



# **Autonomous Emergency Braking Test Protocol (Version I)**

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## AUTONOMOUS EMERGENCY BRAKING TEST PROTOCOL (VERSION I)

This document describes the Insurance Institute for Highway Safety (IIHS) autonomous emergency braking test protocol and is available from the technical protocols section of the IIHS website (<http://www.iihs.org/iihs/ratings/technical-information/technical-protocols>).

### DOCUMENT REVISION HISTORY

There are no previous versions of this document.

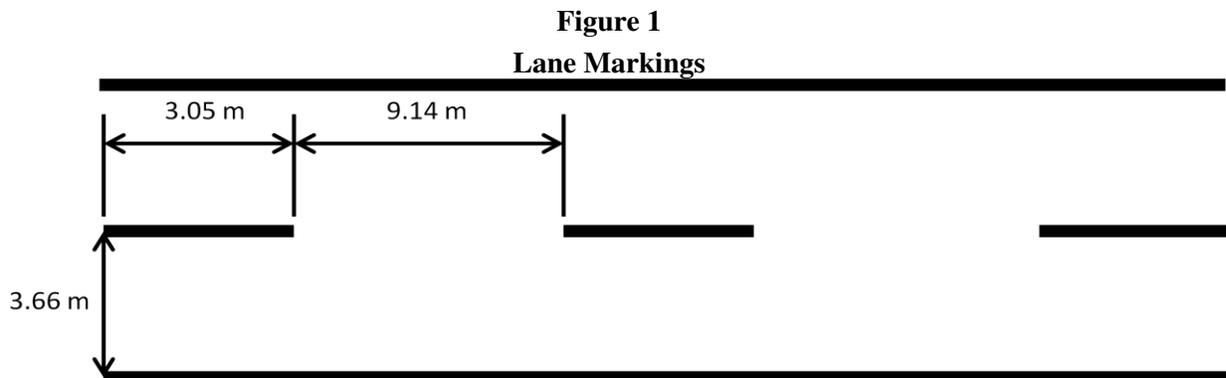
### SUMMARY

This protocol describes the test procedure for establishing the presence on passenger vehicles of autonomous emergency braking (AEB) systems with performance similar to those that have been documented as helping drivers avoid collisions with other vehicles (Highway Loss Data Institute, 2011; IIHS, 2012). The test procedure is based on a potential front-to-rear collision in which the struck vehicle is not moving prior to impact. The stationary vehicle in the test is replaced with an impactable target representing a car. Performance requirements are based on the test vehicle's ability to avoid or mitigate crashes at 20 and 40 km/h.

### TEST ENVIRONMENT

#### Surface and Markings

Tests are conducted on a dry asphalt surface without visible moisture. The surface is straight and flat, with a 1 percent lateral slope for water management. The asphalt is in good condition, free of potholes, bumps, and/or cracks that could cause the test vehicle to pitch excessively. Testing is conducted in the right lane of a two-lane roadway (Figure 1). The roadway is marked with continuous solid white lane markers on the outside and dashed white lane markers in the center. The lane widths are 3.66 m (12 ft), and the dashed lines are 3.05 m (10 ft) in length separated by 9.14 m (30 ft). The width of the lines is 0.1 m (4 in).



#### Surroundings

During testing, no other vehicles, obstructions, or other objects may be within a distance of 3 m on either side of the test path or any closer than 25 m from the stationary test target. Overhead signs, bridges, gantries, or other significant structures within the lane must be more than 5 m above the ground.

## Ambient Conditions

Testing is not conducted during periods of inclement weather. This includes, but is not limited to, rain, snow, hail, fog, smoke, and/or ash. The ambient air temperature must be between 32 and 100 degrees Fahrenheit during testing. Peak wind speeds shall be below 10 m/s to minimize car target and test vehicle disturbance. Natural ambient illumination must be in excess of 2000 lux as measured in a plane parallel to the asphalt surface. The sun altitude, as measured in degrees from the horizon, should not be less than 15 degrees while testing is performed.

