.4137
2	0.5751	0.4181
3	0.5796	0.4181
Average:	0.5783	0.4166

Figure 16 shows the measured chromaticity values from all trials for this vehicle. All three measurement trial values were within the amber color boundary.

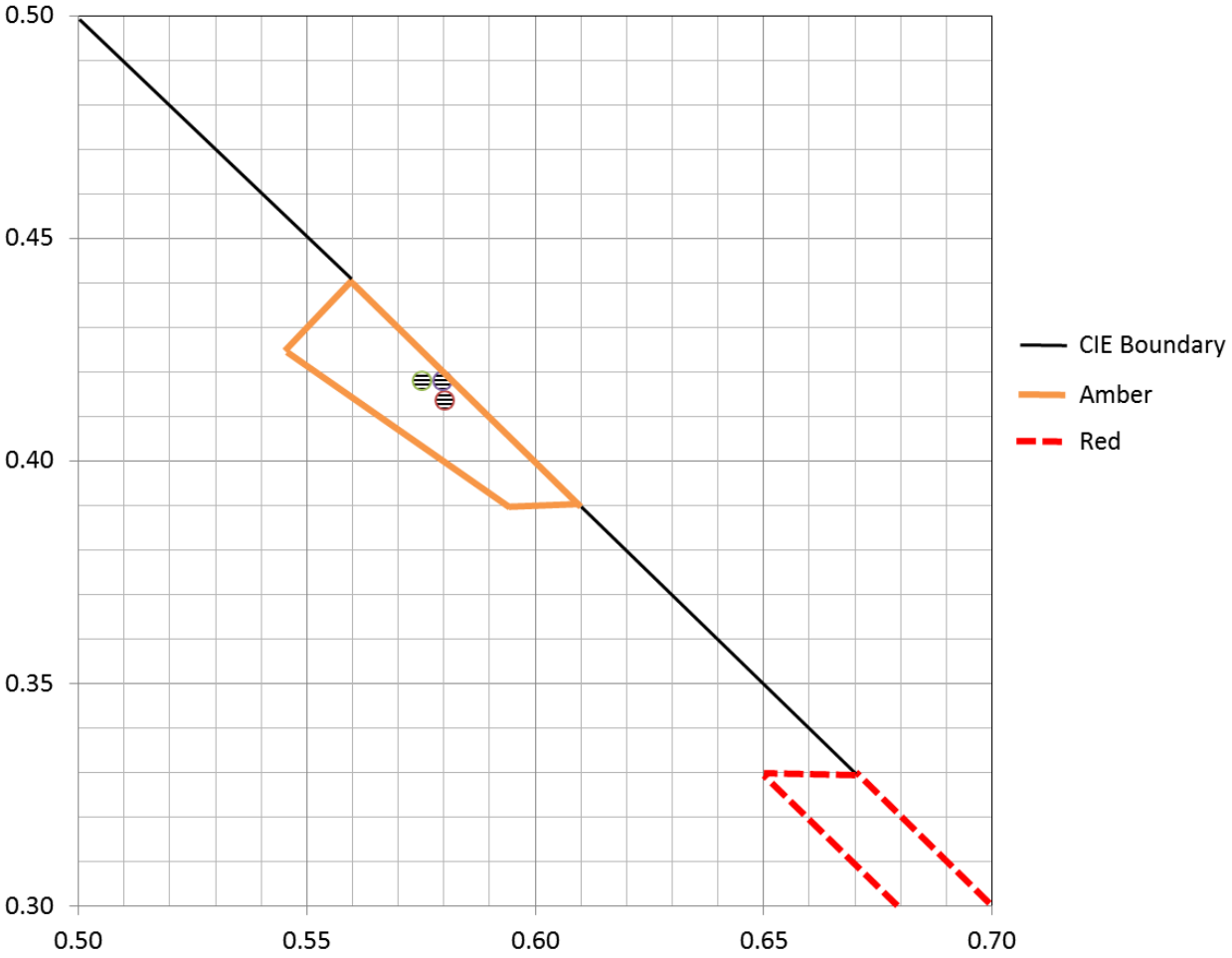

Figure 16. Plot of 3 data points for 2016 Nissan Rogue

3.3 2015 Subaru Legacy

3.3.1 Vehicle Photos

Still, color photographs of the measured 2015 Subaru Legacy are presented in Figures 17 to 20. Photos of the vehicle's manufacturing label, and tire placard are shown in Figures 21 to 22.

