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DEPARTMENT OF TRANSPORTATION

National Highway Traffic Safety Administration

49 CFR Parts 571, 595, and 596

[Docket No. NHTSA-2023-0021]

RIN 2127-AM37

Federal Motor Vehicle Safety Standards; Automatic Emergency Braking Systems for Light Vehicles

AGENCY: National Highway Traffic Safety Administration (NHTSA), Department of Transportation (DOT).

ACTION: Final rule.

SUMMARY: This final rule adopts a new Federal Motor Vehicle Safety Standard to require automatic emergency braking (AEB), including pedestrian AEB (PAEB), systems on light vehicles. An AEB system uses various sensor technologies and sub-systems that work together to detect when the vehicle is in a crash imminent situation, to automatically apply the vehicle brakes if the driver has not done so, or to apply more braking force to supplement the driver's braking. This final rule specifies that an AEB system must detect and react to an imminent crash with both a lead vehicle or a pedestrian. This final rule fulfills a mandate under the Bipartisan Infrastructure Law (BIL) directing the Department to promulgate a rule to require that all passenger vehicles be equipped with an AEB system. The purpose of this final rule is to reduce the number of deaths and injuries that result from crashes in which drivers do not apply the brakes or fail to apply sufficient braking power to avoid or mitigate a crash, and to reduce the consequences of such crashes.

DATES: *Effective Date*: This rule is effective **[INSERT DATE 60 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER]**.

IBR date: The incorporation by reference of certain material listed in the rule is approved by the Director of the *Federal Register* beginning [**INSERT DATE 60 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER].** The incorporation by reference of certain other material listed in the rule was approved by the Director of the Federal Register as of July 8, 2022.

Compliance Date: September 1, 2029. However, vehicles produced by small-volume manufacturers, final-stage manufacturers, and alterers must be equipped with a compliant AEB system by September 1, 2030.

Petitions for reconsideration: Petitions for reconsideration of this final rule must be received not later than **[INSERT DATE 45 DAYS AFTER PUBLICATION IN THE FEDERAL REGISTER]**.

ADDRESSES: Petitions for reconsideration of this final rule must refer to the docket number set forth above (NHTSA-2023-0021) and be submitted to the Administrator, National Highway Traffic Safety Administration, 1200 New Jersey Avenue, S.E., Washington, DC 20590.

FOR FURTHER INFORMATION CONTACT:

For technical issues: Mr. Markus Price, Office of Crash Avoidance Rulemaking, Telephone: 202-366-1810, Facsimile: 202-366-7002. For legal issues: Ms. Sara R. Bennett, Office of the Chief Counsel, Telephone: 202-366-2992, Facsimile: 202-366-3820. The mailing address for these officials is: National Highway Traffic Safety Administration, 1200 New Jersey Avenue, S.E., Washington, DC 20590.

SUPPLEMENTARY INFORMATION:

This final rule adopts a new Federal Motor Vehicle Safety Standard (FMVSS) No. 127 to require automatic emergency braking (AEB), including pedestrian AEB (PAEB), systems on light vehicles. FMVSS No. 127 applies to all passenger cars and to all multipurpose passenger vehicles (MPVs), trucks, and buses with a gross vehicle weight rating (GVWR) of 4,536 kilograms (kg) (10,000 pounds (lbs.)) or less ("light vehicles"). An AEB system uses various sensor technologies and sub-systems that work together to detect when the vehicle is in a crash imminent situation, to automatically apply the vehicle brakes if the driver has not done so, or to apply more braking force to supplement the driver's braking.

This final rule specifies that an AEB system must detect and react to an imminent crash with both a lead vehicle and a pedestrian. This final rule advances DOT's January 2022 National Roadway Safety Strategy, which identified a requirement for AEB, including PAEB technologies, on new passenger vehicles as a key Departmental action to improve vehicle and pedestrian safety. Finally, this final rule fulfills section 24208(a) of BIL, which directs the Secretary of Transportation to promulgate a rule to require that all passenger vehicles be equipped with an AEB system.

NHTSA published the notice of proposed rulemaking preceding this final rule on June 13, 2023 (88 FR 38632).

Table of Contents

I. Executive Summary

In 2019, prior to the COVID-19 pandemic, there were nearly 2.2 million rear-end police-reported crashes involving light vehicles, which led to 1,798 deaths and 574,000 injuries. In addition, there were 6,272 pedestrian fatalities in motor vehicle crashes, representing 17 percent of all motor vehicle fatalities.[1] This represents the continuation of the recent trend of increased pedestrian deaths on our nation's roadways.[2] A further 76,000 pedestrians were injured in motor vehicle crashes. Deaths and injuries in more recent years are even greater.

NHTSA is issuing this final rule to address these significant safety problems through a new Federal Motor Vehicle Safety Standard that requires all light vehicles be equipped with forward collision warning (FCW),[3] automatic emergency braking (AEB), and pedestrian

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[1] https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813079 Pedestrian Traffic Facts 2019 Data, May 2021.
[2] *Id.*, Table 1 Pedestrian fatalities 2010 – 4,302, 2019 – 6,272.
[3] A forward collision warning (FCW) system uses sensors that detect objects in front of vehicles and provides an alert to the driver. An FCW system is able to use the sensors' input to determine the speed of an object in front of it and the distance between the vehicle and the object. If the FCW system determines that the closing distance and velocity between the vehicle and the object is such that a collision may be imminent, the system is designed to induce an immediate forward crash avoidance response by the vehicle operator. FCW systems may detect impending collisions with any number of roadway obstacles, including vehicles and pedestrians. Warning systems in use today provide drivers with a visual warning signal, such as an illuminated telltale on or near the instrument panel, an auditory signal, or a haptic signal that provides tactile feedback to the driver to warn the driver of an impending collision so the driver may intervene. FCW systems alone do not brake the vehicle.

automatic emergency braking (PAEB) technology.[4] AEB systems reduce the frequency and severity of lead vehicle and pedestrian collisions. They employ sensor technologies and sub-systems that work together to sense when the vehicle is in a crash imminent situation, to automatically apply the vehicle brakes if the driver has not done so, and to apply more braking force to supplement the driver's braking. These systems can reduce both lead vehicle rear-end (lead vehicle AEB) and pedestrian (PAEB) crashes. AEB systems have reached a level of maturity to make a significant contribution to reducing the frequency and severity of crashes and are thus ready to be mandated through adoption of a new FMVSS on all new light vehicles.

This rule is estimated to save at least 362 lives and mitigate 24,321 non-fatal injuries a year. It represents a crucial step forward in implementing DOT’s January 2022 National Roadway Safety Strategy (NRSS) to address the rising numbers of transportation deaths and serious injuries occurring on this country’s roadways, including those involving pedestrians.[5]

The crash problem that the agency seeks to address with the AEB requirements in this final rule is substantial.[6] For example, 60 percent of fatal rear-end crashes and 73 percent of crashes resulting in injuries were on roads with posted speed limits of 60 mph or below. Similarly, most of these crashes occurred in clear, no adverse atmospheric conditions – 72 percent of fatal crashes and 74 percent of crashes resulting in injuries. Also, about 51 percent of fatal rear-end crashes and 74 percent of rear-end crashes resulting in injuries, all involving light vehicles, occurred in daylight conditions. In addition, 65 percent of pedestrian fatalities and 67 percent of pedestrian injuries were the result of a strike by the front of a light vehicle. Finally, 77 percent of pedestrian fatalities, and about half of the pedestrian injuries, occur in dark lighting

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[4] Hereafter, when this final rule refers to “AEB” generally, unless the context clearly indicates otherwise, it refers to a system that has: (a) an FCW component to alert the driver to an impending collision with a forward obstacle; (b) a CIB component that automatically applies the vehicle’s brakes if the driver does not respond to the FCW; and (c) a DBS component that automatically supplements the driver’s brake application if the driver applies insufficient manual braking to avoid a crash. Furthermore, unless the context indicates otherwise, reference to AEB includes both lead vehicle AEB and PAEB.

[5] https://www.transportation.gov/sites/dot.gov/files/2022-01/USDOT_National_Roadway_Safety_Strategy_0.pdf.

[6] The Insurance Institute for Highway Safety (IIHS) estimates a 50 percent reduction in front-to-rear crashes of vehicles with AEB (IIHS, 2020) and a 25 to 27 percent reduction in pedestrian crashes for PAEB (IIHS, 2022).

conditions. Importantly, this final rule requires that PAEB systems be able to avoid pedestrian crashes in dark testing conditions.

This final rule is issued under the authority of the National Traffic and Motor Vehicle Safety Act of 1966. Under 49 U.S.C. chapter 301, the Secretary of Transportation is responsible for prescribing motor vehicle safety standards that are practicable, meet the need for motor vehicle safety, and are stated in objective terms. The responsibility for promulgation of FMVSSs is delegated to NHTSA. This rulemaking addresses a statutory mandate under the Bipartisan Infrastructure Law (BIL), codified as the Infrastructure Investment and Jobs Act (IIJA),[7] which added 49 U.S.C. 30129, directing the Secretary of Transportation to promulgate a rule requiring that all passenger motor vehicles manufactured for sale in the United States be equipped with an FCW system and an AEB system.

The Focus on AEB

The decision to mandate AEB builds on decades of research and development, which began in the 1990s, with initial research programs to support development of AEB technologies and methods by which system performance could be assessed. NHTSA began testing AEB systems as part of the New Car Assessment Program (NCAP) in 2010 and reporting on the research and progress surrounding the technologies shortly thereafter.[8] These research efforts led to NHTSA listing FCW systems as a "recommended advanced technology" in NCAP in model year 2011, and in November 2015, added crash imminent braking (CIB)[9] and dynamic brake support (DBS) technologies to the program.[10] Most recently, NHTSA proposed upgrades to the lead vehicle AEB test in its March 2022 request for comment on NCAP.[11]

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[7] Public Law 117-58, § 24208 (Nov. 15, 2021).
[8] 77 FR 39561 (Jul. 2, 2012).
[9] This final rule does not split the terminology of these CIB and DBS functionalities outside of certain contexts, like discussions of NCAP, but instead considers them both as parts of AEB. The final rule includes performance tests that would require an AEB system that has both CIB and DBS functionalities.
[10] 80 FR 68604 (Nov. 5, 2015).
[11] 87 FR 13452 (Mar. 9, 2022). *See* https://www.regulations.gov, docket number NHTSA-2021-0002.

In March 2016, NHTSA and the Insurance Institute for Highway Safety (IIHS) announced a commitment by 20 manufacturers representing more than 99 percent of the U.S. light vehicle market to include low-speed AEB as a standard feature on nearly all new light vehicles not later than September 1, 2022. As part of this voluntary commitment, manufacturers are including both FCW and a CIB system that reduces a vehicle's speed in certain rear-end crash-imminent test conditions.

NHTSA also conducted research to understand the capabilities of PAEB systems beginning in 2011. This work began with an assessment of the most common pedestrian crash scenarios to determine how test procedures could be designed to address them. As part of this research, the agency looked closely at a potential pedestrian mannequin to be used during testing and explored several aspects of the mannequin, including size and articulation of the arms and legs. This work resulted in a November 2019 draft research test procedure providing the methods and specifications for collecting performance data on PAEB systems for light vehicles.[12] This procedure was expanded to cover updated vehicle speed ranges and different ambient conditions and included in a March 2022 request for comments notice proposing to include PAEB, higher speed AEB, blind spot warning and blind spot intervention in NCAP.[13]

Need for Regulation

While the above actions have increased market penetration of AEB systems, reduced injuries, and saved lives, NHTSA believes that mandating AEB systems that can address both lead vehicle and pedestrian crashes is appropriate and necessary to better address the safety need. NHTSA incorporated FCW into NCAP beginning in model year 2011 and AEB into NCAP beginning in model year 2018. This has achieved success, with approximately 65% of new vehicles meeting the lead vehicle test procedures included in NCAP.[14] Similarly, the voluntary

[12] 84 FR 64405 (Nov. 21, 2019).
[13] 87 FR 13452 (Mar. 9, 2022).
[14] Percentage based on the vehicle manufacturer’s model year 2022 projected sales volume reported through the New Car Assessment Program's annual vehicle information request.

commitment resulted in approximately 90 percent of new light vehicles manufactured in 2022 having an AEB system.

That said, the test speeds and performance specifications in NCAP and the voluntary commitment do not ensure that the systems perform in a way that will prevent or mitigate crashes resulting in serious injuries and fatalities. The vast majority of fatalities, injuries, and property damage crashes occur at speeds above 40 km/h (25 mph), which are above those covered by the voluntary commitment.

Voluntary measures are intended to supplement rather than substitute for the FMVSSs, which remain NHTSA's core method of ensuring that all motor vehicles can achieve an adequate level of safety performance. The NCAP program is designed to provide valuable safety-related information to consumers in a simple to understand way, but the agency believes that gaps in market penetration will continue to exist for the most highly effective AEB systems. NHTSA has also observed that, in the case of both electronic stability control and rear visibility, only approximately 70 percent of vehicles had these technologies during the time they were part of NCAP. Thus, while NCAP serves a vital safety purpose, only regulation can ensure that all vehicles are equipped with AEB that meet minimum performance requirements.

These considerations are of even greater weight when deciding whether to require a system that can reduce pedestrian crashes, and the agency has concluded that PAEB is both achievable and necessary. Pedestrian fatalities are increasing, and NHTSA's testing reveals that PAEB systems will be able to significantly reduce these deaths.[15] Manufacturers' responses to adding lead vehicle AEB and other technologies to NCAP suggest that it will take several years after PAEB is introduced to NCAP before the market begins to see significant numbers of new vehicles that are able to meet a finalized NCAP test. Even so, since PAEB addresses the safety of someone other than a vehicle occupant, it is not clear if past experience with NCAP is

[15] NHTSA's accompanying Final Regulatory Impact Analysis (FRIA) estimates the impacts of this final rule. The FRIA can be found in the docket for this final rule. The docket number is listed in the heading of this document.

necessarily indicative of how quickly PAEB systems will reach the market penetration levels of lead vehicle AEB.

A final factor weighing in favor of requiring AEB is that the technology is significantly more mature now than it was at the time of the voluntary commitment and when it was introduced into NCAP. NHTSA's most recent testing has shown that higher performance levels than those in the voluntary commitment or the existing NCAP requirements are now practicable. Many model year 2019 and 2020 vehicles were able to repeatedly avoid impacting the lead vehicle in CIB tests and the pedestrian test mannequin in PAEB tests, even at higher test speeds than those prescribed currently in the agency's CIB and PAEB test procedures.

These results show that AEB systems can reduce the frequency and severity of both lead vehicle and pedestrian crashes. Mandating AEB systems would address a clear and, in the case of pedestrian deaths, growing safety problem. To wait for market-driven adoption, even to the extent spurred on by NCAP, would lead to deaths and injuries that could be avoided if the technology were required.

Summary of the NPRM

In view of the significant safety problem and NHTSA's recent test results, and consistent with the Safety Act and BIL, on June 13, 2023 (88 FR 38632) NHTSA published an NPRM proposing a new FMVSS requiring AEB systems that can address both lead vehicle and pedestrian collisions on all new light vehicles. The proposed lead vehicle AEB test procedures built on the existing FCW, CIB, and DBS NCAP procedures, but proposed higher speed performance requirements. Crash avoidance was proposed at speeds up to 100 km/h (62 mph) when manual braking is applied and up to 80 km/h (50 mph) when no manual braking is applied during the test. NHTSA proposed testing under both daylight and darkness lighting conditions, noting the importance of darkness testing of PAEB because more than three-fourths of all pedestrian fatalities occur in conditions other than daylight.

The proposal included four requirements for the AEB system for both lead vehicles and pedestrians. The AEB system would be required to: (1) provide an FCW at any forward speed greater than 10 km/h (6.2 mph), presented via auditory and visual modalities, with permissible additional warning modes, such as haptic; (2) apply the brakes automatically at any forward speed greater than 10 km/h (6.2 mph) when a collision with a lead vehicle or a pedestrian is imminent, including at speeds above those tested by NHTSA; (3) prevent the vehicle from colliding with the lead vehicle or pedestrian test mannequin when tested according to the proposed test procedures, which would include pedestrian tests in both daylight and darkness and two false positive tests; and (4) provide visual notification to the driver of any malfunction that causes the AEB system not to meet the minimum proposed performance requirements.

To ensure test repeatability, NHTSA proposed specifications for the test devices that would be used in both the lead vehicle and pedestrian compliance tests, relying in large part on relevant International Organization for Standardization standards.

NHTSA proposed that all vehicles manufactured four years after the publication date of a final rule would be required to meet all requirements. NHTSA also proposed that all vehicles manufactured on or after three years after the publication date of a final rule would be required to meet all requirements except that lower speed PAEB performance test requirements would not apply. Small-volume manufacturers, final-stage manufacturers, and alterers would be provided an additional year (added to those above) to meet the requirements of the final rule.

NHTSA sought comments on all aspects of the NPRM and any alternative requirements that would address the safety problem. In response, over 1,000 comments were received from a wide variety of stakeholders and interested persons. These comments are available in the docket for the NPRM.[16]

This Final Rule

[16] https://www.regulations.gov/docket/NHTSA-2023-0021/comments

After careful consideration of all comments, this final rule adopts most of the proposed NPRM requirements, with a few of the changes relevant to significant matters. The differences between the NPRM and the final rule are noted at the end of this Executive Summary and discussed in the relevant sections of this preamble.

With this final rule, NHTSA has issued a Final Regulatory Impact Analysis (FRIA), available in the docket for this final rule (NHTSA-2023-0021).

NHTSA estimates that systems can achieve the requirements of this final rule primarily through upgraded software, with a limited number of vehicles needing additional hardware. Therefore, the incremental cost associated with this rule reflects the cost of a software upgrade that will allow current systems to achieve lead vehicle AEB and PAEB functionality that meets the requirements specified in this rule and the cost to equip a second sensor (radar) on five percent of the estimated fleet that is not projected to have the needed hardware. Taking into account both software and hardware costs, the total annual cost associated with this final rule is approximately $354 million in 2020 dollars.

Table 1 below summarizes the finding of the benefit-cost analysis. The projected benefits of this rule greatly exceed the projected costs. The lifetime monetized net benefit of this rule is projected to be between $5.82 and $7.26 billion with a cost per equivalent life saved of between $550,000 and $680,000, which is far below the Department's recommended value of a statistical life saved, of as $11.6 million in 2020 dollars.