During testing, ambient temperature, ambient illumination, wind speed, and wind direction, are measured and recorded at 1-minute intervals.

## TARGET VEHICLE

### Stationary Target System for AEB Testing

The ADAC Advanced Emergency Braking System (AEBS), which is produced by Messring Systembau GmbH, is used as the stationary target (<http://www.messring.de/test-facilities-and-components/adac/>). The stationary carriage and balloon car are shown in Figure 2. The balloon car is equipped with a U.S.-specific license plate. At the beginning of testing, the target will be inflated to 250 mbar and maintained at that pressure throughout testing. The target cover should also be free of wrinkles during testing.

**Figure 2**  
**ADAC Advanced Emergency Braking System Stationary Target**



## TEST VEHICLE PREPARATION

### General

Tests shall be undertaken using a new vehicle in the “as received” condition with accumulated mileage between 200 and 5,000 miles indicated on the odometer. Prior to commencing preparation and testing ensure that:

1. The tires are new, original equipment tires inflated to the manufacturer’s recommended cold inflation pressure. If more than one recommendation is provided, the tires are inflated to the lightly loaded condition.
2. The fuel tank is filled to at least 90 percent of capacity with the appropriate fuel and maintained to at least 75 percent capacity throughout the testing.

3. All other fluid reservoirs are filled to at least their minimum indicated levels.
4. The vehicle will include the driver and all required equipment during testing. Where possible, the equipment shall be placed on the passenger side of the vehicle. The vehicle test weight should not exceed the vehicle curb weight by more than 200 kg.

## Instrumentation

The test vehicle will be equipped with an Oxford RT2002 Inertial and GPS Navigation System to measure and record speed, longitudinal and lateral acceleration, longitudinal and lateral position, and yaw velocity. These data will be sampled and recorded at a frequency of 100 Hz. Accelerator pedal position and steering wheel angle will be obtained and recorded from the vehicle onboard diagnostics port.

A Racelogic Video VBOX Pro will be used to overlay data obtained from the Oxford RT2002 onto a video image recorded using a 30 fps camera. One camera will be positioned with a driver perspective out of the front windshield. If necessary, a second camera will be used to show the forward collision warning.

**Table 1**  
**Test Vehicle Instrumentation**

Measurement	Equipment	Accuracy
Speed	Oxford RT2002 GPS	0.1 km/h
Longitudinal and lateral acceleration	Oxford RT2002 GPS	0.01 m/s <sup>2</sup>
Longitudinal and lateral position	Oxford RT2002 GPS	0.02 m
Yaw rate	Oxford RT2002 GPS	0.02 %/s
Accelerator pedal position	OBDII	1.0% of full travel
Steering wheel angle	OBDII	1.0°
Impact time	Oxford RT2002 GPS	n/a

## TEST VEHICLE PRE-TEST CONDITIONING

### AEB System Setting

Autonomous braking systems that have different settings for the timing of the braking application will be set to default or normal setting.

### Brake Warm-Up and Maintenance

Before testing, 10 stops will be performed from a speed of 56 km/h with an average deceleration of approximately 0.5 to 0.6 g. Immediately following the series of 56 km/h stops, three additional stops will be performed from a speed of 72 km/h with sufficient brake pedal force to activate the vehicle's antilock braking system (ABS) for the majority of each stop. Following the series of 72 km/h stops, the vehicle will be driven at a speed of 72 km/h for 5 minutes to cool the brakes. At any point during testing, if the test vehicle remains stationary for longer than 15 minutes, a series of three brake stops shall be performed from a speed of 72 km/h to warm the brakes. The longitudinal deceleration of these stops should be roughly 0.7 g. During testing, a minimum of 3 minutes must elapse between the completion of the last warm-up stop and the onset of a valid test trial and/or between the completion of each individual test run.

## **AEB Initialization**

Before AEB system performance can be properly assessed, some vehicles require a brief period of initialization. During this time, diagnostics to verify functionality and sensor calibrations are performed. If system initialization is required, IIHS will obtain and perform the appropriate procedure from the vehicle manufacturer.