Figure 17. 2015 Subaru Legacy - Driver's Side

Figure 18. 2015 Subaru Legacy - Oblique Passenger's Side/Rear View

Figure 19. 2015 Subaru Legacy - Rear Combination Lamp, Close-up

Figure 20. 2015 Subaru Legacy - Rear Turn Signal Illuminated, Close-up

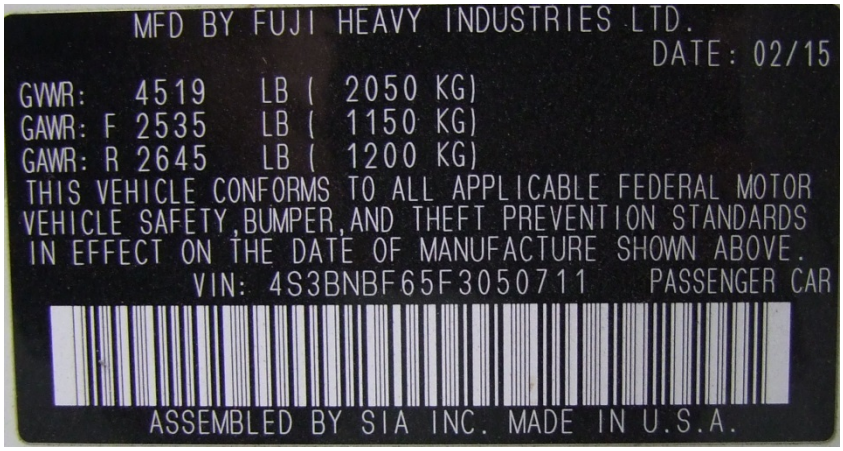

Figure 21. 2015 Subaru Legacy - Manufacturer's Label

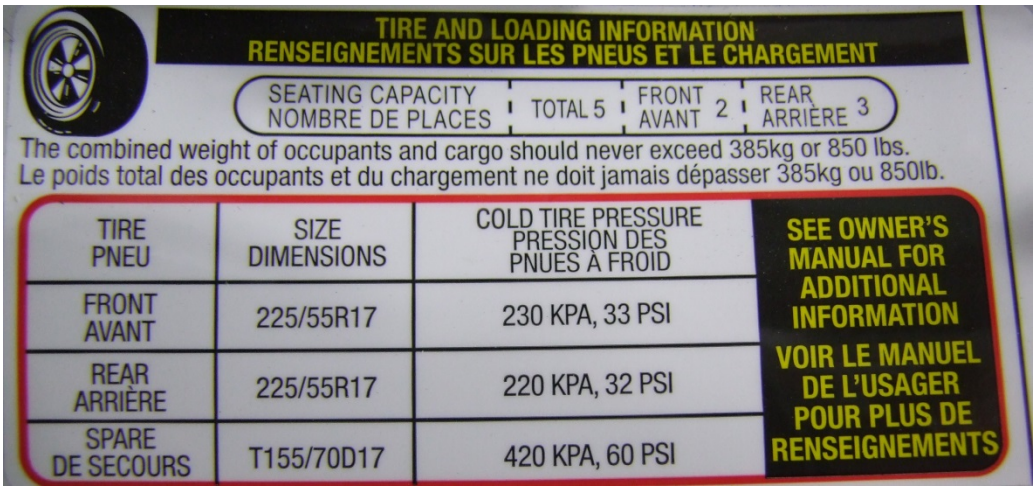

Figure 22. 2015 Subaru Legacy - Tire Placard

3.3.2 Turn Signal Color Measurement Results

Rear turn signal color measurements and an average value for the 2015 Subaru Legacy are provided in the following table.