Table 1: Lifetime Summary of Benefits and Costs for Passenger Cars and Light Trucks (Millions 2020$), Discount Rate

Benefits	3% Discount Rate	7% Discount Rate
Lifetime Monetized	$7,610	$6,180
Costs		
Lifetime Monetized	$354	$354
Net Benefits		

Lifetime Monetized	$7,260	$5,820

Table 2: Estimated Quantifiable Benefits

Benefits	
Fatalities Reduced	362
Injuries Reduced	24,321

Table 3: Estimated Installation Costs (2020$)

Category	Percentage of New Light Vehicle Impacted	Total Annual Cost (Millions)
Software	100%	$282.20
Hardware	5%	$71.86
Total		$354.06

Table 4: Estimated Cost Effectiveness

Cost per Equivalent Life Saved	
AEB Systems	$0.55 to $0.68 million*

*The range presented reflects the use of a 3% or 7% discount rate.

Differences Between this Final Rule and the NPRM

NHTSA has made a number of changes to the NPRM based on information from the comments. The changes are discussed below. NHTSA discusses each of these changes in the relevant sections of this preamble.

- In the NPRM, NHTSA estimated that systems can achieve the proposed requirements through upgraded software alone. Commenters suggested that in some instances additional hardware will also be needed, so the incremental cost associated with this rule now includes the cost of a software upgrade and the cost to equip a second sensor (radar) on the five percent of the estimated fleet that does not now have the needed hardware.
- NHTSA has made changes to lead time and compliance date requirements. The NPRM proposed that all vehicles comply with the requirements within 3 years,

except for some higher speed PAEB performance requirements in darkness (which had 1 year more to comply than other requirements). This final rule requires that manufacturers comply with all provisions of the rule at the end of a 5-year period starting the first September 1 following publication of this rule, which would be September 1, 2029.[17] The requirements of this final rule compel robust AEB systems that are practicable, but the agency has determined that more time is needed for the technology to mature and be deployed into all vehicles.[18] We expect that many vehicles will be equipped with AEB systems that meet the new rule earlier than September 1, 2029, because of redesign schedules, but that manufacturers will be able to meet the requirement for all new vehicles by the new start date.

- This final rule modifies the range of forward speeds at which the AEB must operate. The NPRM required FCW and AEB systems to operate at any forward speed greater than 10 km/h. This final rule places an upper bound on the requirement that an AEB system operate of 145 km/h (90.1 mph) for FCW and lead vehicle AEB and 73 km/h (45.4 mph) for pedestrian AEB. This final rule also clarifies the environmental conditions under which the AEB system must perform to be the same environmental conditions specified in the track testing.
- This final rule includes an explicit prohibition against manufacturers installing a control designed for the sole purpose of deactivation of the AEB system, except where provided below as it relates to law enforcement. This final rule also allows

[17] As proposed in the NPRM, this final rule provides small-volume manufacturers, final stage manufacturers, and alterers an additional year of lead time. As a result of the changes to the proposed lead time and compliance date requirements, small-volume manufactures, final stage manufactures, and alterers would be required to comply with all provisions of the rule starting September 1, 2030.

[18] As part of this extension of the lead time, the agency has removed the graduated approach to the PAEB performance requirements. The NPRM proposed that most PAEB requirements be met 3 years after a final rule, with an additional year for the dark lighting condition requirement. With the 5-year lead time for all requirements, there is no need for the phasing-in of requirements, so the agency is not adopting it.

for controls that have the ancillary effect of deactivating the AEB system. For instance, a manufacturer may choose to deactivate AEB if the driver has activated "tow mode" and the manufacturer has determined that AEB cannot perform safely while towing a trailer.

- This final rule modifies the FCW visual signal location requirement to increase the specified maximum visual angle from 10 degrees to 18 degrees in the vertical direction. This change from the NPRM provides manufacturers with the flexibility to locate the visual warning signal within the typical area of the upper half of the instrument panel and closer to the central field of view of the driver. While the agency continues to believe that an FCW visual warning signal presented near the central forward-looking region is ideal, it does not consider a head-up display to be necessary for the presentation of the FCW visual signal that is part of a complete AEB system.
- The rule contains several additional minor changes as well. These include the following:

--In the obstructed pedestrian scenario in PAEB performance tests, the NPRM did not specify the distance between the pedestrian test dummy and the farthest obstructing vehicle. This final rule corrects this oversight.

--In the false activation tests, this final rule adjusts the regulatory text to clarify that testing for false activation is done with and without manual brake application.

--Some minor parameters and definitions were modified, and various definitions were added, to clarify details of the lead vehicle and PAEB test procedures.

--To increase practicability of running the tests, a third manual brake application controller option, a force only feedback controller, was added. The force feedback controller is substantially similar to the hybrid controller with the commanded brake pedal position omitted, leaving only the commanded brake pedal force application.

--The procedure in Annex C, section C.3 of ISO 19206-2:2018 is specific for pedestrian targets, but recent testing performed by the agency indicates that the three-position measurement specified in Annex C, section C.3 of ISO 19206-3:2021 provides more reduction in multi-path reflections and offers more accurate radar cross section values. The agency is incorporating by reference ISO 19206-3:2021.

II. Background

A. The Safety Problem

There were 38,824 fatalities in motor vehicle crashes on U.S. roadways in 2020 and early estimates put the number of fatalities at 42,795 for 2022.[19] This is the highest number of fatalities since 2005. While the upward trend in fatalities may be related to increases in risky driving behaviors during the COVID-19 pandemic,[20] agency data show an increase of 3,356 fatalities between 2010 and 2019.[21] Motor vehicle crashes have also trended upwards since 2010, which corresponds to an increase in fatalities, injuries, and property damage.

Overall Rear-End Crash Problem

NHTSA uses data from the Fatality Analysis Reporting System (FARS) and the Crash Report Sampling System (CRSS) to account for and understand motor vehicle crashes. As defined in a NHTSA technical manual relating to data entry for FARS and CRSS, rear-end crashes are incidents where the first event is defined as the frontal area of one vehicle striking a vehicle ahead in the same travel lane. In a rear-end crash, as instructed by the 2020 FARS/CRSS Coding and Validation Manual, the vehicle ahead is categorized as intending to head either straight, left or right, and is either stopped, travelling at a lower speed, or decelerating.[22]

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[19] https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813266, https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813428.

[20] These behaviors relate to increases in impaired driving, the non-use of seat belts, and speeding. NHTSA also cited external studies from telematics providers that suggested increased rates of cell phone manipulation during driving in the early part of the pandemic.

[21] NHTSA's Traffic Safety Facts Annual Report, Table 2, https://cdan.nhtsa.gov/tsftables/tsfar.htm# Accessed March 28, 2023.

[22] https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813251 Category II Configuration D. Rear-End.

In 2019, rear-end crashes accounted for 32.5 percent of all crashes, making them the most prevalent type of crash.[23] Fatal rear-end crashes increased from 1,692 in 2010 to 2,363 in 2019 and accounted for 7.1 percent of all fatal crashes in 2019, up from 5.6 percent in 2010. Because data from 2020 and 2021 may not be representative of the general safety problem due to the COVID-19 pandemic, and data from 2022 are not yet available, the following discussion refers to data from 2010 to 2020 when discussing rear-end crash safety problem trends, and 2019 data when discussing specific characteristics of the rear-end crash safety problem. While injury and property-damage-only rear-end crashes from 2010 (476,000 and 1,267,000, respectively) and 2019 (595,000 and 1,597,000, respectively) are not directly comparable due to differences in database structure and sampling, the data indicate that these numbers have not significantly changed from 2010-2015 (NASS-GES sampling) and 2016-2019 (CRSS sampling).

Table 5: 2010-2020 Rear-end crashes All Vehicle Types By Crash Severity[24]

First Harmful Event	Rear-End Crash Severity			
	Fatal	Injury	Property-Damage-Only	Total Rear-End
	Number	Number	Number	Number
2010	1,692	476,000	1,267,000	1,745,000
2011	1,808	475,000	1,245,000	1,721,000
2012	1,836	518,000	1,327,000	1,847,000
2013	1,815	503,000	1,326,000	1,831,000
2014	1,971	522,000	1,442,000	1,966,000
2015	2,225	556,000	1,543,000	2,101,000
2016	2,372	661,000	1,523,000	2,187,000
2017	2,473	615,000	1,514,000	2,132,000
2018	2,459	594,000	1,579,000	2,175,000
2019	2,363	595,000	1,597,000	2,194,000
2020	2,428	417,000	1,038,000	1,457,000

[23] https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813141 Traffic Safety Facts 2019, Table 29
[24] Compiled from NHTSA's Traffic Safety Facts Annual Report, Table 29 from 2010 to 2020, https://cdan.nhtsa.gov/tsftables/tsfar.htm# Accessed March 28, 2023.

The table below presents a breakdown of all the crashes in 2019 by the first harmful event where rear-end crashes represent 7.1 percent of the fatal crashes, 31.1 percent of injury crashes and 33.2 percent (or the largest percent) of property-damage-only crashes.

Table 6: 2019 Crashes, by First Harmful Event, Manner of Collision, and Crash Severity[25]

First Harmful Event	Crash Severity					
	Fatal		Injury		Property-Damage-Only	
	Number	Percent	Number	Percent	Number	Percent
Collision with Motor Vehicle in Transport:						
Angle	6,087	18.2	531,000	27.7	956,000	19.9
Rear-end	2,363	7.1	595,000	31.1	1,597,000	33.2
Sideswipe	917	2.7	138,000	7.2	739,000	15.4
Head On	3,639	10.9	91,000	4.7	86,000	1.8
Other / Unknown	150	0.4	8,000	0.4	69,000	1.4
Collision with a Fixed Object:						
	9,579	28.6	281,000	14.7	657,000	13.7
Collision with Object Not Fixed:						
	7,826	23.4	214,000	11.2	648,000	13.5
Non-collision:						
	2,870	8.6	58,000	3.0	54,000	1.1

The following paragraphs provide a breakdown of rear-end crashes by vehicle type, posted speed limit, light conditions and atmospheric conditions for the year 2019 based on NHTSA's FARS, CRSS, and the 2019 Traffic Safety Facts sheets.

Rear-End Crashes by Vehicle Type

In 2019, passenger cars and light trucks were involved in the vast majority of rear-end crashes. NHTSA's "Manual on Classification of Motor Vehicle Traffic Accidents" provides a

[25] NHTSA's Traffic Safety Facts Annual Report, Table 29 for 2019, https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813141 Accessed March 29, 2024.

standardized method for crash reporting. It defines passenger cars as “motor vehicles used primarily for carrying passengers, including convertibles, sedans, and station wagons,” and light trucks as “trucks of 10,000 pounds gross vehicle weight rating or less, including pickups, vans, truck-based station wagons, and utility vehicles.”[26] The 2019 data show that crashes where a passenger car or light truck is a striking vehicle represent at least 70 percent of fatal rear-end crashes, 95 percent of crashes resulting in injury, and 96 percent of damage only.[27]

Table 7: Rear-End Crashes with Impact Location - Front, by Vehicle Type, in 2019[28]

Vehicle Body Type, Initial Impact-Front	Fatal	Injury	Property-Damage-Only
Passenger Car	888	329,000	906,000
Light Truck	910	245,000	642,000
All Other	762	31,000	57,000

Rear-End Crashes by Posted Speed Limit

When looking at posted speed limit and rear-end crashes, data show that the majority of the crashes happened in areas where the posted speed limit was 60 mph (97 km/h) or less. The table below shows the rear-end crash data by posted speed limit and vehicle type from 2019. About 60 percent of fatal crashes were on roads with a speed limit of 60 mph (97 km/h) or lower. That number is 73 percent for injury crashes and 78 percent for property-damage-only crashes.

Table 8: 2019 Rear-end Crashes Involving Passenger Cars, MPVs, and Light Trucks with Frontal Impact by Posted Speed Limit[29, 30]

	Passenger Cars, Light trucks, by Crash Severity

[26] https://www-fars.nhtsa.dot.gov/help/terms.aspx.
[27] NHTSA’s Traffic Safety Facts Annual Report, 2019, https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813141.
[28] Generated from FARS and CRSS databases (https://www.nhtsa.gov/file-downloads?p=nhtsa/downloads/FARS/2019/National/, https://www.nhtsa.gov/file-downloads?p=nhtsa/downloads/CRSS/2019/, accessed October 17, 2022).
[29] Generated from FARS and CRSS databases (https://www.nhtsa.gov/file-downloads?p=nhtsa/downloads/FARS/2019/National/, https://www.nhtsa.gov/file-downloads?p=nhtsa/downloads/CRSS/2019/, accessed October 17, 2022).
[30] Total percentages may not equal the sum of individual components due to independent rounding throughout the Safety Problem section.

Vehicles by Posted speed limit	Fatal		Injury		Property-Damage-Only	
	Number	Percent	Number	Percent	Number	Percent
25 mph or less	16	1%	28,000	5%	103,000	7%
30	30	2%	24,000	4%	78,000	5%
35	95	5%	91,000	16%	267,000	17%
40	87	5%	66,000	11%	175,000	11%
45	223	12%	129,000	22%	373,000	24%
50	99	6%	19,000	3%	58,000	4%
55	401	22%	55,000	10%	122,000	8%
60	133	7%	12,000	2%	31,000	2%
65 and above	684	38%	75,000	13%	153,000	10%
All other	30	2%	75,000	13%	187,000	12%
Total:	1,798	100%	574,000	100%	1,547,000	100%

Rear-End Crashes by Light Condition

Slightly more fatal rear-end crashes (51 percent) occurred during daylight than during dark-lighted and dark-not-lighted conditions combined (43 percent) in 2019. Injury and property-damage-only rear-end crashes were reported to have happened overwhelmingly during daylight, at 76 percent for injury rear-end crashes and 80 percent for property-damage-only rear-end crashes. The table below presents a summary of all 2019 rear-end crashes of light vehicles by light conditions, where the impact location is the front of a light vehicle.

Table 9: 2019 Rear-end Crashes with Light Vehicle Front Impact, by Light Condition[31]

Light Condition	Crash severity					
	Fatal		Injury		Property-Damage-Only	
	Number	Percent	Number	Percent	Number	Percent
Daylight	925	51%	436,000	76%	1,232,000	80%
Dark - Not Lighted	438	24%	28,000	5%	59,00060,767	4%
Dark - Lighted	349	19%	86,000	15%	192,000	12%
All Other	86	5%	24,000	4%	65,000	4%
Total	1,798	100%	574,000	100%	1,547,000	100%

[31] Generated from FARS and CRSS databases (https://www.nhtsa.gov/file-downloads?p=nhtsa/downloads/FARS/2019/National/, https://www.nhtsa.gov/file-downloads?p=nhtsa/downloads/CRSS/2019/, accessed October 17, 2022).

Rear-End Crashes by Atmospheric Conditions

In 2019, the majority of rear-end crashes of light vehicles were reported to occur during clear skies with no adverse atmospheric conditions. These conditions were present for 72 percent of all fatal rear-end crashes, while 14 percent of fatal rear-end crashes were reported to occur during cloudy conditions. Similar trends are reported for injury and property-damage-only crashes. A summary of 2019 rear-end crashes of light vehicle with frontal impact by atmospheric conditions is presented in the table below.

Table 10: 2019 Rear-End Crashes Involving Light Vehicles with Frontal Impact, by Atmospheric Conditions[32]

Crashes Atmospheric Conditions	Crash Severity					
	Fatal		Injury		Property-Damage-Only	
	Number	Percent	Number	Percent	Number	Percent
Clear, No Adverse	1,295	72%	426,000	74%	1,113,000	72%
Cloudy	247	14%	87,000	15%	245,000	16%
All Other	256	14%	61,000	11%	189,000	12%
Total	1,798	100%	574,000	100%	1,547,000	100%

Pedestrian Fatalities and Injuries

While the number of fatalities from motor vehicle traffic crashes is increasing, pedestrian fatalities are increasing at a greater rate than the general trend and becoming a larger percentage of total fatalities. In 2010, there were 4,302 pedestrian fatalities (13 percent of all fatalities), which increased to 6,272 (17 percent of all fatalities) in 2019. The latest agency estimation data indicate that there were 7,345 pedestrian fatalities in 2022.[33] Since data from 2020 and 2021 may not be representative of the general safety problem due to the COVID-19 pandemic and data for 2022 are early estimates, the following sections refer to data from 2010 to 2020 when discussing pedestrian safety problem trends, and 2019 data when discussing specific

[32] Generated from FARS and CRSS databases (https://www.nhtsa.gov/file-downloads?p=nhtsa/downloads/FARS/2019/National/, https://www.nhtsa.gov/file-downloads?p=nhtsa/downloads/CRSS/2019/, accessed October 17, 2022).
[33] https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813448.

characteristics of the pedestrian safety problem. While the number of pedestrian fatalities is increasing, the number of pedestrians injured in crashes from 2010 to 2020 has not changed significantly, with exception of the 2020 pandemic year. As shown in the table below, the number and percentage of pedestrian fatalities and injuries for the 2010 to 2020 period is presented in relationship to the total number of fatalities and total number of people injured in all crashes.

Table 11: 2010-2020 Traffic Crash Fatalities and Pedestrian Fatalities, and Injured People and Pedestrians Injured[34]

Year	Total Fatalities[1]	Pedestrian Fatalities[1]		Total People Injured[2]	Pedestrian Injured[2]	
		Number	Percent of Total Fatalities		Number	Percent of Total Injured
2010	32,999	4,302	13%	2,248,000	70,000	3%
2011	32,479	4,457	14%	2,227,000	69,000	3%
2012	33,782	4,818	14%	2,369,000	76,000	3%
2013	32,893	4,779	15%	2,319,000	66,000	3%
2014	32,744	4,910	15%	2,343,000	65,000	3%
2015	35,484	5,494	15%	2,455,000	70,000	3%
2016	37,806	6,080	16%	3,062,000	86,000	3%
2017	37,473	6,075	16%	2,745,000	71,000	3%
2018	36,835	6,374	17%	2,710,000	75,000	3%
2019	36,355	6,272	17%	2,740,000	76,000	3%
2020	38,824	6,516	17%	2,282,015	55,000	2%

[1] Data source: FARS 2010–2019, 2020 Annual Report (ARF)
[2] Data source: NASS GES 2010–2015, CRSS 2016–2019

The following sections present a breakdown of pedestrian fatalities and injuries by initial impact point, vehicle type, posted speed limit, lighting condition, and pedestrian age for the year 2019.