## **STATIONARY TARGET TEST**

### **Target Vehicle Placement**

The target vehicle shall be positioned in the center of a travel lane, with its longitudinal axis oriented parallel to the roadway edge, facing the same direction as the front of the test vehicle, so that the test vehicle approaches the rear of the target vehicle.

### **Impact Point**

The impact point is measured when the forward-most location of the test vehicle makes contact with the target vehicle. The position of the target vehicle should be easily reproducible for multiple tests.

### **Test Vehicle Speed**

Tests against the stationary target vehicle are conducted at 20 and 40 km/h.

### **AEB Activation**

The point at which vehicle longitudinal deceleration reaches  $0.5 \text{ m/s}^2$  will be considered the start of AEB.

### **Test Vehicle Approach**

At the start of each test, the test vehicle will begin moving between 150 and 200 m from the stationary target vehicle and slowly accelerate towards the target. For the 20 and 40 km/h tests, the approach phase begins 30 and 60 m before the target vehicle, respectively. For both tests, the approach phase ends when the test vehicle impacts the target or the test vehicle comes to a stop before making impact with the target. During the approach phase, the driver shall do the following:

- Modulate the throttle using smooth inputs to maintain the nominal test speed,
- Use the least amount of steering input necessary to maintain the test vehicle in the center of the lane,
- Avoid the use of abrupt steering inputs or corrections, and;
- Not contact to the brake pedal

In order for the test to be considered valid, the following criteria must be met during the approach phase:

- The vehicle speed shall remain within  $\pm 1.0 \text{ km/h}$  of the nominal test speed until impact with the target or activation of autonomous braking,
- The yaw rate must remain within the range of  $\pm 1 \text{ }^\circ/\text{s}$ ,
- The lateral distance between the centerline of the test vehicle relative to the centerline of the target shall not exceed  $\pm 0.3 \text{ m}$ , and;
- The accelerator pedal position must not fluctuate by more than  $\pm 5.0$  percent of the full travel from the original pedal position at the start of the valid approach phase.

## **Test Trials**

A minimum of five valid runs should be performed at each test speed. The overall speed reduction will be calculated based on the average of all valid test runs.

## **Calculating AEB Speed Reduction**

Speed reduction is calculated by subtracting the test vehicle speed at the time of impact from the test vehicle speed prior to AEB activation. The test vehicle speed before AEB activation will be calculated based on the average speed for 0.1 second prior to AEB activation. If the test vehicle does not contact the target, the impact speed is considered to be zero.

## **DATA ANALYSIS**

### **Accelerator Pedal Position**

The accelerator pedal position will be measured as a percentage of the full accelerator pedal travel.

### **Lateral and Longitudinal Position**

The lateral and longitudinal position will be measured in meters, and the raw data will be used to evaluate the vehicle position.

### **Longitudinal Acceleration**

Longitudinal acceleration will be measured with an accelerometer in  $\text{m/s}^2$ . The raw data is digitally filtered with a 12-pole phaseless Butterworth filter with a cutoff frequency of 6 Hz.

### **Speed**

The speed will be measured in km/h, and the raw data will be used to evaluate speed.

### **Car Target Impact Point**

The impact point is measured by the Oxford System. The “zero” location will be at the point where the test vehicle makes initial contact with the target vehicle. A tape switch may be used to verify impact at the “zero” location.

### **Yaw Rate**

The yaw rate will be measured in degrees per second. The raw data is digitally filtered with a 12-pole phaseless Butterworth filter with a cutoff frequency of 6 Hz.

## **REFERENCES**

Highway Loss Data Institute. 2011. Volvo City Safety loss experience: initial results. *Loss Bulletin* 28(6). Arlington, VA.

Insurance Institute for Highway Safety. 2012. They're working: insurance claims data show which new technologies are preventing crashes. *Status Report* 47(5):1-7.