Table 4. Summary of Rear Turn Signal Color Measurement Data for 2015 Subaru Legacy.

Trial	x	y
1	0.5662	0.4252
2	0.5838	0.4064
3	0.5684	0.4236
Average:	0.5728	0.4184

Figure 23 shows the measured values from all trials for this vehicle overlaid on the CIE 1931 Chromaticity Diagram (and FMVSS No. 108 Figure 1). All three measurement trial values were within the amber color boundary.

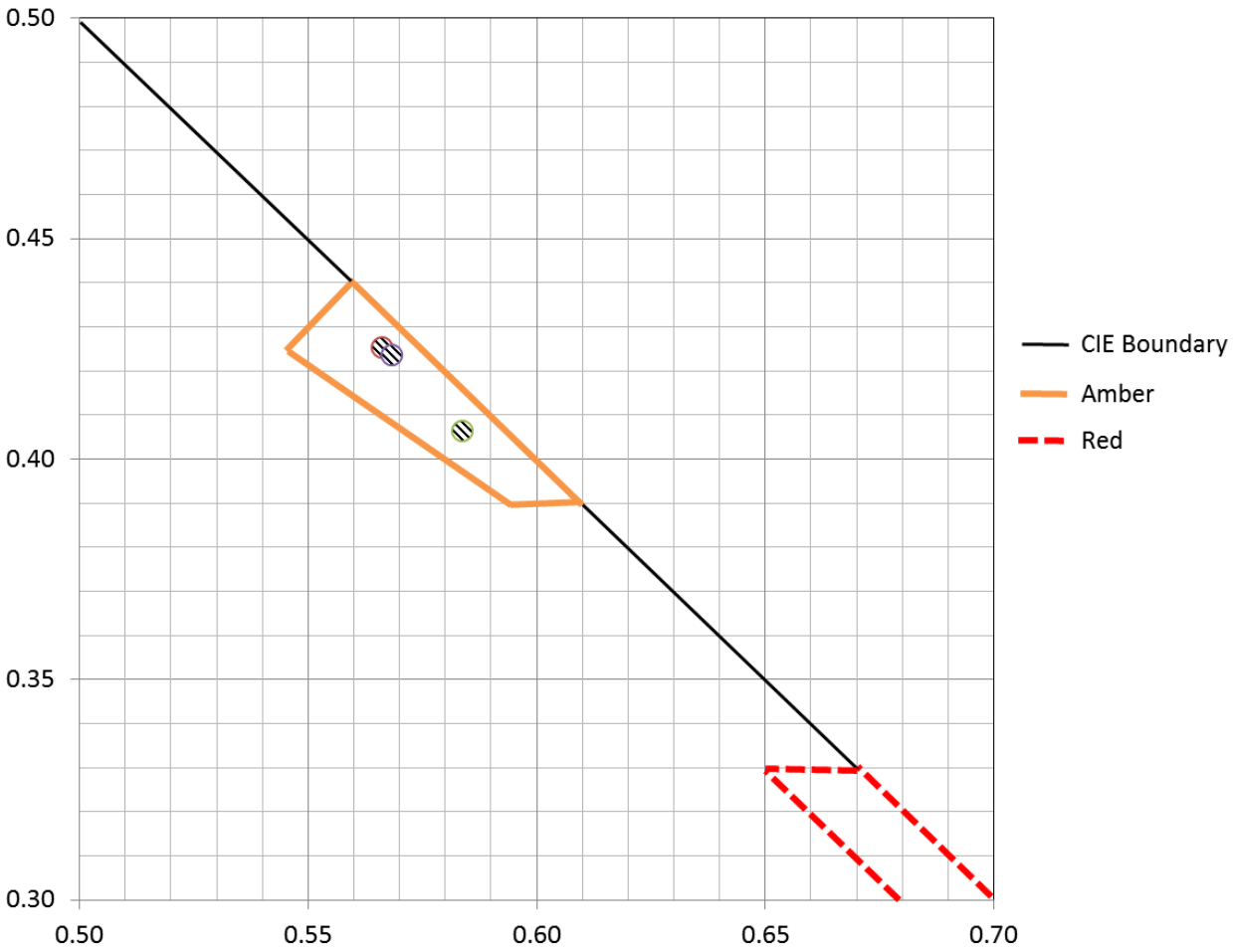

Figure 23. Plot of 3 data points for 2015 Subaru Legacy

3.4 2016 Chevrolet Malibu

3.4.1 Vehicle Photos

Still, color photographs of the measured 2016 Chevrolet Malibu are presented in Figures 24 to 27. Photos of the vehicle's window sticker, manufacturing label, and tire placard are shown in Figures 28 to 30.