Pedestrian Fatalities and Injuries by Initial Point of Impact and Vehicle Type

In 2019, the majority of pedestrian fatalities, 4,638 (74 percent of all pedestrian fatalities), and injuries, 52,886 (70 percent of all pedestrian injuries), were in crashes where the initial point of impact on the vehicle was the front. When the crashes are broken down by vehicle

[34] https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813079 Pedestrian Traffic Facts 2019 Data, May 2021, https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813310 Pedestrian Traffic Facts 2020, Data May 2022.

body type, the majority of pedestrian fatalities and injuries occur where the initial point of impact was the front of a light vehicle (4,069 pedestrian fatalities and 50,831 pedestrian injuries) (see the table below).[35]

Table 12: 2019 Pedestrian Fatalities and Injuries, by Initial Point of Impact Front and Vehicle Body Type[36]

Vehicle Body Type, Initial Impact - Front	Crash Severity			
	Pedestrian Fatalities		Pedestrian Injuries	
	Number	Percent	Number	Percent
Passenger Car	1,976	43%	30,968	59%
Light Truck	2,093	45%	19,863	38%
All Other	569	12%	2,055	4%
Total	4,638	100%	52,886	100%

Pedestrian Fatalities and Injuries by Posted Speed Limit Involving Light Vehicles

In 2019, the majority of pedestrian fatalities from crashes involving light vehicles with the initial point of impact as the front occurred on roads where the posted speed limit was 45 mph or less, (about 70 percent). There is a near even split between the number of pedestrian fatalities in 40 mph and lower speed zones and in 45 mph and above speed zones (50 percent and 47 percent respectively with the remaining unknown or not reported). As for pedestrian injuries, in 34 percent of the sampled data, the posted speed limit is either not reported or unknown. In 2019, 57 percent of the pedestrians were injured when the posted speed limit was 40 mph or below, and 9 percent when the posted speed limit was above 40 mph with the remaining not reported, reported as unknown, or reported as no speed limit. The table below shows the number of pedestrian fatalities and injuries for each posted speed limit.

Table 13: 2019 Pedestrian Fatalities and Injuries Involving Light Vehicles, by Posted Speed Limit and Initial Point of Impact Front[37]

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[35] As described previously, passenger cars and light trucks are the representative population for vehicles with a gross vehicle weight rating (GVWR) of 4,536 kg (10,000 lbs.) or less.

[36] NHTSA's Traffic Safety Facts Annual Report, Table 99 for 2019, https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813141 Accessed March 29, 2024.

[37] The accompanying FRIA estimates the impacts of the rule based on the estimated travel speed of the striking vehicle. This table presents the speed limit of the roads on which pedestrian crashes occur.

Posted speed limit	Crash Severity			
	Pedestrian Fatalities		Pedestrian Injuries	
	Number	Percent	Number	Percent
5 mph	3	0.07%	185	0.36%
10 mph	7	0.17%	287	0.56%
15 mph	10	0.25%	865	1.70%
20 mph	14	0.34%	479	0.94%
25 mph	346	8.50%	9,425	18.54%
30 mph	325	7.99%	4,254	8.37%
35 mph	765	18.80%	9,802	19.28%
40 mph	551	13.54%	3,703	7.28%
45 mph	821	20.18%	3,094	6.09%
50 mph	177	4.35%	302	0.59%
55 mph	463	11.38%	546	1.07%
60 mph	105	2.58%	130	0.26%
65 mph	199	4.89%	241	0.47%
70 mph	103	2.53%	105	0.21%
75 mph	19	0.47%	4	0.01%
80 mph	2	0.05%	25	0.05%
Not Reported	118	2.90%	15,017	29.54%
Unknown	16	0.39%	176	0.35%
No Statutory Limit / Non-Trafficway Area	25	0.61%	2,191	4.31%
Total	4,069	100%	50,831	100%

Pedestrian Fatalities and Injuries by Lighting Condition Involving Light Vehicles

The majority of pedestrian fatalities where the front of a light vehicle strikes a pedestrian occurred in dark lighting conditions, 3,131 (75 percent). There were 20,645 pedestrian injuries (40 percent) in dark lighting conditions and 27,603 pedestrian injuries (54 percent) in daylight conditions.

Table 14: 2019 Pedestrian Fatalities and Injuries Involving Light Vehicles, by Lighting Condition and Initial Point of Impact Front[38]

Light Condition	Crash Severity			
	Pedestrian Fatalities		Pedestrian Injuries	
	Number	Percent	Number	Percent

[38] Generated from FARS and CRSS databases (https://www.nhtsa.gov/file-downloads?p=nhtsa/downloads/FARS/2019/National/, https://www.nhtsa.gov/file-downloads?p=nhtsa/downloads/CRSS/2019/, accessed October 17, 2022).

Daylight	767	19%	27,603	54%
Dark–Not Lighted	1,464	36%	4,551	9%
Dark–Lighted	1,621	40%	15,996	31%
Dark–Unknown Light	46	1%	98	0%
All Other	171	4%	2,583	5%
Total	4,069	100%	50,831	100%

Pedestrian Fatalities and Injuries by Age Involving Light Vehicles

In 2019, 646 fatalities and approximately 106,600 injuries involved children aged 9 and below. Of these, 68 fatalities and approximately 2,700 injuries involved pedestrians aged 9 and below in crashes with the front of a light vehicle. As shown in the table below, the first two age groups (under age 5 and ages 5 to 9) each represent less than 1 percent of the total pedestrian fatalities in crashes with the front of a light vehicle. These age groups also represent about 1.5 and 3.8 percent of the total pedestrian injuries in crashes with the front of a light vehicle, respectively. In contrast, age groups between age 25 and 69 each represent approximately 7 percent of the total pedestrian fatalities in crashes with the front of a light vehicle, with the 55 to 59 age group having the highest percentage at 10.9 percent. Pedestrian injury percentages were less consistent, but distributed similarly, to pedestrian fatalities, with lower percentages reflected in children aged 9 and below and adults over age 70.

Table 15: 2019 Pedestrians Fatalities and Injuries in Traffic Crashes Involving Light Vehicles by Initial Point of Impact Front[39] and Age Group[40]

Age Group	United States Population (thousand)	Percent of Population	Pedestrian Fatalities		Pedestrians Injuries	
			Light Vehicle Front-Impact Ped. Fatalities	Percent of Total Pedestrian Fatalities in Light Vehicle Front-Impact	Light Vehicle Front-Impact Ped. Injuries	Percent of Total Pedestrian Injuries in Light Vehicle Front-Impact

[39] Generated from FARS and CRSS databases (https://www.nhtsa.gov/file-downloads?p=nhtsa/downloads/FARS/2019/National/, https://www.nhtsa.gov/file-downloads?p=nhtsa/downloads/CRSS/2019/, accessed October 17, 2022).

[40] https://www.census.gov/data/tables/2019/demo/age-and-sex/2019-age-sex-composition.html, Table 12.

				Crashes		Crashes
<5	19,736	6.1%	37	0.9%	770	1.5%
5-9	20,212	6.2%	31	0.8%	1,907	3.8%
10-14	20,827	6.4%	58	1.4%	2,830	5.6%
15-20	20,849	6.4%	159	3.9%	5,673	11.2%
21-24	21,254	6.6%	173	4.3%	3,190	6.3%
25-29	23,277	7.2%	287	7.1%	4,394	8.6%
30-34	21,932	6.8%	315	7.7%	3,735	7.3%
35-39	21,443	6.6%	316	7.8%	3,636	7.2%
40-44	19,584	6.0%	277	6.8%	2,812	5.5%
45-49	20,345	6.3%	294	7.2%	2,745	5.4%
50-54	20,355	6.3%	350	8.6%	3,311	6.5%
55-59	21,163	6.5%	442	10.9%	3,678	7.2%
60-64	20,592	6.3%	379	9.3%	3,469	6.8%
65-69	17,356	5.4%	303	7.4%	2,594	5.1%
70-74	14,131	4.4%	207	5.1%	1,724	3.4%
75-79	9,357	2.9%	172	4.2%	1,136	2.2%
80+	11,943	3.7%	252	6.2%	1,127	2.2%
Unknown			17	0.4%	2,103	4.1%
Total			4,069	100%	50,831	100%

B. Bipartisan Infrastructure Law (BIL)

This final rule responds to Congress's directive that NHTSA require AEB on all passenger vehicles. On November 15, 2021, the President signed the Bipartisan Infrastructure Law, codified as the Infrastructure Investment and Jobs Act (Pub. L. 117-58). Section 24208(a) of BIL added 49 U.S.C. 30129, directing the Secretary of Transportation to promulgate a rule to establish minimum performance standards with respect to crash avoidance technology and to require that all passenger motor vehicles manufactured for sale in the United States be equipped with a forward collision warning (FCW) system and an automatic emergency braking system. The FCW and AEB system is required to alert the driver if the vehicle is closing its distance too quickly to a vehicle ahead or to an object in the path of travel ahead and a collision is imminent, and to automatically apply the brakes if the driver fails to do so. This final rule responds to this mandate and is estimated to reduce the frequency and severity of vehicle-to-vehicle rear-end crashes and to reduce the frequency and severity of vehicle crashes into pedestrians.

BIL requires that "all passenger motor vehicles" manufactured for sale in the United States be equipped with AEB and FCW. The BIL term "passenger motor vehicle" encompasses more vehicle categories than the term "passenger car" that NHTSA defines in 49 CFR 571.3. Thus, including multipurpose passenger vehicles, trucks, and buses aligns with Congress's mandate. Additionally, NHTSA considers passenger cars, truck, buses, and multipurpose passenger vehicles as light vehicles and generally uses the 10,000 GVWR cut-off for FMVSS that apply to light vehicles.[41] As a result, in this final rule, NHTSA requires AEB and FCW on all passenger cars and multipurpose passenger vehicles, trucks, and buses with a gross vehicle weight rating (GVWR) of 10,000 lbs. or less.

BIL further requires that an FCW system alert the driver if there is a "vehicle ahead or an object in the path of travel" if a collision is imminent.

NHTSA interprets BIL as requiring AEB capable of detecting and responding to vehicles and objects and authorizing NHTSA to promulgate specific performance requirements. NHTSA's rule requires light vehicles to be equipped with FCW and automatic emergency braking (AEB), and the proposal defines AEB as a system that detects an imminent collision with vehicles, objects, and road users,[42] in or near the path of a vehicle and automatically controls the vehicle's service brakes to avoid or mitigate the collision.

As discussed in the NPRM, section 24208 of BIL does not limit NHTSA's broad authority to issue motor vehicle safety regulations under the Safety Act. NHTSA interprets BIL

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[41] *See*, for example, 49 CFR 571.138, 571.208, and 571.111.
[42] While AEB is defined as a system that detects imminent collision with vehicles, objects, and road users, the performance requirements focus on protecting pedestrians until NHTSA can develop additional research to support a proposal to expand the performance requirements.

as a mandate to act on a particular vehicle safety issue and as complementary to NHTSA's authority under the Safety Act. Thus, pursuant to its authority under 49 U.S.C 30111, NHTSA is requiring all light passenger vehicles to be equipped with PAEB in addition to AEB. NHTSA is ensuring that PAEB is available on all light passenger vehicles to address a significant safety problem, and in so doing, recognizes the availability of technology capable of preventing needless injuries and lost lives.

C. High-level Summary of Comments on the NPRM

NHTSA received more than a thousand comments on the proposed rule. The agency received comments from a wide variety of commenters including advocacy groups, manufacturers, trade associations, suppliers, and individuals. The advocacy groups submitting comments included AAA Inc. (AAA), AARP, Advocates for Highway and Auto Safety (Advocates), America Walks, American Foundation for the Blind (AFB), Association of Pedestrian and Bicycle Professionals (APBP), Center for Auto Safety (CAS), Consumer Reports, DRIVE SMART Virginia, Insurance Institute for Highway Safety (IIHS), International Association of Fire Chiefs, Intelligent Transportation Society of America (ITS America), League of American Bicyclists (League), McHenry County Bicycle Advocates, National Safety Council (NSC), Paralyzed Veterans of America (PVA), United Spinal Association, Utah Public Lands Alliance, and Vulnerable Road Users Safety Consortium (VRUSC). Trade associations submitting comments included Alliance for Automotive Innovation (Alliance), American Chemistry Council, American Motorcyclist Association (AMA), Automotive Safety Council (ASC), Autonomous Vehicle Industry Association (AVIA), the Governors Highway Safety Association (GHSA), Lidar Coalition, the Motor and Equipment Manufacturers Association (MEMA), National Automotive Dealers Association (NADA), National Association of City Transportation Officials (NACTO), Association for the Work Truck Industry (NTEA), SAE International (SAE), and Specialty Equipment Market Association (SEMA). We also received comments from individual vehicle manufacturers such as FCA US LLC (FCA), Ford Motor

Company (Ford), General Motors LLC (GM), American Honda Motor, Co., Inc. (Honda), Hyundai Motor Company (Hyundai), Mitsubishi Motors R & D of America, Inc. (Mitsubishi), Nissan North America, Inc. (Nissan), Porsche Cars North America (Porsche), Rivian Automotive, LLC (Rivian), Toyota Motor North America, Inc. (Toyota), and Volkswagen Group of America (Volkswagen). Suppliers and developers commenting on the NPRM included Adasky North America (Adasky), Applied Intuition (Applied), Aptiv, Automotive Electronics Products COMPAL Electronics, Inc. (COMPAL), Autotalks, Forensic Rock, LLC (Forensic Rock), Humanetics Safety (Humanetics), Hyundai America Technical Center, Inc. (HATCI), Hyundai MOBIS, imagery Inc. (Imagery), LHP Inc. (LHP), Luminar Technologies, Inc. (Luminar), Mobileye Vision Technologies LTD (Mobileye), Owl Autonomous Imaging, Inc. (Owl AI), Radian Labs LLC (Radian), Robert Bosch LLC (Bosch), Teledyne FLIR (Teledyne), ZF North America (ZF), and Zoox, Inc. (Zoox). Government agencies that commented included the National Transportation Safety Board (NTSB), the City of Houston (Houston), City of Philadelphia (Philadelphia), Humboldt County Association of Governments, Maryland Department of Transportation Motor Vehicle Administration (MDOT), Multnomah County, and Nashville Department of Transportation and Multimodal Infrastructure (Nashville). Healthcare and insurance companies submitting comments included American Property Casualty Insurance Association (APCIA), National Association of Mutual Insurance Companies, and Richmond Ambulance Authority. The agency also received approximately 970 comments from individual commenters. In general, the commenters expressed support for the goals of this rulemaking, and many commenters offered recommendations on the most appropriate way to achieve those goals.

Many commenters shared their general support for requiring AEB as standard equipment on passenger vehicles, while others opposed finalizing the proposed rule for various technical and policy reasons. In general, safety advocates supported finalizing the rule, while vehicle manufacturers opposed various aspects of the proposal, even if they expressed general support for AEB technology. The agency received comments on many aspects of the rule, including comments on the application, the performance requirements, the test procedure conditions and parameters, and the proposed lead time and phase-in schedule.

Consumer advocacy groups primarily supported the rule, with concerns regarding manual deactivation and the proposed requirements regarding PAEB. They urged that any conditions for AEB deactivation be restricted and have data supporting deactivation and asserted that any manual deactivation would need to have multiple steps and require the vehicle to be stationary. Many suggested that the testing speeds be increased to cover a larger portion of the safety problem. Another concern raised by advocacy groups was the lack of test procedures covering bicyclists and users of mobility devices and wheelchairs. They recommended that the agency add more PAEB testing scenarios, noting that there is a significant safety risk for pedestrians and all vulnerable road users. In general, advocacy groups supported the full collision avoidance, no-contact requirement for all proposed AEB tests as a necessity to uphold the strength of the rule.

While vehicle manufacturers supported the installation of AEB, the most significant concerns focused on the stringency of the requirements. The NPRM proposed the AEB system be operational at any forward speed above 10 km/h (6.2 mph). Several vehicle manufacturers and the Alliance opposed the open-ended upper bound, stating it was impracticable or that it would lead to false activations. These commenters stated that the lack of a defined maximum operational speed could create implementation ambiguity and difficulty complying with the rule due to significant development costs. The NPRM further proposed full collision avoidance with the lead vehicle during AEB testing (a no-contact performance requirement). The Alliance, and multiple manufacturers expressing support for the Alliance' comments, stated that a no-contact performance requirement is not practicable and increases the potential for unintended consequences such as inducing unstable vehicle dynamics, removing the driver's authority, increasing false activations, and creating conditions that limit bringing new products to market. These commenters asserted that a lack of rigorous testing by the agency leaves questions as to actual vehicle performance in the field.

The vehicle manufacturers also commented on the feasibility of specific performance requirements under the proposed phase-in schedule, arguing that the agency was mistaken to assume in the NPRM that most vehicles have the necessary hardware to implement this rule. They commented that the proposed phase-in schedule may require redesigns to their systems outside of the normal product development cycle and contended that such a scenario would significantly increase the costs and burdens of compliance. The manufacturers requested that the agency delay the rule by as much as eight years to afford them time to redesign their systems in conjunction with the normal vehicle redesign schedule.

Manufacturers and suppliers generally opposed the agency's proposal to prohibit manual deactivation of the AEB system above 10km/h. Commenters stated the need for deactivation during various scenarios, including four-wheel drive operation, towing, off-road use, car washes and low traction driving. There were multiple suggestions to adopt the deactivation criteria of the United Nations Economic Commission for Europe (UNECE) Regulation No. 152, in place of the NPRM proposed criteria, and to align with UNECE Regulation No. 152 more generally.

Among suppliers and developers, there was not a consensus on the no-contact requirement. Commenters such as Adasky and Luminar expressed support for the no-contact requirement, stating that current technology is capable of this performance. ZF, Aptiv, and Hyundai MOBIS believed the proposed no-contact requirement was not practicable and suggested harmonization with UNECE Regulation No. 152. Generally, those opposed to the no-contact requirement supported hybrid or speed reduction approaches.[43]

ZF, HATCI, and Aptiv supported the ability to manually deactivate the AEB system and recommended harmonization with UNECE Regulation No. 152 deactivation criteria. Imagry

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[43] A kind of hybrid approach would maintain no-contact requirements for lower-mid-range speeds while permitting contact at higher speed if acceptable speed reductions that reduce the risk of serious injury can be achieved in the higher-speed scenarios.

opposed the entirety of the NPRM as drawing resources and development away from fully autonomous driving, while Autotalks supported the regulation as “urgently needed.”

Finally, most individual commenters expressed general support to the goals of this rule, citing the vulnerability of pedestrians on or near roadways. A significant portion of these commenters also noted that children, people with dark skin tones, and those using a wheelchair or mobility device are particularly vulnerable. Individual commenters opposed to this rule cited concerns about off-road operation and false activation.

D. Summary of the Notice of Proposed Rulemaking

NHTSA published the NPRM for this final rule on June 2, 2023 (88 FR 38632). Because this final rule adopts almost all of the requirements proposed in the NPRM, this summary is brief and mirrors the description of the final rule provided in the Executive Summary, *supra*.

1. The NPRM proposed creating a new FMVSS to require AEB systems on light vehicles that can reduce the frequency and severity of both rear-end and pedestrian crashes. The proposed AEB performance requirements were intended to ensure that an AEB system is able to automatically and completely avoid collision with the rear of another vehicle or a pedestrian in specific combinations of scenarios and speeds, while continuing to alert and apply the brakes at speeds beyond those in the test procedure.

2. The NPRM proposed four requirements for the AEB systems. The proposed AEB system must: (a) provide the driver with a forward collision warning (FCW) at any forward speed greater than 10 km/h (6.2 mph); (b) automatically apply the brakes at any forward speed greater than 10 km/h (6.2 mph) when a collision with a lead vehicle or a pedestrian is imminent; (c) prevent the vehicle from contacting the lead vehicle (i.e., vehicle test device) or pedestrian test device when tested according to the proposed test procedures; and (d) detect AEB system malfunctions and notify the driver of any malfunction that causes the AEB system not to meet the proposed minimum performance requirements of the safety standard.

3. The NPRM's test procedures evaluate the lead vehicle AEB performance, PAEB performance, and two scenarios that evaluate situations where braking is not warranted (i.e., false positives). Under this proposed requirement, crash avoidance braking is considered to have occurred when the automatic portion of the brake activation (excluding any manual braking) exceeds 0.25g.

4. For the lead vehicle AEB performance, the agency proposed three test scenarios: lead vehicle stopped, lead vehicle decelerating, and lead vehicle slower-moving. Each lead vehicle scenario is tested at specific speeds or within specified ranges of speeds to evaluate the AEB performance with and without applying manual braking to the subject vehicle.

For the lead vehicle stopped scenario, the agency proposed that the subject vehicle must perform when no manual braking is used at speeds ranging from 10 km/h to 80 km/h, and from 70 km/h to 100 km/h when manual braking is used. The subject (and lead vehicle) speeds proposed for the decelerating lead vehicle scenario were 50 km/h and 80 km/h while the proposed range of lead vehicle deceleration was 0.3 g to 0.5 g. Additionally, for the decelerating lead vehicle scenario, the agency proposed a headway range of 12 m to 40 m for each of the two subject vehicle speeds. For the slower-moving lead vehicle scenario, a subject vehicle must perform at speeds ranging from 40 km/h to 80 km/h when no manual braking is used, while a subject vehicle must perform at speeds ranging from 70 km/h to 100 km/h when manual braking is used.

5. For the assessment of PAEB performance, the proposed test procedures evaluate the subject vehicle in three pre-crash scenarios involving pedestrians: (a) where the pedestrian crosses the road in front of the subject vehicle, (b) where the pedestrian walks alongside the road in the path of the subject vehicle, and (c) where the pedestrian stands in the roadway in front of the subject vehicle. The NPRM proposed a specified range of speeds in both daylight and darkness lighting conditions with lower and upper beam headlamps activated.

6. NHTSA proposed that AEB systems continuously detect system malfunctions. If an AEB system detects a malfunction that prevents it from performing its required safety function, the vehicle would provide the vehicle operator with a warning. The warning would be required to remain active as long as the malfunction exists while the vehicle's starting system is on. NHTSA considers a malfunction to include any condition in which the AEB system fails to meet the proposed performance requirements. NHTSA proposed that the driver be warned in all instances of component or system failures, sensor obstructions, environmental limitations (like heavy precipitation), or other situations that would prevent a vehicle from meeting the proposed AEB performance requirements.

7. With respect to compliance dates, the NPRM proposed that vehicles manufactured on or after September 1, three years after the publication date of a final rule, but before September 1, four years after the publication date of a final rule, would be required to meet all requirements except that lower speed PAEB performance test requirements. Vehicles manufactured four years after the publication date of a final rule would be required to meet all requirements specified in the final rule. NHTSA proposed that small-volume manufacturers, final-stage manufacturers, and alterers would be provided an additional year of lead time for all requirements.

E. Additional Research Conducted in 2023

While past testing conducted in support of the NPRM provided ample support for the proposed performance requirements, NHTSA conducted additional research in 2023, which included an evaluation of the newest vehicles available on the market.[44] The new research confirmed that AEB and PAEB performance maintained good performance when compared with previous testing. This research used three test scenarios to evaluate the AEB performance of six light vehicles. The vehicles tested included the 2023 BMW iX, 2023 Ford F-150 Lightning, 2023

[44] NHTSA's 2023 Light Vehicle Automatic Emergency Braking Research Test Summary and NHTSA's 2023 Light Vehicle Pedestrian Automatic Emergency Braking Research Test Summary, available in the docket for this final rule (NHTSA-2023-0021).

Hyundai Ioniq 5 Limited, 2024 Mazda CX-90 Turbo S, 2023 Nissan Pathfinder SL, and the 2023 Toyota Corolla Hybrid XLE. The lead vehicle testing evaluated the effects of regenerative braking settings for electric (and some hybrid) vehicles, adaptive cruise control settings, and ambient lighting conditions on the AEB performance of these vehicles.

The lead vehicle scenarios used in this research included the proposed conditions of lead vehicle stopped, moving, and decelerating. All conditions and parameters for this research were consistent with those described in the proposed rule. For nominal testing (tests not designed to investigate a particular condition or parameter) the Toyota used in this research avoided contacting the vehicle test device at all speeds tested from 10 km/h to 80 km/h (50 mph) in the lead vehicle stopped condition. The Mazda avoided contacting the lead vehicle test device in all lead vehicle stopped conditions up to 60 km/h (37.5 mph).

Table 16: Lead Vehicle Stopped Test Results
No Manual Braking
Summary (Nominal Condition)

Test Conditions	**Trial #**	**2023 BMW iX xDrive50**	**2023 Ford F-150 Lightning**	**2023 Hyundai Ioniq 5**	**2024 Mazda CX-90**	**2023 Nissan Pathfinder**	**2023 Toyota Corolla Hybrid**
SV[45] = 10 km/h POV[46] = 0 km/h	1	CA	CA	CA	CA	CA	CA
	2	9.6	CA	CA	CA	CA	CA
	3	CA	CA	CA	CA	CA	CA
	4	CA	CA	CA	CA	CA	CA
	5	CA	CA	CA	CA	CA	CA
SV = 40 km/h POV = 0 km/h	1	CA	CA	CA	CA	CA	CA
	2	39.2	CA	CA	CA	CA	CA
	3	40.3	CA	CA	CA	CA	CA
	4	CA	CA	CA	CA	CA	CA
	5	CA	CA	CA	CA	CA	CA
SV = 50 km/h	1	CA	CA	CA	CA	CA	CA
	2	CA	CA	CA	CA	CA	CA

[45] SV is short for “subject vehicle.”
[46] POV is short for “principal other vehicle.”

POV = 0 km/h	3	CA	CA	CA	CA	CA	CA
	4	49.4	CA	CA	CA	CA	CA
	5	CA	CA	CA	CA	CA	CA
SV = 60 km/h POV = 0 km/h	1	--	12.0	1.0	CA	34.9	CA
	2	--	CA	2.5	CA	--	CA
	3	--	16.8	2.8	CA	--	CA
	4	--	CA	--	CA	--	CA
	5	--	11.1	--	CA	--	CA
SV = 70 km/h POV = 0 km/h	1	--	--	--	21.8	--	CA
	2	--	--	--	20.7	--	CA
	3	--	--	--	22.4	--	CA
	4	--	--	--	--	--	CA
	5	--	--	--	--	--	CA
SV = 80 km/h POV = 0 km/h	1	--	--	--	--	--	CA
	2	--	--	--	--	--	CA
	3	--	--	--	--	--	CA
	4	--	--	--	--	--	CA
	5	--	--	--	--	--	CA

CA – No Contact occurred during testing
The number in each cell reports the relative speed in which the vehicle tested impacted the lead vehicle test device in km/h
-- Means that no test was conducted for this parameter based on test conducted at other speeds

The Toyota, BMW, and Hyundai avoided contacting the lead vehicle test device in the lead vehicle moving scenarios for all speeds tested. The Mazda contacted the test device in a single trial at 80 km/h (50 mph) while avoiding contact in all other tested conditions including 4 other trials conducted at 80 km/h.

Table 17: Lead Vehicle Moving Test Results
No Manual Braking
Summary (Nominal Condition)

Test Conditions	**Trial #**	**2023 BMW iX xDrive50**	**2023 Ford F-150 Lightning**	**2023 Hyundai Ioniq 5**	**2024 Mazda CX-90**	**2023 Nissan Pathfinder**	**2023 Toyota Corolla Hybrid**
SV = 70 km/h	1	CA	CA	CA	CA	CA	CA
	2	CA	CA	CA	CA	20.9	CA
	3	CA	CA	CA	CA	17.4	CA

POV = 20 km/h	4	CA	CA	CA	CA	13.2	CA
	5	CA	CA	CA	CA	--	CA
SV = 80 km/h POV = 20 km/h	1	CA	17.4	CA	CA	--	CA
	2	CA	17.2	CA	9.4	--	CA
	3	CA	22.8	CA	CA	--	CA
	4	CA	--	CA	CA	--	CA
	5	CA	--	CA	CA	--	CA

CA – No Contact occurred during testing
The number in each cell reports the relative speed in which the vehicle tested impacted the lead vehicle test device in km/h
-- Means that no test was conducted for this parameter

For the lead vehicle decelerating scenario, the BMW did not contact the lead vehicle test device in any tested condition while the Toyota contacted the test device during three of the five trials performed at 80 km/h. Other vehicles contacted the test device as shown in the table below.

Table 18: Lead Vehicle Deceleration Test Results
No Manual Braking
Summary (Nominal Condition)

Test Conditions	**Trial #**	**2023 BMW iX xDrive50**	**2023 Ford F-150 Lightning**	**2023 Hyundai Ioniq 5**	**2024 Mazda CX-90**	**2023 Nissan Pathfinder**	**2023 Toyota Corolla Hybrid**
SV = 50 km/h POV = 50 km/h POV decel = 0.5g headway = 12 m	1	CA	CA	CA	CA	CA	CA
	2	CA	CA	CA	CA	20.3	CA
	3	CA	CA	CA	CA	CA	CA
	4	CA	CA	4.0	CA	CA	CA
	5	CA	CA	CA	CA	CA	CA
SV = 80 km/h POV = 80 km/h POV decel = 0.5g SV-to-POV headway = 12 m	1	CA	12.6	15.2	21.5	27.1	CA
	2	CA	12.2	13.9	--	--	5.1
	3	CA	12.2	13.7	--	--	CA
	4	CA	--	--	--	--	2.9
	5	CA	--	--	--	--	2.5

CA – No Contact occurred during testing
The number in each cell reports the relative speed in which the vehicle tested impacted the lead vehicle test device in km/h
-- Means that no test was conducted for this parameter

The agency also studied lead vehicle AEB performance in darkness. Results from the dark ambient lighting tests are shown in the table below. The lead vehicle stopped scenario was used for all day/darkness comparative tests. The results observed during the dark ambient tests were largely consistent with those produced during the daylight tests. The dark versus day contact results observed for a given test speed were identical or nearly identical for the Hyundai, Mazda, Nissan, and Toyota. Where impacts occurred, the impact speeds were very close.

Table 19: Lead Vehicle Stopped – No Manual Braking Summary (Dark Ambient Lighting)

Test Conditions	**Trial #**	**2023 BMW iX xDrive50**	**2023 Ford F-150 Lightning**	**2023 Hyundai Ioniq 5**	**2024 Mazda CX-90**	**2023 Nissan Pathfinder**	**2023 Toyota Corolla Hybrid**
SV = 10 km/h POV = 0 km/h	1	CA	CA	CA	CA	CA	CA
	2	CA	CA	CA	CA	CA	CA
	3	CA	CA	CA	CA	CA	CA
	4	CA	CA	CA	CA	3.0	CA
	5	CA	CA	CA	CA	CA	CA
SV = 40 km/h POV = 0 km/h	1	CA	CA	CA	CA	CA	CA
	2	CA	CA	CA	CA	CA	CA
	3	CA	CA	CA	CA	CA	CA
	4	CA	CA	CA	CA	CA	CA
	5	CA	CA	CA	CA	CA	CA
SV = 50 km/h POV = 0 km/h	1	CA	CA	CA	CA	CA	CA
	2	CA	CA	CA	CA	CA	CA
	3	CA	CA	CA	CA	CA	CA
	4	CA	CA	CA	CA	CA	CA
	5	44.2	CA	CA	CA	CA	CA
SV = 60 km/h POV = 0 km/h	1	54.6	22.8	3.7	CA	30.6	CA
	2	--	24.6	4.2	CA	--	CA
	3	--	23.7	4.2	CA	--	CA
	4	--	--	--	CA	--	CA
	5	--	--	--	CA	--	CA
SV = 70 km/h	1	--	--	--	21.3	--	CA
	2	--	--	--	20.8	--	CA
	3	--	--	--	26.9	--	CA

POV = 0 km/h	4	--	--	--	--	--	CA
	5	--	--	--	--	--	CA
SV = 80 km/h POV = 0 km/h	1	--	--	--	--	--	CA
	2	--	--	--	--	--	CA
	3	--	--	--	--	--	CA
	4	--	--	--	--	--	CA
	5	--	--	--	--	--	CA

CA – No Contact occurred during testing
The number in each cell reports the relative speed in which the vehicle tested impacted the lead vehicle test device in km/h
-- Means that no test was conducted for this parameter

The agency also studied the effects of regenerative braking settings for electric and hybrid electric vehicles on the performance of lead vehicle AEB. Again, the lead vehicle stopped test scenario was used for this comparison. The regenerative braking settings did not have a negative effect on the performance of the tested AEB systems. As expected, performance under the highest regenerative braking settings was slightly better that the lower, or off, settings. However, the effect of regenerative brake setting on the vehicle's ability to avoid contact with the lead vehicle test device was dependent on the vehicle tested.

Table 20: Lead Vehicle Stopped – No Manual Braking Summary (Lowest Regen. Brake Setting).

Test Conditions	**Trial #**	**2023 BMW iX xDrive50**	**2023 Ford F-150 Lightning**	**2023 Hyundai Ioniq 5**
SV = 10 km/h POV = 0 km/h	1	CA	CA	CA
	2	9.6	CA	CA
	3	CA	CA	CA
	4	CA	CA	CA
	5	CA	CA	CA
SV = 40 km/h POV = 0 km/h	1	CA	CA	CA
	2	39.2	CA	CA
	3	40.3	CA	CA
	4	CA	CA	CA
	5	CA	CA	CA
	1	CA	CA	CA

SV = 50 km/h POV = 0 km/h	2	CA	CA	CA
	3	CA	CA	CA
	4	49.4	CA	CA
	5	CA	CA	CA
SV = 60 km/h POV = 0 km/h	1	--	12.0	1.5
	2	--	CA	2.2
	3	--	16.8	2.1
	4	--	CA	--
	5	--	11.1	--

CA – No Contact occurred during testing
The number in each cell reports the relative speed in which the vehicle tested impacted the lead vehicle test device in km/h
-- Means that no test was conducted for this parameter

Table 21: Lead Vehicle Stopped – No Manual Braking Summary (Highest Regen. Brake Setting).

Test Conditions	**Trial #**	**2023 BMW iX xDrive50**	**2023 Ford F-150 Lightning**	**2023 Hyundai Ioniq 5**
SV = 10 km/h POV = 0 km/h	1	CA	CA	CA
	2	CA	CA	CA
	3	CA	CA	CA
	4	CA	CA	CA
	5	CA	CA	CA
SV = 40 km/h POV = 0 km/h	1	CA	CA	CA
	2	CA	CA	CA
	3	CA	CA	CA
	4	CA	CA	CA
	5	CA	CA	CA
SV = 50 km/h POV = 0 km/h	1	CA	CA	CA
	2	CA	CA	CA
	3	CA	CA	CA
	4	CA	CA	CA
	5	CA	CA	CA
SV = 60 km/h POV = 0 km/h	1	CA	15.5	CA
	2	CA	16.1	1.3
	3	CA	11.3	CA
	4	CA	--	CA

	5	CA	--	CA
SV = 70 km/h POV = 0 km/h	1	CA	--	16.4
	2	CA	--	14.9
	3	CA	--	18.0
	4	CA	--	--
	5	CA	--	--
SV = 80 km/h POV = 0 km/h	1	CA	--	--
	2	CA	--	--
	3	CA	--	--
	4	CA	--	--
	5	CA	--	--

CA – No Contact occurred during testing
The number in each cell reports the relative speed in which the vehicle tested impacted the lead vehicle test device in km/h
-- Means that no test was conducted for this parameter

The agency also conducted additional PAEB testing. The same vehicles used for the lead vehicle testing presented above were used to evaluate their PAEB performance consistent with the proposed rule. The results of this testing are summarized in the table below. The table provides the maximum speed tested at which the vehicle avoided contacting the pedestrian test device. Of specific note, one vehicle avoided contacting the pedestrian test device at all speeds tested. Some vehicles contacted the test device at 10 km/h but under further testing, demonstrated the ability to avoid contacting the pedestrian test device at much higher speeds. Further details of this testing and additional results are available in the report contained in the docket provided at the beginning of this final rule.

Table 22: Pedestrian AEB Performance
2023 Test Results Summary

	Dir.	Overlap	Obst.	Speed (km/h)		Lighting Condition	Pathfinder	Ioniq 5	Corolla Hybrid	iX xDrive50	F150 Lighting	CX-90
				V_{SV}	V_P							
	Right	25%	No	Any 10 - 60	5	Daylight	50	40	60	50	60	60

Pedestrian Crossing Road	Right	50%	No	Any 10 - 60	5	Daylight	60	60	60	60	60	60
				Any 10 - 60		Lower Beams	60	50	60	60	50	60
				Any 10 - 60		Upper Beams	60	50	60	60	60	60
	Left	50%	No	Any 10 - 60	8	Daylight	50	50	60	60	60	60
	Right	50%	Yes	Any 10 - 50	5	Daylight	40	40	50	50	50	40
Stationary Pedestrian	Right	25%	No	Any 10 - 55	0	Daylight	55	55	55	55	55	55
				Any 10 - 55		Lower Beams	20	50	55	55	30	55
				Any 10 - 55		Upper Beams	55	55	55	55	55	55
Pedestrian Moving Along the Path	Right	25%	No	Any 10 - 65	5	Daylight	50	60	65	65	65	65
				Any 10 - 65		Lower Beams	-	60	65	40	40	60
				Any 10 - 65		Upper Beams	-	60	65	65	65	65

- Denotes the vehicle did not avoid contacting the pedestrian test device at any tested speed.