Figure 24. 2016 Chevrolet Malibu - Driver's Side

Figure 25. 2016 Chevrolet Malibu - Oblique Passenger's Side/Rear View

Figure 26. 2016 Chevrolet Malibu - Rear Combination Lamp, Close-up

Figure 27. 2016 Chevrolet Malibu - Rear Turn Signal Illuminated, Close-up

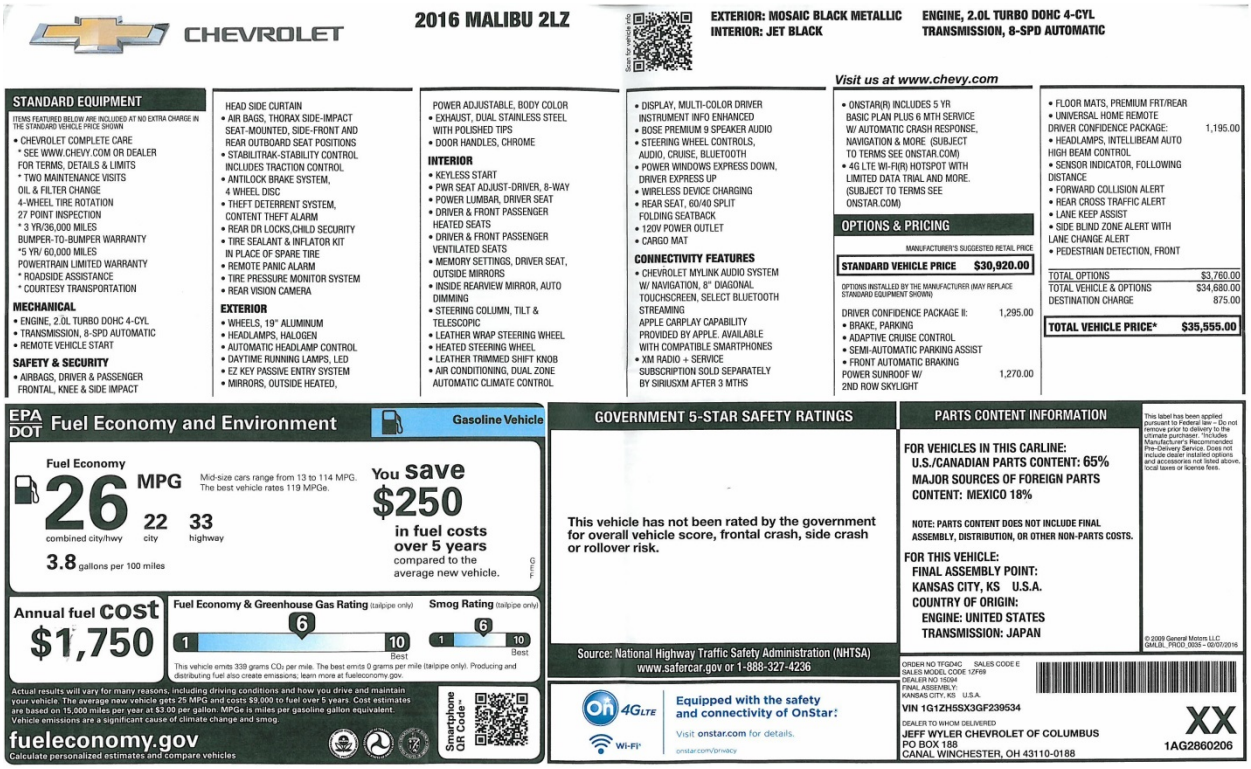

Figure 28. 2016 Chevrolet Malibu - Dealer's Sticker

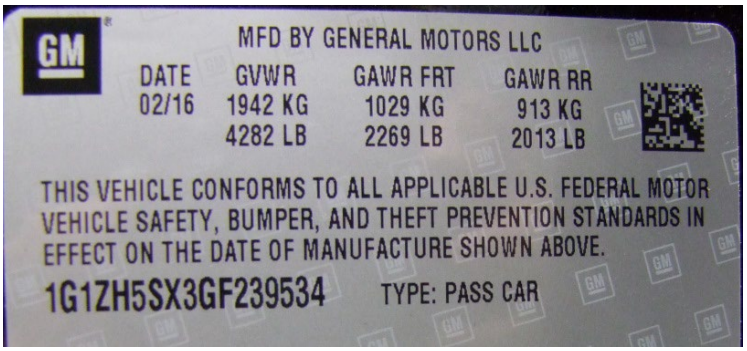

Figure 29. 2016 Chevrolet Malibu - Manufacturer's Label

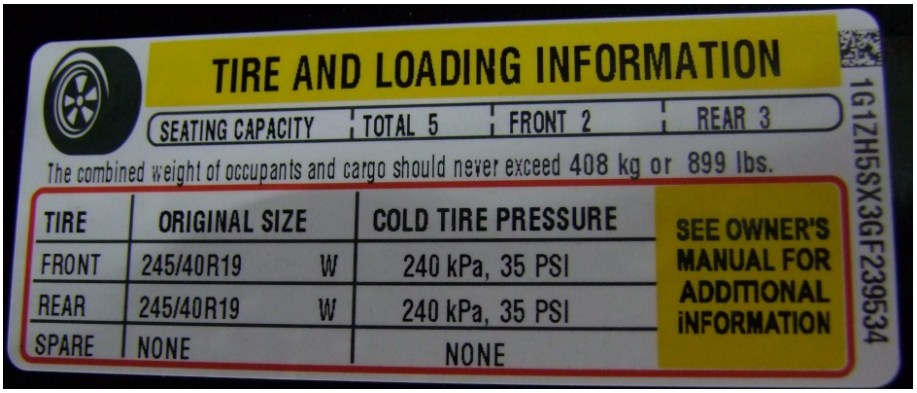

Figure 30. 2016 Chevrolet Malibu - Tire Placard

3.4.2 Turn Signal Color Measurement Results

Rear turn signal color measurements and an average value for the 2016 Chevrolet Malibu are provided in Table 5.

Table 5. Summary of Rear Turn Signal Color Measurement Data for 2016 Chevrolet Malibu

Trial	x	y
1	0.6811	0.3184
2	0.6908	0.3089
Average:	0.6860	0.3137

The following figure shows the measured values from all trials for this vehicle overlaid on the CIE 1931 Chromaticity Diagram (and FMVSS No. 108 Figure 1). All three measurement trial values were outside the amber color boundary.