III. Final Rule and Response to Comments

A. Summary of the Final Rule (and Modifications to the NPRM)

With a few notable exceptions, this final rule adopts the performance requirements from the proposed rule. This rule requires manufacturers to install AEB systems that meet specific performance requirements. These performance requirements include the installation of an AEB system, track testing requirements for avoiding both lead vehicles and pedestrians, false activations test requirements, and malfunction indication requirements.

This final rule includes four requirements for AEB systems for both lead vehicles and pedestrians. First, there is an equipment requirement that vehicles have an AEB system that provides the driver with an FCW at any forward speed greater than 10 km/h (6.2 mph) and less than 145 km/h (90.1 mph). The FCW must be presented via auditory and visual modalities when a collision with a lead vehicle or a pedestrian is imminent. This final rule includes specifications for the auditory and visual warning components consistent with those of the proposed rule, with some modifications to keep the effectiveness of the FCW while reducing the potential costs associated with this rule for some vehicle designs. Similarly, this final rule includes an equipment requirement that light vehicles have an AEB system that applies the brakes automatically at any forward speed that is greater than 10 km/h (6.2 mph) and less than 145 km/h (90.1 mph) when a collision with a lead vehicle is imminent, and at any forward speed greater than 10 km/h (6.2 mph) and less than 73 km/h (45.4 mph) when a collision with a pedestrian is imminent. The maximum speed of lead vehicle AEB is modified from the NPRM, which did not include upper limits on speeds. NHTSA also clarified that this requirement applies only when environmental conditions permit.

Second, the AEB system is required to prevent the vehicle from colliding with the lead vehicle or pedestrian test devices when tested according to the standard's test procedures. These track test procedures have defined parameters, including travel speeds up to 100 km/h (62.2 mph), that ensure that AEB systems prevent crashes in a controlled testing environment. The three scenarios for testing vehicles with a lead vehicle and four scenarios for testing vehicles with a pedestrian test device are finalized as proposed. The agency has finalized pedestrian tests in both daylight and darkness, while testing using the lead vehicle test device is conducted in daylight only as proposed.

Third, this final rule includes the two false activation tests, driving over a steel trench plate and driving between two parked vehicles, in which the vehicle is not permitted to brake in excess of specified amounts proposed in the NPRM.

Finally, a vehicle must detect AEB system malfunctions and notify the driver of any malfunction that causes the AEB system not to meet the minimum proposed performance requirements. The system must continuously detect system malfunctions, including performance degradation caused solely by sensor obstructions. If the system detects a malfunction, or if the system adjusts its performance such that it will not meet the requirements of the finalized standard, the system must provide the vehicle operator with a telltale notification. This final rule has also clarified that the purpose of the malfunction telltale is to provide information about the operational state of the vehicle. Some commenters understood the NPRM to have required that the malfunction telltale activate based on information about the vehicle's surroundings such as low friction road surfaces.

This final rule includes several changes to the NPRM based on the comments received:

First, NHTSA includes in this final rule an explicit prohibition against manufacturers installing a control designed for the sole purpose of deactivating the AEB system but allows for controls that have the ancillary effect of deactivating the AEB system (such as deactivating AEB if the driver has activated "tow mode" and the manufacturer has determined that AEB cannot perform safely while towing).

NHTSA also modifies the FCW visual signal location requirement in this final rule to increase the specified visual angle from 10 degrees to 18 degrees in the vertical direction. This change from the NPRM provides manufacturers with the flexibility to locate the visual warning signal within the typical area of the upper half of the instrument panel and closer to the central field of view of the driver. While the agency continues to believe that an FCW visual warning signal presented near the central forward-looking region is ideal, it does not consider a head-up display to be necessary for the presentation of the FCW visual signal.

In addition, NHTSA modifies in this final rule the range of forward speeds at which the AEB must operate. The NPRM required FCW and AEB systems to operate at any forward speed greater than 10 km/h. This final rule places an upper bound on the requirement that an AEB system operate of 145 km/h (90.1 mph) for FCW and lead vehicle AEB and 73 km/h (45.4 mph) for pedestrian AEB. This final rule also clarifies the environmental conditions under which the AEB system must perform to be the same environmental conditions specified in the track testing.

NHTSA also makes a minor adjustment in this final rule to the measurement method used to characterize the radar cross-section for the pedestrian test devices. It maintains the cross-section boundaries contained within the proposed rule as incorporated from ISO 19206-2:2018 but uses parts of the updated measurement method incorporated from ISO 10206-3:2021. This newer method was proposed for use in measuring the vehicle test device, while the older measurement method was proposed for the pedestrian test devices. The newer method provides for better filtration of noise by using average measurements taken at three radar heights as opposed to the single measurement height specified in the older method. This final rule modifies the measurement methods for the pedestrian test device to match the method used when characterizing the vehicle test device.

Finally, this final rule makes a few significant changes to the lead-time and phase-in requirements. Instead of the deadline proposed under the NPRM, this final rule requires that manufacturers comply with all provisions of the rule at the end of the 5-year period starting the first September 1 after this publication. This will provide manufacturers with more time to meet the requirements of this final rule, as most vehicles do not currently meet all of the performance requirements set forth in this final rule and in light of manufacturer redesign schedules. The added lead time avoids significantly increasing the costs of the rule by compelling equipment redesigns outside of the normal production cycle.

As part of this extension of the lead time, the agency has removed the phase-in approach to the PAEB performance requirements. While the NPRM proposed the most stringent PAEB requirements be met 4 years after a final rule (1 year more than all the other requirements), the agency is finalizing a 5-year lead time for all requirements (eliminating the phasing in of requirements during the lead time).

B. Application

NHTSA proposed that the new FMVSS No. 127 apply to all passenger cars and to all multipurpose passenger vehicles, trucks, and buses with a GVWR of 4,536 kilograms (10,000 pounds) or less. The agency did not propose that the new FMVSS apply to vehicles with a GVWR over 4,536 kilograms (10,000 pounds) or to include motorcycles or low-speed vehicles.

Vehicle Body Types

Several commenters requested that NHTSA consider various vehicle types in the application of the new FMVSS. The Alliance noted that the agency's analysis focused only on performance for sedan, SUV and crossover, and pickup vehicles, and did not consider the constraints associated with the installation of sensors on vehicles with certain vehicle designs such as sports cars, which may affect system capabilities based on unique design characteristics and low profile. FCA noted that the NPRM did not include the low-speed vehicle (LSV) class and supported their inclusion in this rule, in part based on the inclusion of LSVs in the most recent modifications to FMVSS No. 111 and FMVSS No. 141.

While NHTSA acknowledges the Alliance's concerns that mounting forward-looking sensors on certain vehicle body types, such as sports cars, may present some challenges, we believe that technology already present on some existing production vehicles can be adapted to address the concern. We also believe that 5 years provides adequate lead time for manufacturers to consider the changes necessary to their models to implement AEB. We further note that manufacturers are not restricted as to sensor placement. Existing production vehicles have sensors located in a variety of places. NHTSA is aware of several vehicles equipped with radar and camera sensors mounted in the cabin near the rearview mirror. Such a sensor configuration would avoid the installation constraints imposed by small bumpers, avoid placement behind carbon fiber material, and accommodate placement further above the ground.

Regarding FCA's comment, LSVs were excluded from the scope of the final rule for several reasons. First, there are no LSVs on the market that NHTSA is aware of that are currently equipped with AEB or PAEB. This means that NHTSA was not able to procure a vehicle for testing or otherwise evaluate how a LSV would perform if equipped with AEB/PAEB. Second, there is a lack of specific safety data to support an argument that LSVs should be equipped with AEB/PAEB. NHTSA does not want to preclude such vehicles from being equipped with these safety systems, but the current safety data does not provide justification for including them in this rule. Finally, and as discussed in the FRIA, LSVs were not included due to uncertainty about the feasibility and practicability of AEB for those vehicles. Although LSVs were included in the two most recent standard of significance (FMVSS 111 Backup Camera and FMVSS 141 Sound for Electric Vehicles) without practicability concerns, we note that those standards include requirements that provide aids to assist the driver or alerts the driver. In such cases, those features do not require the vehicle to react but instead elicit a driver reaction. As these vehicles were not included in the testing conducted by the agency, our analysis is unable to characterize the performance of AEB on these vehicles. Therefore, in the absence of any data to characterize how these systems may perform on LSVs, they were not included in the final rule.

Heavier Vehicles

The Alliance and FCA commented about the interaction between the proposed standard and FMVSS Nos. 105 and 135, which regulate braking. The Alliance recommended a comprehensive review of the impact of the proposed rule with appropriate accommodations to exclude or include a cap on the applicability of the proposal based on vehicle weight. The Alliance stated that typical electronic stability control (ESC) systems may not provide the fluid flow rates needed to produce the braking performance necessary to meet the proposed rule. FCA noted that the proposed standard applies to vehicles between 7,716 pounds GVWR (the upper limit for FMVSS No. 135 application) and 10,000 pounds GVWR, opining that this proposed standard is not intended to force changes in the underlying braking performance of vehicles in that range and noting that testing has not been conducted on vehicles over 7,000 pounds GVWR. FCA suggested limiting application of proposed FMVSS No. 127 to vehicles under 7,716 pounds GVWR.

NHTSA evaluated compliance test results for FMVSS No. 135 conducted over the last several years. There were 30 vehicles included in this testing, including small sedans, large pickup trucks, minivans, SUVs and other vehicle types to which this new FMVSS would apply. The results indicate that the braking performance of nearly all vehicles was much better than what FMVSS No. 135 requires and the average deceleration for the larger pickup trucks also outperformed some of the smaller sedans, SUVs, and minivans. These test results indicate that braking performance is more than sufficient to permit compliance with this final rule without a need for braking changes or supplements. While this rule is not intended to force changes in the underlying braking performance of vehicles, the commenters stopped short of asserting that braking improvements would be necessary, stating only that improvements may be necessary. Moreover, even if underlying braking performance improvements were necessary, nothing in the comments suggests that there are any technical barriers or any other impediments that would make such improvements infeasible.

Automated Driving Systems

Several commenters suggested exempting vehicles with automated driving systems from the application of some or all of the proposed FMVSS No. 127. Volkswagen recommended exempting autonomous vehicles (AVs) from the parts of the regulation that involve displaying warnings and the parts for which manipulation of manual controls is part of the test procedure. Similarly, AVIA requested that the forward collision warning requirements not apply to AVs.

Zoox requested that the proposed FMVSS not apply to AVs. Zoox viewed the proposed rule as directed toward human drivers, and that applying it to AVs may result in unintended consequences, such as establishing emergency collision avoidance standards for AVs without considering other avoidance tools available to AVs, thereby constraining their safety capabilities.

AVIA also provided suggested changes to the proposed application language that would exclude vehicles equipped with ADS from the requirement to have an AEB system if the ADS meets the performance requirements of the proposed standard. The Alliance commented that ADS-equipped vehicles without manual controls should be exempt from the driver warning and DBS requirements, which it viewed as relevant only when there is a human driver and similarly that the DBS requirements should be applicable only if a brake pedal is installed or required to be installed in the vehicle.

NHTSA expects that ADS-equipped vehicles are capable of meeting the performance requirements of this rule, especially those related to identifying crash imminent situations with vehicles and pedestrians and applying the brakes to avoid contact. Volkswagen is correct that NHTSA is considering how to address telltales, alerts, and warnings, like FCW, in the context of vehicles driven by ADS.[47] While NHTSA continues to engage in research to support the related rulemakings evaluating the application of existing FMVSS to ADS-equipped vehicles, NHTSA is finalizing this rule for all light vehicles and will consider future modifications regarding telltales, alerts, and warnings, as well as crash avoidance standards, generally, for ADS-equipped vehicles as needed under separate rulemaking efforts.[48]

C. Definitions

The proposed rule contained key definitions to facilitate the understanding of the rule. While there were 15 proposed definitions included in section S4 of the proposed new FMVSS, this section focuses on those raised in comments.

AEB System

The NPRM defined an automatic emergency braking system as a system that detects an imminent collision with vehicles, objects, and road users in or near the path of a vehicle and automatically controls the vehicle's service brakes to avoid or mitigate the collision. Several commenters recommended changes to the definition of AEB system:

Bosch asked NHTSA to consider adopting the definition of "Advanced Emergency Braking System (AEBS)" used in United Nations Regulation No. 152 (UNECE R152) to promote global harmonization and enhance clarity in the terminology used across various jurisdictions.

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[47] See https://www.reginfo.gov/public/do/eAgendaViewRule?pubId=202304&RIN=2127-AM07.
[48] See https://www.reginfo.gov/public/do/eAgendaViewRule?pubId=202304&RIN=2127-AM00.

Porsche and Volkswagen stated that the AEB system requirements throughout the NPRM require performance metrics specific to mitigating collisions with lead vehicles and pedestrians, generally not mitigating collisions with objects, but the proposed definition for AEB includes reference to "objects" and "road users." Specifically, Porsche referred to the requirements that the vehicle is required not to apply braking when encountering a steel trench plate. Porsche expressed concern that, by including "object," the AEB definition could introduce confusion in whether braking could be applied in false activation tests. Volkswagen noted that the trench plate could be categorized as an "object." Bosch commented that the broad definition poses challenges in requiring that there is no collision with any "object."

In reference to the term "road users," Porsche and Volkswagen commented that the NPRM referenced pedestrians and was not more broadly inclusive of other road-users such as bicyclists. Both recommended replacing the term "road user" with "pedestrian" to align with the proposed requirements. Bosch did not specifically address the term "road users," but recommended that NHTSA replace "object" with "pedestrian" in the proposal for more clarity and consistency in the context of the FCW and AEB system.

An anonymous commenter stated that the AEB system definition does not specify what constitutes a "crash imminent situation" or how the system determines if the driver has not applied the brakes, or how much braking force is applied to the system. This commenter noted that these are important details that may affect the performance and effectiveness of the AEB system.

BIL requires that an FCW system alert the driver if there is a "vehicle ahead or an object in the path of travel" if a collision is imminent. Consistent with this definition, NHTSA defines an AEB system as one that detects an imminent collision with a vehicle or with an object. However, nothing in the definition of AEB system requires vehicles to detect and respond to imminent collisions with all vehicles or all objects in all scenarios. Such a requirement would be unreasonable given the wide array of harmless objects that drivers could encounter on the roadway that do not present safety risks.

The agency has reviewed the various definitions used in the NPRM to assess whether meaningful harmonization could be achieved with UNECE regulations. In UNECE Regulation No. 152, "Advanced Emergency Braking System (AEBS)" means a system which can automatically detect an imminent forward collision and activates the vehicle braking system to decelerate the vehicle with the purpose of avoiding or mitigating a collision. The definition proposed in the NPRM is functionally very similar, but uses language from BIL. Unlike UNECE Regulation No. 152, NHTSA's definition also provides a level of clarity as to where the detection of vehicles, objects, and road users must occur, that is "in or near the path of a vehicle."

The commenters' concern that this definition requires detection of and reaction to "all objects" is unfounded. NHTSA has also considered the use of the term "road users" in the AEB definition. NHTSA is aware of manufacturers that have designed AEB systems to detect pedestrians. However, the performance requirements make clear that this final rule requires detection and reaction to pedestrians and lead vehicles. The use of "objects" and "road users" merely identify potential hazards on a road that may require emergency braking, but are not intended to impose requirements beyond the requirements set forth in the standard.

The agency considered comments seeking inclusion of various performance requirements in the definitions section. Those comments did not explain why such a change is necessary. As a general matter of regulatory structure, NHTSA limits the definition section to defining terms; the operative regulatory text is the appropriate location for performance requirements and other directives of substantive effect.

Therefore, NHTSA adopts the proposed definition of AEB, which is defined as a system that detects an imminent collision with vehicles, objects, and road users in or near the path of a vehicle and automatically controls the vehicle's service brakes to avoid or mitigate the collision.

Forward Collision Warning

The NPRM defined forward collision warning as an auditory and visual warning provided to the vehicle operator by the AEB system that is designed to induce immediate forward crash avoidance response by the vehicle operator.

Consistent with its comment about alignment of the definition of AEB with UNECE R152, Bosch recommended that NHTSA adopt UNECE R152's Collision Warning definition for the FCW definition: "a warning emitted by the [Advanced Emergency Brake System] AEBS to the driver when the AEBS has detected a potential forward collision."

NHTSA has finalized the definition of FCW as an auditory and visual warning provided to the vehicle operator by the AEB system that is designed to induce immediate forward crash avoidance. This definition provides clarity that both an auditory and visual warning are necessary for a complete warning that is most likely to reengage a distracted driver. For purposes of the test procedure established in this final rule, if only the visual or only the auditory component of the FCW is provided, then the FCW onset has not happened, and the test procedure steps will not take place until both the auditor and visual components are both in place. As such, the UNECE R152 definition suggested by the commenters does not provide this needed clarity.

Zoox also recommended changes to the FCW definition to clarify applicability to conventional vehicles with human drivers only. As noted above, NHTSA is finalizing this rule for all light vehicles and will consider future modifications regarding telltales, alerts, and warnings, as well as crash avoidance standards, generally, for ADS-equipped vehicles as needed under separate rulemaking efforts. Because NHTSA is not adjusting requirements to accommodate ADS, no definition changes are required to address this issue.

Onset

Commenters requested clarification or addition to the definitions to further clarify the proposed requirements and test procedures. The NPRM defined "forward collision warning onset" as the first moment in time when a forward collision warning is provided. Automotive Safety Council sought clarification whether this would be measured in terms of a signal output on the Controller Area Network (CAN) bus, or measured by sound physically emitted from the speaker. NHTSA clarifies that FCW onset would be determined via measurement of the FCW auditory signal sound output within the vehicle cabin and the illumination of the FCW visual signal. CAN bus information would not be used to assess FCW onset.

The NPRM did not provide a definition of braking onset. Humanetics stated that the term "vehicle braking onset" needed further clarification in all test protocols. Humanetics suggested a target value of speed change or deceleration value should be used as an indicator of the time of braking onset.

NHTSA has decided to clarify the term "vehicle braking onset" in the regulation text as Humanetics suggested, by defining the "subject vehicle braking onset" as the point at which the subject vehicle achieves a deceleration of 0.15g due to the automatic control of the service brakes. To ensure clarity in the PAEB test procedure, NHTSA has used the term "subject vehicle braking onset" to clarify that NHTSA is referring to the vehicle braking onset of the subject vehicle. The 0.15g deceleration was adopted based on the agency's experience conducting AEB testing as this value has proven a reliable marker for PAEB onset during track testing.[49]

Other Definitions

NHTSA does not believe that any further additional definitions are necessary for manufacturers to understand the performance requirements of the standard or their obligations. NHTSA believes that terms appearing within the proposed definitions are sufficiently clear from the context of the regulation. For example, we believe the meaning of "crash imminent situation" is discernable from close review of the performance requirements, including the test procedures;

[49] https://www.regulations.gov/document/NHTSA-2021-0002-0002.

from these, the commenter can determine what the agency would consider crash imminent for the set of testable ranges included in this rule.

Finally, NHTSA acknowledges Consumer Reports' and AAA's requests to limit the use of the terms CIB and DBS. NHTSA has already done this by excluding those terms from the regulatory text. While NHTSA used CIB and DBS throughout the preamble to the NPRM and in this final rule, it is doing so because these terms are frequently used by industry, and their use in the preamble helps readers understand what NHTSA is saying, particularly in the context of prior research and NCAP, which use those terms.

D. FCW and AEB Equipment Requirements

NHTSA proposed that an FCW must provide the driver warning of an impending collision when the vehicle is traveling at a forward speed greater than 10 km/h (6.2 mph). Similarly, the NPRM require a vehicle to have an AEB system that applies the service brakes automatically when a collision with a lead vehicle or pedestrian is imminent at any forward speed greater than 10 km/h (6.2 mph). NHTSA stated in the NPRM that this minimum speed should not be construed to prevent a manufacturer from designing an AEB system that activates at speeds below 10 km/h (6.2 mph).

This proposed requirement was described as an equipment requirement with no associated performance test. No specific speed reduction or crash avoidance would be required. However, this requirement was included to ensure that AEB systems are able to function at all times, including at speeds above those NHTSA proposed as part of the performance test requirements where on-track testing is currently not practicable. NHTSA received comments regarding both the minimum required activation speed and the lack of maximum activation speed.

1. Minimum Activation Speed

Comments

MEMA supported not having FCW and AEB performance requirements at a speed below 10 km/h (6 mph), opining that AEB systems do not offer consistent performance at such low speeds.

Bosch and Volkswagen suggested changing the FCW minimum activation speed to 30 km/h. Bosch believed that FCW may not be beneficial at lower speeds because the AEB system proves to be a sufficient solution. Bosch stated that at lower velocities no driver reaction is required because the AEB intervention can fully avoid the collision after the "last time to steer" has already occurred. According to Bosch, as the vehicle speed increases, from 30 km/h upwards, the last point to steer gradually moves to a point after the last point to brake. In effect, a driver warning then becomes beneficial, and FCW can help the driver take appropriate action to avoid or mitigate a collision.

Volkswagen stated that setting a requirement for FCW at low speeds can lead to high false positive rates. Volkswagen also noted that meeting the proposed performance requirements depended on the FCW being issued before the activation of AEB, and could lead to very sensitive system behavior, especially for PAEB. Volkswagen suggested increasing the minimum FCW activation speed to 30 km/h, but suggested it would still be acceptable to display the FCW symbol simultaneously with AEB activation at speeds below 30 km/h to make the driver aware of the event that just occurred.

The Center for Auto Safety disagreed with the 10 km/h minimum speed threshold saying that it was not clear why it was selected. The Center for Auto Safety commented that PAEB should be activated as soon as the vehicle is shifted into gear to avoid injurious or fatal rollovers of children and other hazards. Consumer Reports commented that it understood the technical reasons for the proposed minimum speed of 10 km/h (6.2 mph), but expressed concern that such a lower speed bound would fail to address the issue of what it described as "frontover" incidents.[50] Consumer Reports said there had been an increase in "frontover" incidents since 2016, and that it believed that the increasing market share of larger vehicles with increased blind zones was correlated with this increase.

Agency Response

NHTSA is finalizing a minimum activation speed of 10 km/h as proposed. The agency considered increasing this minimum to 30 km/h, as suggested by some commenters, to avoid unwanted and unnecessary alert at low speeds. However, after considering the potential impacts of such a modification, particularly the safety of pedestrians, the agency is finalizing the minimum activation speed as proposed for the forward collision warning. This 10 km/h minimum threshold is also harmonized with UNECE Regulation No. 152. Furthermore, as stated in the NPRM, 6 of 11 manufacturers whose owner's manuals NHTSA reviewed indicated that their AEB system have a minimum speed below 10 km/h. NHTSA is encouraged that manufacturers are choosing to have lower speed thresholds for AEB functionality.

As for frontover crashes, NHTSA agrees with Consumer Reports about the importance of understanding driver visibility and about the need to reduce such crashes. Additional research is needed to develop accurate and rigorous methods of evaluating direct visibility from the driver's seat. Research is also needed to better understand the safety problem and the scenarios associated with forward blind zones and frontover crashes. Beginning in January 2023, two new non-traffic

[50] There is not yet a finalized definition of "frontover" that is used within NHTSA or outside of NHTSA, and NHTSA is currently researching how this crash type should be defined. As NHTSA previously indicated, until more data is gathered via the Non-Traffic Surveillance (NTS) system, actual frontover crash counts are difficult to confirm due to the challenges law enforcement faces in distinguishing these crashes from other forward moving vehicle impacts with non-motorists and to the locations where these crashes often occur. For example, a forward moving vehicle crash involving a driver turning into a driveway and striking a child playing in the driveway would typically not be considered a frontover; but if that driver struck the child while pulling out of a garage (having backed into the garage), it would be considered a frontover. These nuances pose difficulties for law enforcement to accurately capture frontover incidents which, in turn, complicates our data collection. Additionally, frontover crashes frequently occur in driveways and parking lots that are not located on the public trafficway; thus, law enforcement may not report these occurrences using a crash report.

crash data elements related to backovers[51] and frontovers were added to the agency's Non-Traffic Surveillance System, which will enhance evaluation of the scope and factors associated with frontover crashes.

2. Maximum Activation Speed

Comments

The National Transportation Safety Board (NTSB) supported the proposed requirements for FCW, specifically pertaining to the necessity of the warning at all speeds above 10 km/h, but the NTSB stated that FCW activation must never delay AEB engagement. NTSB stated that its support was rooted in several NTSB investigations of vehicles operating in partial automation mode at the time of the crash.

In contrast, many commenters raised substantial concerns about the proposed NPRM requirement that FCW and AEB function, at least at some level, at all speeds and under all environmental conditions. Among these concerns was that the requirement would not meet various aspects of the Safety Act.

The Alliance disagreed with the agency setting undefined performance requirements that are not stated in objective terms consistent with 49 U.S.C. 30111 and urged NHTSA to provide clarification when issuing a final rule that compliance verification will be measured only by defined test procedures that meet established criteria for rulemaking. It objected to what it viewed as undefined performance requirements without a clearly demonstrated safety need that create significant challenges from a product development perspective, making it unclear whether or how NHTSA might seek to verify compliance. Without defined and objective criteria, the

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[51] NHTSA has previously defined backover crashes as crashes where non-occupants of vehicles (such as pedestrians or cyclists) are struck by vehicles moving in reverse. See https://www.federalregister.gov/documents/2014/04/07/2014-07469/federal-motor-vehicle-safety-standards-rear-visibility.

Alliance thought that policy uncertainty would create ambiguity about potential enforcement actions as there would be no clear parameters to reliably measure performance.

The Alliance suggested that a defined upper bound or maximum operational speed for the AEB/PAEB system was needed due to the possible unstable vehicle dynamics that could result from hard braking at very high speeds. Furthermore, the Alliance opposed open-ended performance requirements through regulation without objective test procedures, noting that it becomes increasingly more challenging to provide significant levels of speed reductions at higher speeds, and it viewed the expectation that manufacturers are capable of providing undefined levels of avoidance at all speeds as neither practicable nor reasonable. According to the Alliance, requirements that exceed the current speed ranges must be supported by relevant data to support practicability and must include defined and objective test procedures. The Alliance noted that the complexity of designing systems capable of going beyond what the agency proposes to test would likely result in significant development costs that are not accounted for in the agency's cost-benefit analysis and that would add unnecessary costs for consumers, while diverting research and development efforts from other priority areas that may yield greater improvements in vehicle safety.

Multiple automakers expressed similar concerns, some recommending that NHTSA limit AEB activation to maximum speeds and several specifying suggested upper bounds. For example, Honda suggested that NHTSA limit AEB activation to when the vehicle is traveling at maximum 135 km/h (84 mph) when approaching a lead vehicle traveling at maximum 75 km/h (47 mph) and limit pedestrian AEB activation to when the vehicle is traveling at maximum 88 km/h (55 mph). Porsche suggested that for the lead vehicle, DBS apply to speeds above 100 km/h (62 mph) and for pedestrians to speeds above 65 km/h (40 mph), and that crash imminent braking (CIB) be required to operate between 10 km/h (6 mph) and 100 km/h (62 mph) for lead vehicle and between 10 km/h (6 mph) and 65 km/h (40 mph) for pedestrian. Porsche also provided suggested regulatory text.[52]

NTSB expressed similar concerns about the need for testing, stating that without a dedicated test protocol or an explicit statement about the extent of operational functionality, broader capabilities (above the testing requirements) remain only presumed and not necessarily expected. NTSB encouraged NHTSA to clarify its intent and expectations for system performance in scenarios and conditions outside the proposed test-track compliance testing by considering additional testing or other compliance tools to examine the performance of AEB systems under other real-world conditions, and particularly whether the operational functionality would extend to non-tested hazards such as traffic safety hardware, bicyclists and motorcyclists, and vehicles with untested profiles or at varying angles and offsets.

Commenters raised potential technical challenges to effective implementation of the proposed requirement. For example, Honda was concerned about AEB and radar sensor limitations when operating at high speeds—mainly the complex interdependency between speed and the distance and accuracy at which objects must be detected to be avoided (or even to mitigate a crash). Honda noted that higher speeds mean that objects will need to be detected at greater distances, and at greater distances there is less image resolution, greater positional error, and greater impact from things like roadway geometry. Honda and Porsche stated that requiring braking to occur at unrestricted high speeds leads to misidentification of objects and increases false positive activations.

Honda further asserted that camera resolution is limited by the pixel count on the image capture chip and that at longer distances, the number of pixels for an object will be reduced, resulting in blur that makes it difficult to detect objects (the blur can be further exacerbated by the designed focal length of the lens). Further, Honda stated that a higher resolution can be

[52] https://www.regulations.gov/comment/NHTSA-2023-0021-0868.

achieved only through new sensor hardware that would require further developmental work as well as more processing power, including a change of imaging processing electronic control unit (ECU). Honda stated that for camera-radar fusion systems, small errors in the fusion algorithm are amplified at higher speeds (due to the longer distances) and could compromise the system's performance. Additionally, according to Honda, these reductions in sensor accuracy significantly increase the risk of misidentification of potential objects and may lead to excessive false positive activations, potentially creating negative safety consequences. This could include situations where the system mistakenly recognizes the same lane as the adjacent lane or roadway objects as other vehicles.

Other commenters also raised concerns about the potential for false activations caused by the need for AEB to operate at very high speeds. For example, Volkswagen commented that false activation becomes more of a risk as speeds increase, and that these risks are not controllable, as defined in ISO 26262.

Commenters raised concerns about whether braking was the most appropriate avoidance maneuver in high-speed scenarios. Honda was concerned that AEB activation might interfere with other technologies such as the Automatic Emergency Steering. Mitsubishi, and Toyota echoed the Alliance's concern that in some situations AEB activation while traveling at high speed may induce unstable vehicle dynamics. Mitsubishi stated that these situations may occur due to unfavorable interactions with road surface conditions, road curvature, or for other unpredictable reasons. Mitsubishi thought that such activation could also lead to unexpected outcomes for a vehicle following the subject vehicle.

Rivian stated that if post-crash review is used to assess compliance, it may introduce a number of uncontrollable or subjective variables into the compliance evaluation. Rivian opined that post-crash review would necessarily involve evaluation of a motor vehicle that is no longer a new motor vehicle and that may have been modified or altered in a manner to affect the AEB performance. It further noted that varying environment or roadway conditions could also impact the AEB performance and, without a proper comparison using reference test equipment, it would be difficult to identify discrepancies between the expected AEB results and the actual results, limiting the technical effectiveness of a post-crash review.

Commenters suggested a number of different solutions to resolve their concerns. Most requested that the all-speeds requirement be removed. Alternatively, Honda and others (as noted earlier) asked that NHTSA establish a maximum speed at which AEB detection performance is assessed according to an established test procedure. Volkswagen asked that NHTSA exclude activation against vulnerable road users at high speeds, believing it would decrease false positive rates significantly. Volkswagen thought this could be justified as pedestrians would not be expected on the roads with these higher speeds.

Agency Response

<u>Authority under the Safety Act</u>

Various commenters asserted that performance requirements without objective test criteria were inconsistent with the Safety Act's requirements for objectivity and practicability. NHTSA believes that these assertions reflect a misunderstanding of the proposal. Essentially, NHTSA proposed specific performance requirements for AEB within a defined range of speeds (accompanied by specific testing procedures) and, separately, an equipment requirement—i.e., a requirement for a functioning vehicle AEB system. The proposed requirement for a functioning AEB system at all speeds was an equipment requirement, not a performance requirement. Case law supports that where a performance standard is not practical or does not sufficiently meet the need for safety, NHTSA may specify an equipment requirement as part of an FMVSS.[53] Testing at high speeds is not practical due to the dynamics of such testing and testing equipment limitations. As detailed in the NPRM, the testing requirement upper speeds are based on the

[53] *Chrysler Corp. v. Dep't of Transp., OT*, 515 F.2d 1053 (6th Cir. 1975) (holding that NHTSA's specification of dimensional requirements for rectangular headlamps constitutes an objective performance standard under the Safety Act).

capability to safely and repeatably conduct testing. The testing devices can only be driven, and can only tolerate impacts, up to certain speeds. These edge speeds are the main limiting factor for the upper bound of the testing speeds, as testing above those speeds would be impractical. NHTSA has previously specified an equipment requirement without an accompanying test procedure. For example, under FMVSS No. 126, NHTSA issued an equipment requirement for understeer and explained why a performance test for understeer was too cumbersome for the agency and the regulated community.[54] In the final rule for FMVSS No. 126, NHTSA stated that historically, "the agency has striven to set motor vehicle safety standards that are as performance-based as possible, but we have interpreted our mandate as permitting the adoption of more specific regulatory requirements when such action is in the interest of safety."[55]

There are other FMVSS that contain equipment requirements, sometimes in addition to performance requirements. FMVSS No. 111 has several requirements that are equipment requirements. S5.1 of FMVSS No. 111 requires that each passenger car be equipped with an inside rearview mirror of unit magnification, which is the equipment requirement without an associated test procedure. S5.3 requires that any vehicle that has an inside rearview mirror that does not meet the performance requirements for field of view included in S5.1.1 must also have an outside rearview mirror meeting certain performance requirements. FMVSS No. 135 requires that the service brakes shall be activated by means of foot control. This is an equipment requirement in an FMVSS that also has performance requirements. S5.1 of FMVSS No. 224, "Rear impact protection," requires trailers and semitrailers with a GVWR of 4,536 kg or more to be equipped with a rear impact guard certified as meeting FMVSS No. 223, "Rear impact guards."

Technical Concerns

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[54] 72 FR 17236 (Apr. 6, 2007).
[55] *Id*. at 17299.

Various commenters raised concerns about technical limitations that might create challenges for AEB systems at high speeds, such as sensor limitations, false activations, and whether hard braking was an appropriate response at higher speeds.

NHTSA is aware, from a review of owner's manuals, that many manufacturers have equipped their vehicles with AEB systems that activate at speeds higher than the testable ranges NHTSA proposed. As an example, the 2022 Toyota Prius Prime owner's manual informs vehicle owners that the maximum AEB activation speed for its system is 180 km/h (112 mph). Other examples include: the 2023 Hyundai Palisade lists the maximum AEB activation speed as 200 km/h (124.27 mph), the 2018 Tesla Model 3 Dual Motor lists the maximum AEB activation speed as 150 km/h (93.2 mph), the 2021 Volvo S60 lists the maximum AEB activation speeds as 115 km/h (71.4 mph), the 2021 Ford Bronco lists the maximum AEB activation speed as 120 km/h (74.5 mph), and the 2022 Lexus NX 250 lists a maximum AEB activation speed of 180 km/h (111.8 mph). This demonstrates that it is common practice for AEB systems to function above the testable range of speeds.

The agency considered comments asserting that higher travel speeds require longer sensing ranges. However, the equipment requirement does not specify a particular speed reduction or level of avoidance. The agency considered the kinematics for an AEB system installed on a vehicle that meets the track test requirements at 80 km/h without manual braking. For a vehicle with automatic initiated deceleration capabilities of 0.7g, in a lead vehicle stopped situation, the brakes must be applied at a distance of approximately 37 m (equates to a time-to-collision of 1.66 s). In such a situation, the vehicle's sensor range would need to demonstrate capabilities at a distance of at least 37 m. In a similar rear end collision situation with the vehicle traveling at 145 km/h and an identical detection range of 37 m, the time-to-collision would be only 0.91 s. If the vehicle applied the same 0.7g deceleration at the same 37 m distance, a collision would not be avoided. A theoretical collision would occur with the vehicle impacting the stopped vehicle at 119 km/h (74 mph). However, the vehicle would have an AEB system that applied the brakes when a crash is imminent, as the proposal would require.

Requiring that the AEB system function at higher speeds has significant safety benefits. According to the injury risk curve used in the FRIA available in this docket, the probability of a fatality occurring in a rear-end collision where the striking vehicle is impacting at 90 mph is almost 20 percent. That probability is reduced to 6.8 percent for a travel speed of 74 mph. That reduction in fatality risk is afforded with little to no additional sensing system capabilities beyond what is required to satisfy the track tested requirements. In other words, if the AEB system activates at 90 mph and slows the vehicle down by just 16 mph, the risk of a fatality declines significantly. If the system were deactivated at speeds above the test procedure limit of 62 mph, many more fatalities would occur than if the system is activated and functioning with the capabilities required to satisfy the track tested requirements. Beyond 145 km/h (90.1 mph), however, the expected safety benefits are greatly diminished, primarily because very high travel speeds are relatively uncommon and currently above legal operating speeds in the U.S.

NHTSA does recognize that pedestrian crash interactions are much less straightforward kinematically than a lead vehicle rear-end crash interaction. This is because the pedestrian may be moving in any number of directions in front of the vehicle, including suddenly darting in front of a vehicle, making detection and mitigation more challenging as speed increases. In such situations, the agency agrees with commenters that it is not practical to require an alert and braking at speeds greatly above those for which the track test applies. For this reason, this final rule reduces the speed range for pedestrian detection functionality to any speed greater than 10 km/h (6.2 mph) and less than 73 km/h (45.4 mph). Similarly, for pedestrian AEB functionality, this final rule reduces the upper end speed for which alerts and braking are required to 73 km/h (45.4 mph). This speed range balances practicability and safety.