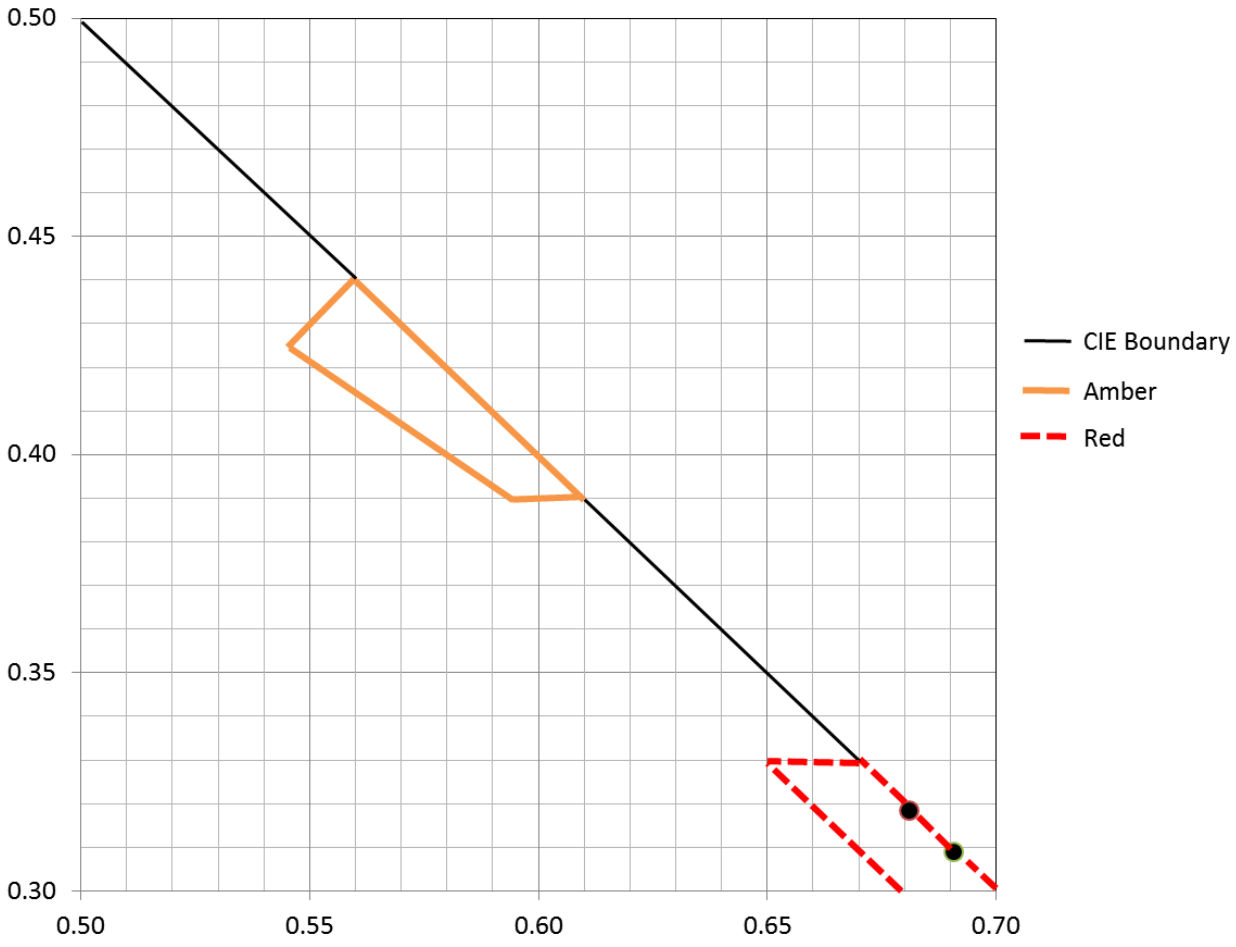

Figure 31. Plot of 2 data points for 2016 Chevrolet Malibu

4.0 SUMMARY

This report summarizes an effort to evaluate a test procedure for confirming the color of rear turn signal lamps on a production light vehicle. The draft laboratory test procedure consists of measuring the color of the light emitted by a vehicle turn signal lamp using a colorimeter and an adaptation of the tristimulus method and chromaticity coordinates as described in FMVSS No. 108. The results of this test demonstrate broad differences between the color red and amber but cannot be used to determine compliance with FMVSS No. 108.

Four vehicles were subjected to the draft test procedure. Rear turn signal lamps were determined to be amber in color for two vehicles, red for the third vehicle, and a color other than amber or red for the fourth vehicle. Figure 32 summarizes these results. Overall, the test procedure was found to be easy to carry out and effective in determining turn signal lamp color.