Post-Crash Review

As for Rivian's comment on post-crash review, NHTSA can determine compliance with this equipment requirement through visual observation and other information, if requested from the manufacturer. Post-crash review is an important tool to the agency. NHTSA acknowledges Rivian's discomfort with post-crash review being considered as a primary tool for compliance purposes, but NHTSA does not believe post-crash review will be necessary to enforce this requirement. Instead, NHTSA believes it can rely on visual observation, manufacturer test results used as a basis for certification, and other information to determine whether a vehicle meets this equipment requirement.

Conclusion

After careful consideration and in response to commenters stating that there was not a safety need justifying the lack of a maximum speed cap on this equipment requirement, NHTSA has decided to modify the proposed requirement. The agency recognizes that while vehicles are capable of very high speeds, the current maximum speed limit in the United States is 85 mph. With this in mind and in response to comments urging a speed cap for AEB operation, NHTSA decided to require that AEB systems operate (i.e., warn the driver and apply the brakes) at speeds up to 145 km/h (90.1 mph) for lead vehicle detection and 73 km/h (45.4 mph – based on the overall complexity of detecting and differentiating between an imminent pedestrian crash and a pedestrian encounter that is unlikely to result in a crash, such as when a pedestrian is located on the sidewalk) for pedestrian detection. NHTSA also believes that adopting this speed cap is consistent with the agency's analysis of the safety problem and with NHTSA's goals of resolving as much of the safety problems as possible.

NHTSA believes this requirement is feasible, particularly in light of the absence of any performance requirements (for example, that a vehicle brake automatically to avoid contact) other than at the speeds tested in the performance requirements specified in this standard. This final rule simply requires that an AEB system function to warn and apply the brakes at speeds up to 145 km/h (90.1 mph) for FCW and lead vehicle AEB. The agency is not preventing manufacturers from having FCW activate at speeds above 145 km/h (90.1 mph). NHTSA is aware from recent research into owner's manuals that many AEB systems operate at speeds above the testable range, and NHTSA wants to ensure that manufacturers have the flexibility to provide FCW (and AEB) at speeds above those included in this final rule. This maximum required activation speed addresses the concerns raised by commenters about a requirement without an upper bound.

3. Environmental Conditions

In the NPRM, NHTSA explained that this equipment requirement was intended to complement the performance requirements by, among other things, ensuring that AEB systems continue to function in all environments, not just the test track environment. Unlike track testing, real world traffic scenarios may involve additional vehicles, pedestrians, bicyclists, buildings, and other objects within the view of the sensors and should not negatively affect their operation.

NHTSA received several comments expressing concern about the unspecified environmental conditions included in the NPRM.

NHTSA is committed to establishing performance requirements that are as reflective of the real world as possible, and that encourage manufacturers to develop robust AEB systems with sufficient resiliency to handle the widely variable scenarios they are intended to handle. In general, NHTSA is concerned that high system brittleness will not provide the maximum safety benefits and could be confusing to the public because of expectations about how AEB systems should work. The language of the NPRM sought to provide safety under environmental conditions outside of those specified in a track testing environment.

That said, NHTSA agrees with commenters that the expectation that the AEB system work in unspecified environments should be clarified for manufacturers to certify that their vehicles will meet the equipment requirement established by this final rule. There are environmental conditions that may preclude the safe application of automatic braking, and to a lesser extent warnings. However, the complexity of conditions and combination of conditional factors make it difficult to clearly enumerate those conditions. Therefore, this final rule now clearly specifies the conditions in which the systems are expected to perform to meet the equipment requirement are those conditions specified for testing the performance requirements. Notwithstanding this specificity, NHTSA encourages manufacturers to continue working toward delivering AEB systems that are robust and that function in as many real-world environments as possible.

The Utah Public Lands Alliance commented that the proposed rule did not take into account the complexities of off-road environments, such as obstacles, mud, rocks, and varying slopes, which may render the AEB less effective or even cause false alarms, disrupting the driving experience. NHTSA notes that the final rule does not include off-road environments as a required aspect of AEB performance because the agency's authority under the Safety Act focuses on the on-road environment.

E. AEB System Requirements (Applies to Lead Vehicle and Pedestrian)

1. Forward Collision Warning Requirements

Because the window of time that FCW affords a driver in a crash-imminent situation is small, the proposed warning characteristics were intended to facilitate quick direction of the driver's attention to the roadway in front of them and to compel the driver to apply the brakes assertively. The FCW criteria proposed were based on many years of warning research and vehicle crash avoidance research conducted by NHTSA and others as described in the NPRM. The criteria seek to achieve an effective warning strategy that is consistent across vehicle models and proven by research to promote the highest likelihood of drivers quickly understanding the situation and responding efficiently to avoid a crash.

Comments

Commenters generally supported a requirement for an FCW to be presented for lead vehicle and pedestrian scenarios. However, a majority of commenters preferred more flexibility of FCW implementation than is afforded by the requirements, as summarized below.

Multiple commenters were opposed to the degree of specificity included in the proposed FCW requirements. These commenters thought that the state of varied implementation of FCW that exists currently was sufficient. For example, Volkswagen opined that the regulation "should specify the warning modes (visual, auditory, optionally haptic), but leave the implementation up to the manufacturer if the warning is easily perceivable and visually distinguishable from other warnings." Volkswagen thought that variation in FCW strategy across manufacturers would not be a problem since manufacturers "explain their warning strategy in their owner's manuals." Similarly, the Alliance contended that U.S. customers may be "already familiar with the ISO symbol and flashing alert" and that it "would be beneficial to safety" for NHTSA to allow flexibility for manufacturers to select the visual warnings deemed to be most effective in the context of the overall vehicle HMI.

IIHS cited its own research as a basis for contending that the proposed FCW "design requirements are unnecessarily overly prescriptive" given that "existing industry practices for FCW are not only effective for preventing crashes but are also acceptable and understandable to drivers." IIHS highlighted its crash data analyses for FCW-equipped vehicles stating, "Our analyses of police-reported crashes and insurance loss data indicate that most FCW systems are effective for preventing rear-end crashes despite disparate designs. Cicchino (2017) examined rear-end crash involvement rates for vehicles with FCW from five automakers relative to vehicles without the system. The presence of FCW was associated with statistically significant reductions in rear-end crash involvement rates for three of the five automakers."

Some commenters suggested that the FCW requirements should more closely follow other related standards. Ford recommended establishing FCW requirements similar to existing

AEB regulations from Europe (UNECE R152[56]), Australia (ADR98[57]), and Korea (KMVSS[58]) instead of restricting the individual components of the warning. Hyundai opposed "overly specifying details for FCW and oppose[d] the use of SAE J2400 standards (particularly 10-degree vision cone provision)." Porsche's comments sought additional flexibility and alignment with UNECE Regulation No. 152.

Lastly, multiple commenters voiced support for standardization of FCW characteristics. The GHSA indicated support for FCW standardization, stating that "increased consistency will bolster the safety impact of these features as drivers become more accustomed to what to expect and how to react when these systems are engaged." AAA also expressed support for standardization, stating that "consumers would find it beneficial to standardize visual alert characteristics… such as the location of the warning." AAA cited its previous testing experience that found "characteristics among vehicles significantly vary with some warnings hardly noticeable relative to visual warnings presented in other vehicles." As a result, AAA urged NHTSA to "consider standardization requirements for visual alerts to promote consistency and understanding for all drivers, particularly hearing-impaired drivers who may not perceive an auditory signal."

Agency Response

NHTSA notes the general support from commenters for requiring some kind of FCW to be presented prior to AEB activation. The point of FCW is to elicit a timely and productive crash avoidance response from the driver, thereby mitigating or, if possible, avoiding the need for AEB to intervene in a crash-imminent situation. The proposed FCW characteristics outlined

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[56] UN Regulation No 152 – Uniform provisions concerning the approval of motor vehicles with regard to the Advanced Emergency Braking System (AEBS) for M1 and N1 vehicles [2020/1597] (OJ L 360 30.10.2020, p. 66, ELI: http://data.europa.eu/eli/reg/2020/1597/oj).

[57] Australian Design Rule, Vehicle Standard (Australian Design Rule 98/01 – Advanced Emergency Braking for Passenger Vehicles and Light Goods Vehicles) 2021.

[58] Korean Motor Vehicle Safety Standard (KMVSS) Article 15-3, "Advanced Emergency Braking Systems (AEBS)."

in the NPRM are based on more than 35 NHTSA research efforts related to crash avoidance warnings or forward collision warnings conducted over the past nearly 30 years. Other research, existing standards (ISO Standards 15623 and 22839), and SAE documents (J3029 and J2400) also were considered as input for the proposed requirements. While multiple commenters sought flexibility for automakers to use an FCW of their own preference in lieu of one conforming to the proposed specification, no safety data were provided concerning consumers' degree of understanding of the wide variety of existing FCW implementations—just generalized statements about consumer familiarity. NHTSA does not view these arguments as sufficient to overcome the value of standardization as a means of ensuring consumer familiarity.

Data from NHTSA's 2023 AEB testing showed that each of six test vehicle models from different manufacturers used a different FCW visual signal or symbol. Only one model used the ISO FCW symbol. FCW visual symbols that differ by manufacturer and, in some cases across models from the same manufacturer, are likely to lead to confusion among consumers. The observed substantial variety in existing FCW implementations highlights the need for improved consistency of FCW visual symbols to increase efficient comprehension of crash-imminent warnings by vehicle operators and aid them in understanding the reason for their vehicle's (or, indeed, an unfamiliar rental vehicle's) active crash avoidance intervention. Allowing for individual design choices—even those with positive safety records—does not address this important safety consideration.

Such confusion has also been documented by past research. Research by industry published in a 2004 SAE paper focused on comprehension testing of active safety symbols and assessed the ISO FCW symbol and the SAE J2400 FCW symbol to assess their ability to communicate the idea, "Warning: You may be about to crash into a car in front of you." Results of that research showed the ISO FCW symbol to have 45 percent "high comprehension" and the SAE J2400 symbol to have 23 percent high comprehension. However, while high comprehension was noted for the lead vehicle crash scenario, NHTSA is not aware of any data supporting effectiveness of the ISO FCW symbol for communicating the idea of an impending forward pedestrian crash." [59]

NHTSA acknowledges the research by IIHS showing crash reduction benefits from some existing FCW designs. IIHS research results found that some automakers' FCW designs were associated with higher crash reductions than others. However, this research did not evaluate FCW characteristics by automaker or by model for vehicle models it studied and whether such characteristics may have contributed to FCW effectiveness differences, so care should be taken when drawing conclusions. Regardless, while the IIHS studies have shown some existing FCW in light vehicles are effective for preventing rear-end crashes, research does not support an argument against taking other measures to increase FCW effectiveness, as this action seeks to do. It is likely that increasing the consistency of FCW characteristics and standardization of the primary warning signals across vehicles and models will lead to benefits beyond those documented to date due to increased driver understanding of the meaning of FCW signals.

The agency disagrees with Volkswagen's comment that explanations in the owner's manual adequately inform consumers about manufacturer-specific FCW signals. A British study found that only 29% of motorists surveyed had read their car handbook in full.[60] That same study examined owner's manual word counts and estimated that the time required to read some of the longest would take up to 12 hours. An April 2022 Forbes article states that "the average new-vehicle's owners' manuals, which, concurrent with the complexity of contemporary cars, have become imposingly thick and mind-numbing tomes of what should be essential information... remain unread in their respective models' gloveboxes."[61] With these concerns in

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[59] Campbell, John & Hoffmeister, David & Kiefer, Raymond & Selke, Daniel & Green, Paul & Richman, Joel. (2004). Comprehension Testing of Active Safety Symbols. 10.4271/ 2004-01-0450.
[60] "Car Handbooks Are Longer Than Many Famous Novels - Have You Read Yours?" https://www.bristolstreet.co.uk/news/car-handbooks-are-longer-than-many-famous-novels--have-you-read-yours/.
[61] "Here's Why Nobody Reads Their Car's Owner's Manual" https://www.forbes.com/sites/jimgorzelany/2022/04/07/heres-why-nobody-reads-their-cars-owners-manual/?sh=2a76d5d4462d.

mind, NHTSA does not believe that owner's manual information is an acceptable substitute for standardization of this important safety functionality across all vehicles.

After careful review of these comments, NHTSA has decided to adopt a majority of the proposed FCW requirements unchanged as described in the following sections.

a. FCW Signal Modality

NHTSA proposed that FCW modalities and related characteristics of auditory and visual components be the same for lead vehicle AEB and PAEB performance, and that the FCW be presented to the vehicle operator via at least two sensory modalities—auditory and visual. The FCW auditory signal was proposed to be the primary means used to direct the vehicle operator's attention to the forward roadway. NHTSA did not propose to require a haptic FCW signal component but invited comment on whether requiring FCW to contain a haptic component presented via any location may increase FCW effectiveness or whether an FCW haptic signal presented in only one standardized location should be allowed.

Comments

Of those commenting on FCW signal modality, all supported a multimodal FCW signal strategy. Multiple commenters including NTSB, Consumer Reports, Ford, GHSA, Honda, MEMA, and Porsche expressed support for the combination of auditory and visual warning modalities that was proposed by NHTSA. For example, NTSB expressed support for visual and auditory warning, and noted several NTSB investigations in which visual warnings were found to be ineffective in capturing drivers' attention. GHSA expressed support for requiring standardized auditory and visual warnings when a collision is imminent, believing that increased consistency would bolster the safety impact of these features. Ford supported an auditory and visual alert based on their experience implementing an FCW system. Honda stated that a multimodal auditory and visual warning provided sufficient redundancy. Consumer Reports also highlighted the importance of providing a visual warning for those who are hearing impaired, who are listening to music, or are otherwise distracted.

The remaining supporters of the multimodal approach preferred the flexibility to use any combination of possible modalities (auditory, visual and haptic). These included the Alliance, ASC, Bosch, GM, HATCI, and Rivian. For example, the Alliance agreed with the agency's conclusion that the auditory signal should be the primary means of communicating with the driver, but expressed support for allowing warnings to be provided using any combination of two of the three alert modalities, with a third allowable, but not required. ASC recommended that the warnings be aligned with UNECE Regulation No. 152. ASC and ZF also cited research showing FCW with auditory and haptic components prompt a quicker driver reaction time than FCW with auditory and visual components.

Ford and MEMA agreed that OEMs should be permitted to supplement the primary auditory and visual FCW signal modalities with a haptic warning component. Bosch encouraged NHTSA to include haptic as one of the warning modes, citing the potential for advantages in loud environments or with hearing impaired individuals. Volkswagen agreed with NHTSA's proposal to not require an FCW haptic component, but clarified that if haptic was required, then only two out of the three warning types should be required. HATCI requested that NHTSA permit haptic signals to be used as the primary or secondary warning, stating that haptic warnings draw the driver's attention to the hazard without requiring them to identify a warning symbol with their eyes.

Consumer Reports suggested that a haptic signal may cause driver confusion because haptic steering signals are also used by many lane departure warning systems, which activate more frequently. Along the same line, Porsche noted its desire "to avoid causing driver confusion related to other safety systems where haptic signals may be more appropriate (e.g., steering wheel vibration used for lane keeping)."

Agency Response

After consideration of the comments, NHTSA is moving forward with the originally proposed requirements for a primary FCW auditory signal and a secondary visual signal, while neither requiring nor prohibiting a supplementary FCW haptic signal. While a few commenters expressed the desire to require a haptic FCW signal, no supporting data were provided. Therefore, NHTSA declines to make a haptic warning signal a requirement. However, NHTSA cautions those interested in implementing supplementary FCW haptic signals to take steps to ensure that the haptic signal used will not be confused with those currently used in association with systems not designed to elicit a forward crash avoidance response, for example, lane-keeping driver assistance features.

b. FCW Auditory Signal Requirements

NHTSA proposed that the FCW auditory signal would be the primary warning modality and asserted criteria to ensure that the FCW would be successful in quickly capturing the driver's attention, directing the driver's attention to the forward roadway, and compelling the driver to quickly apply the brakes. NHTSA proposed that the FCW auditory signal's fundamental frequency be at least 800 Hz and that it include a duty cycle, or percentage of time the sound is present, of 0.25 - 0.95, and a tempo in the range of 6-12 pulses per second. This final rule also includes FCW requirements that were discussed in the NPRM. Specifically, the FCW auditory signal is required to have a minimum intensity of 15-30 dB above the masked threshold.

Comments

GHSA, Honda, and Rivian supported the proposed standardized FCW auditory signal requirements. Honda stated that the proposed tone, tempo, and frequency would contribute to making this a distinct and recognizable warning, especially if standardized across the fleet. Rivian agreed that a common FCW auditory signal is necessary so that drivers can easily recognize warning conditions across different vehicle makers and models.

Multiple commenters, including the Alliance, Ford, Nissan, Porsche, Toyota, and Volkswagen indicated a preference for more flexibility in the allowed FCW auditory signal characteristics. More specifically, the Alliance and Nissan stated that not defining the required sound level and characteristics is consistent with UNECE Regulation No. 152. Ford recommended that the manufacturer be provided with flexibility to design FCW auditory warning signals. Ford stated that the parameters for an audible alert are often tuned for different vehicle applications or customizable by drivers. Both Porsche and Volkswagen contended that consumers may be used to existing FCW auditory signals used in current vehicles. Volkswagen further stated that allowing flexibility in FCW auditory signal characteristics enables manufacturers to update or adjust the warnings as technologies evolve.

Regarding FCW auditory signal distinguishability, IIHS recommended that NHTSA consider IIHS's method for assessing auditory seat belt reminders to ensure auditory FCWs are easily discerned by drivers beyond ambient levels of sound inside the vehicle.

On the issue of FCW auditory signal deactivation, Hyundai MOBIS encouraged NHTSA to consider permitting the audible warning to be suppressed as long as the FCW visual warning remains illuminated.

Agency Response

The FCW auditory signal minimum intensity requirement was inadvertently left out of the proposed regulatory text, although it was discussed in the preamble of the NPRM. Multiple commenters addressed the topic of FCW auditory signal intensity in their comments. While multiple commenters disagreed with NHTSA's proposed FCW auditory signal criteria, NHTSA's data from 2023 AEB testing also showed that some existing systems already meet some of the FCW proposed requirements. One vehicle, a 2024 Mazda CX-90, met all proposed FCW auditory requirements. Two vehicles met all proposed auditory requirements except the minimum intensity requirement of 15–30 dB above the masked threshold. Two other vehicles met 3 of the 5 FCW auditory signal requirements while the last vehicle met only 2 of the 5 requirements. All six vehicles' FCW auditory signals met the proposed duty cycle requirement and four of the six met the fundamental frequency requirement. Some variety in AEB test vehicles' FCW auditory signals was also seen. FCW auditory signal intensities above the masked threshold spanned a range of 28.8 dBA and five of the six tested vehicles did not meet the proposed intensity requirement. FCW auditory signals fundamental frequencies ranged from 600 to 2000 Hz.