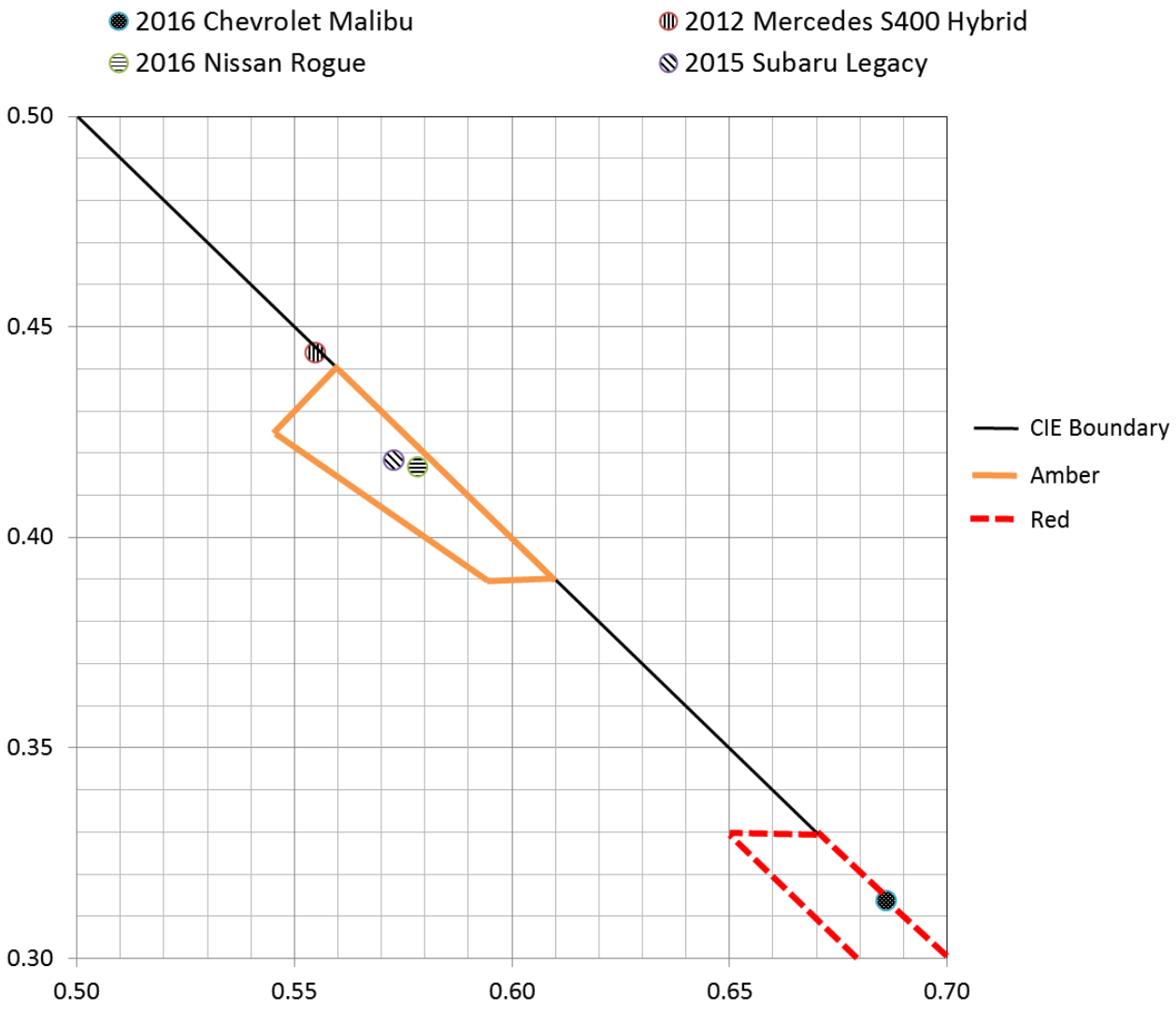

Figure 32. Summary Plot of Turn Signal Color Measurement Average Values by Vehicle

5.0 REFERENCES

1. Allen, K. (2009, April). The effectiveness of amber rear turn signals for reducing rear impacts (Report No. DOT HS 811 115). Washington, DC: National Highway Traffic Safety Administration.

2. 49 CFR Sec. 571.108, Standard No. 108; Lamps, reflective devices, and associated equipment.

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