NHTSA believes that auditory signal intensities are especially important for FCW because of the urgency of the crash-imminent situation, the goal of compelling a driver to apply the brakes, and the speed with which action is necessary. Additionally, the minimum sound intensity is supported by research that provides a strong foundation for this requirement. Commenters who did not support the proposed FCW auditory signal requirements provided no data to document the effectiveness of existing FCW auditory signals, nor the purported benefits of permitting vehicle manufacturers to choose their own unique FCW designs. While providing flexibility for design choices that have been proven to increase safety is valuable, providing flexibility that allows for differences related to branding or that just serves to make a model unique does not add safety value.

Regarding Ford's comment expressing interest in the ability to decrease FCW auditory signal intensity when the driver's alertness level is confirmed to be high, NHTSA notes that the proposed requirements provide leeway for manufacturers to implement a less invasive advisory or preliminary alert that would precede the required FCW. It also would not prevent multiple intensities that all meet the minimum requirement in this final rule.

NHTSA disagrees with the suggestion by Hyundai MOBIS to permit the auditory warning to be suppressed as long as the FCW visual warning remains illuminated. As the FCW auditory signal is considered the primary means of warning a potentially inattentive driver, allowing the auditory FCW signal to be suppressed would undercut its important safety function.

After considering the comments, NHTSA has decided to finalize the proposed FCW auditory signal intensity discussed in the preamble of the NPRM in this final rule.

c. FCW Auditory Signal Presentation with Simultaneous Muting of Other In-Vehicle Audio

In the preamble to the NPRM, NHTSA explained its intent to require muting or substantial reduction in volume of other in-vehicle audio (i.e., entertainment and other non-critical audio information) during the presentation of the FCW. This requirement would serve to ensure that the FCW auditory signal is conspicuous to the vehicle operator and detectable at the critical moment at which a crash avoidance response by the driver is needed. However, this intended requirement was inadvertently left out of the proposed regulatory text.

Comments

ASC, MEMA, and ZF supported the muting or reducing other in-vehicle audio during an audio FCW alert because the FCW alert is the highest priority in the vehicle and should override all other sounds. ASC and MEMA suggested that FCW alert volume should rise with speed to overcome external sounds like wind noise or road noise.

Honda, Porsche and Volkswagen opposed muting of other in-vehicle audio during FCW presentation. Honda stated that, because environmental sound levels can vary drastically, it is unnecessary to require audio muting. Honda cited the lack of a sound level requirement for the FMVSS No. 208 seatbelt warning as rationale for not needing such a requirement for FCW. Porsche and Volkswagen suggested that it is the driver's responsibility to ensure that in-vehicle audio does not interfere with the driving task. Volkswagen cited the requirement of a both a visual and audio warning as justification for not requiring muting of in-vehicle audio. Volkswagen also questioned how to accommodate other mandatory audio signals if these occur simultaneous with the collision warning.

Agency Response

Regarding Honda's comparison to the FMVSS No. 208 auditory warning signal requirement for fastening seatbelts, NHTSA does not believe the two requirements are comparable. The immediate consequences associated with an impending forward crash are not comparable to those associated with vehicle occupants fastening seat belts at the start of a drive.

In response to concerns expressed by Volkswagen and Porsche about addressing multiple simultaneous auditory signals, NHTSA will clarify that the audio required to be muted would be any audio for other than crash avoidance or safety purposes, such as music or other entertainment related audio.

Regarding the assertions by both Porsche and Volkswagen that drivers are responsible for ensuring that in-vehicle audio system use does not interfere with the driver's full attention to the driving task, the situations in which FCW is expected to emit sound are urgent enough that the most attentive driver would need to be able to hear the auditory signal. NHTSA does not believe that attention or inattention is the crux of the issue, though inattention could complicate a driver's response. It is important to ensure that the FCW auditory signal is audible even when sound levels from in-vehicle sources are high.

Although the requirement to mute other in-vehicle audio during the presentation of the FCW was inadvertently left out of the proposed regulatory text, NHTSA is including such a requirement in this final rule. Similar to the issue of auditory intensity, multiple commenters addressed the topic of muting. The requirement will be finalized to require that in-vehicle audio not related to a safety purpose or safety system (i.e., entertainment and other audio content not related to or essential for safe performance of the driving task) must be muted, or reduced in volume to within 5 dB of the masked threshold, during presentation of the FCW auditory signal. This specification will serve to ensure that the amplitude of the FCW auditory signal is at least 10 dB above the masked threshold (MT) to preserve the saliency of the auditory warning.[62]

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[62] Campbell, J.L., Brown. J.L., Graving, J.S., Richard, C.M., Lichty, M.G., Sanquist, T.,… & Morgan, J.L. (2016, December). Human factors design guidance for driver-vehicle interfaces (Report No. DOT HS 812 360). Washington, DC: National Highway Traffic Safety Administration. “The amplitude of auditory signals is in the range of 10–30 dB above the masked threshold (MT), with a recommended minimum level of 15 dB above the MT (e.g., [1, 2, 3]). Alternatively, the signal is at least 15 dB above the ambient noise [3].”

d. FCW Visual Symbol Requirements

NHTSA proposed that FCW visual signals must use the SAE J2400 (2003–08) symbol.[63] The SAE J2400 symbol relates the idea of an impending frontal crash without depicting a particular forward object and, as such, is readily applicable to both lead vehicle and pedestrian scenarios. The FCW visual signal would be required to be red, as is generally used to communicate a dangerous condition and as recommended by ISO 15623 and SAE J2400 (2003–08). Because the FCW visual signal is intended to be confirmatory for the majority of drivers and because NHTSA-sponsored research[64] has shown that instrument-panel-based crash warnings can draw drivers' eyes downward away from the roadway at a critical time when crash avoidance action may be needed[65] the symbol would be required to be steady burning.

Comments

Multiple commenters voiced support for standardization of FCW characteristics. For example, the Governors Highway Safety Association (GHSA) indicated support for FCW standardization, stating that increased consistency will bolster the safety impact of these features. AAA cited its previous testing experience that some warnings were hardly noticeable relative to visual warnings presented in other vehicles.

Multiple commenters were opposed to specificity included in the proposed FCW requirements. These commenters thought that the state of varied implementation of FCW that exists currently was sufficient. For example, Volkswagen described the proposed warning strategy for AEB as too prescriptive. Volkswagen thought the regulation should specify the warning modes, but leave the implementation up to the manufacturer if the warning is easily perceivable and visually distinguishable from other warnings. Volkswagen thought that

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[63] SAE J2400 2003–08 (Information report). Human Factors in Forward Collision Warning Systems: Operating Characteristics and User Interface Requirements.

[64] DOT HS 812 191 September 2015, Evaluation of Heavy-Vehicle Crash Warning Interfaces. https://www.nhtsa.gov/sites/nhtsa.gov/files/812191_evalheavyvehiclecrashwarninterface.pdf

[65] ''Evaluation of Forward Collision Warning System Visual Alert Candidates and SAE J2400,'' SAE Paper No. 2009–01–0547, https://trid.trb.org/view/1430473.

variation in FCW strategy across manufacturers would not be a problem because manufacturers explain their warning strategy in their owner's manuals. NADA, Nissan, Mitsubishi, and Porsche also suggested manufacturers have more flexibility to choose the form of visual warning.

The Alliance opined that NHTSA should allow flexibility for manufacturers to select the visual warnings deemed to be most effective in the context of the overall vehicle human-machine interface, which could include ISO or SAE symbols, word-based warnings, or other flashing or steady burning illumination as appropriate. The Alliance stated that NHTSA has not presented data to indicate that any one visual alert type or symbol is any more or less effective than another. Consumer Reports supported standardization but recommended that a word be used rather than a symbol.

Some commenters suggested that the FCW requirements should more closely follow other related standards. Ford recommended establishing FCW requirements similar to existing AEB regulations from Europe,[66] Australia,[67] and Korea[68] instead of restricting the individual components of the warning. Hyundai opposed the use of SAE J2400 standards, including the symbol. Hyundai believed it was more appropriate to adopt ISO 15623. Porsche's comments seek additional flexibility and alignment with UNECE Regulation No. 152.

Hyundai MOBIS, Toyota, the Alliance, Ford, and Honda, disagreed with the steady burning requirement for the FCW visual signal, expressing support for allowing it to flash. Honda recommended aligning with the specifications of ISO 15008.

Honda supported both visual symbol and word-based FCW options. Honda recommended that NHTSA allow flexibility to continue using already well understood text-

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[66] UN Regulation No 152 – Uniform provisions concerning the approval of motor vehicles with regard to the Advanced Emergency Braking System (AEBS) for M1 and N1 vehicles [2020/1597] (OJ L 360 30.10.2020, p. 66, ELI: http://data.europa.eu/eli/reg/2020/1597/oj).
[67] Australian Design Rule, Vehicle Standard (Australian Design Rule 98/01 – Advanced Emergency Braking for Passenger Vehicles and Light Goods Vehicles) 2021.
[68] Korean Motor Vehicle Safety Standard (KMVSS) Article 15-3, "Advanced Emergency Braking Systems (AEBS)."

based warnings like “BRAKE!,” which Honda currently employs, reasoning that a well-designed warning would instruct drivers what to do to avoid a hazard. Rivian also supported allowing the use of the word, “BRAKE,” in lieu of an FCW visual symbol.

Agency Response

After careful review of these comments, NHTSA has decided to adopt the proposed standardized FCW visual warning requirements unchanged. While multiple commenters sought flexibility for automakers to use an FCW visual signal of their own choice rather than a standardized signal, no safety data were provided concerning consumers’ degree of understanding of the wide variety of existing FCW implementations nor any safety advantages or benefits of not standardizing the visual symbol. The proposed FCW characteristics outlined in the NPRM are based on more than 35 NHTSA research efforts related to crash avoidance warnings or forward collision warnings conducted over the past nearly 30 years. Other research, existing standards (ISO Standards 15623 and 22839), and SAE documents (J3029 and J2400) also were considered as input for the proposed requirements. NHTSA does not view the provided arguments as sufficient to overcome the value of standardization as a means of ensuring consumer familiarity and ensuring the applicability of the chosen symbol to both lead vehicle and pedestrian scenarios.

Data from NHTSA's 2023 AEB testing showed that each of six test vehicle models from different manufacturers used a different FCW visual signal or symbol. Only one model used the ISO FCW symbol. FCW visual symbols that differ by manufacturer and, in some cases across models from the same manufacturer, are likely to lead to confusion among consumers. The observed substantial variety in existing FCW implementations highlights the need for improved consistency of FCW visual symbols to increase efficient comprehension of crash-imminent warnings by vehicle operators and aid them in understanding the reason for their vehicle’s (or an unfamiliar rental vehicle's) active crash avoidance intervention. Allowing for individual design choices does not address this important safety consideration.

Such confusion relating to automotive symbol comprehension has also been documented by NHTSA research. Past research conducted by NHTSA to assess comprehension of vehicle symbols including the ISO tire pressure, ISO tire failure, and ISO engine symbols showed that while 95 percent of subjects correctly identified the engine symbol, recognition percentages for the ISO tire pressure and tire failure icons were the lowest of the 16 icons tested, 37.5 percent and 25 percent, respectively."[69] Research by industry published in a 2004 SAE paper focused on comprehension testing of active safety symbols and assessed the ISO FCW symbol and the SAE J2400 FCW symbol to assess their ability to communicate the idea, "Warning: You may be about to crash into a car in front of you." Results of that research showed the ISO FCW symbol to have 45 percent "high comprehension" and the SAE J2400 symbol to have 23 percent high comprehension. However, while high comprehension was noted for the lead vehicle crash scenario, NHTSA is not aware of any data supporting effectiveness of the ISO FCW symbol for communicating the idea of an impending forward pedestrian crash." [70]

Consumer Reports "Guide to ADAS" states that "CR's most recent survey data shows that industry-wide, only 48% of owners of vehicles equipped with FCW say they understand how it works."[71] NHTSA believes that improved consistency of FCW visual symbols is important to increase efficient comprehension of crash-imminent warnings.

NHTSA acknowledges the research by IIHS showing crash reduction benefits from some existing FCW designs. IIHS research results found that some automakers' FCW designs were

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[69] Mazzae, E. N. and Ranney, T. A. (2001). "Development of an Automotive Icon for Indication of Significant Tire Underinflation." Article in Proceedings of the Human Factors and Ergonomics Society Annual Meeting · October 2001. DOI: 10.1177/154193120104502317.
[70] Campbell, John & Hoffmeister, David & Kiefer, Raymond & Selke, Daniel & Green, Paul & Richman, Joel. (2004). Comprehension Testing of Active Safety Symbols. 10.4271/ 2004-01-0450.
[71] Consumer Reports' Guide to ADAS Usability: Consumer insights on understanding, use, and satisfaction of ADAS December 2022. https://data.consumerreports.org/wp-content/uploads/2021/09/consumer-reports-active-driving-assistance-systems-ux-guide-revised-december-09-2022.pdf.

associated with higher crash reductions than others. However, this research did not evaluate FCW characteristics by automaker or by model for vehicle models it studied and whether such characteristics may have contributed to FCW effectiveness differences, so care should be taken when drawing conclusions. Regardless, the IIHS studies have shown some existing FCW in light vehicles FCW systems are effective for preventing rear-end crashes, research does not support an argument against taking other measures to increase FCW effectiveness. It is likely that increasing the consistency of FCW characteristics and standardization of the primary warning signals across vehicles and models will lead to benefits beyond those documented to date due to increased driver understanding of the meaning of FCW signals.

The agency disagrees with Volkswagen's comment that explanations in the owner's manual adequately inform consumers about manufacturer-specific FCW signals. As noted previously, a British study found that only 29% of motorists surveyed had read their car handbook in full.[72] That same study examined owner's manual word counts and estimated that the time required to read some of the longest would take up to 12 hours. An April 2022 Forbes article states that "the average new-vehicle's owners' manuals, which, concurrent with the complexity of contemporary cars, have become imposingly thick and mind-numbing tomes of what should be essential information... remain unread in their respective models' gloveboxes."[73] With these concerns in mind, NHTSA does not believe that owner's manual information is an acceptable substitute for standardization of this important safety functionality across all vehicles.

Finally, as for the use of words instead of a symbol, as noted in the NPRM, word-based FCW visual warnings are used by some U.S. vehicle models including, ''BRAKE!," "BRAKE," and "STOP!". SAE J2400 also includes a word-based visual warning recommendation

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[72] "Car Handbooks Are Longer Than Many Famous Novels - Have You Read Yours?" https://www.bristolstreet.co.uk/news/car-handbooks-are-longer-than-many-famous-novels--have-you-read-yours/.
[73] "Here's Why Nobody Reads Their Car's Owner's Manual"https://www.forbes.com/sites/jimgorzelany/2022/04/07/heres-why-nobody-reads-their-cars-owners-manual/?sh=2a76d5d4462d.

consisting of the word, "WARNING." With regard to this existing use of word-based FCW visual warnings in some models, research by Consumer Reports noted in its online "Guide to forward collision warning" found that for some models, visual warning word use was found to be confusing to some drivers surveyed. Specifically, survey respondents reported a common complaint that "their vehicle would issue a visual "BRAKE" alert on the dash, but it wouldn't bring the car to a stop."[74] While NHTSA does find merit in the rationale for using an effective word-based visual warning for FCW purposes, we have decided in favor of the value of consistency across U.S. vehicles to promote consumer recognition of a dedicated FCW symbol. This symbol-based strategy for the FCW visual signal follows is consistent with the strategies of ISO 15623 and SAE J2400 (2003–08).

NHTSA notes, however, that this requirement does not preclude the use of a word-based warning that supplements the required FCW symbol presentation. In that event, NHTSA agrees with Honda and Consumer Reports that the word, "BRAKE!", including the exclamation point, is likely the best choice for effective communication to the driver the need for them to apply the brakes. NHTSA believes, as has been suggested by Consumer Reports, that there is a tendency for drivers to interpret some words used as warnings as describing an action being performed by the vehicle, rather than a command to the driver. To avoid such confusion by the driver, NHTSA recommends that manufacturers wishing to complement the FCW symbol with a word-based warning use, "BRAKE!" to aid in drivers interpreting the word as an instruction.

Finally, with respect to the steady-burning requirement, NHTSA does not agree with commenters recommending that the FCW visual warning be allowed to flash. As the FCW visual signal is intended to be secondary to the FCW auditory signal, allowing the symbol to flash in an attempt to draw the drivers' attention could actually draw the drivers' gaze downward to the

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[74] ''Guide to forward collision warning: How FCW helps drivers avoid accidents.'' Consumer Reports. https://www.consumerreports.org/carsafety/forward-collision-warning-guide/. Accessed April 2022.

instrument panel rather than to the forward roadway at a critical time for the driver to initiate a crash avoidance response.

After evaluation of the comments, the agency has determined to retain the proposal requirement for the visual symbol from SAE J2400 (2003–08), "Human Factors in Forward Collision Warning Systems: Operating Characteristics and User Interface Requirements" (Information report), to communicate the idea of an impending frontal crash without depicting a particular forward object. With no comments opposed to requiring the FCW visual signal to be presented using the color red, NHTSA is also finalizing that requirement as proposed and clarifying that it will apply to the required FCW symbol and any manufacturer-chosen words to accompany the required symbol.

e. FCW Visual Signal Location Requirements

The agency proposed that the FCW visual signal be presented within a 10-degree cone of the driver's forward line of sight.[75] This requirement is based on SAE J2400, "Human Factors in Forward Collision Warning Systems: Operating Characteristics and User Interface Requirements," paragraph 4.1.14. This FCW visual signal location guidance is also consistent with ISO 15623, which states that the FCW visual signal shall be presented in the ''main glance direction.'' Multiple research studies provide support for a visual warning location close to the driver's forward line of sight. NHTSA-sponsored research also supports this requirement, showing that instrument-panel-based crash warnings can draw drivers' eyes downward away from the roadway at a critical time when crash avoidance action may be needed.[76] Industry-sponsored research published in 2009 also indicates that an FCW visual signal presented in the

[75] Line of sight based on the forward-looking eye midpoint (Mf) as described in FMVSS No. 111, ''Rear visibility,'' S14.1.5.
[76] DOT HS 812 191 September 2015, Evaluation of Heavy-Vehicle Crash Warning Interfaces. https://www.nhtsa.gov/sites/nhtsa.gov/files/812191_evalheavyvehiclecrashwarninterface.pdf

instrument panel can slow driver response.[77] The 10-degree requirement would also increase the likelihood of FCW visual signal detection by hearing-impaired drivers.

Comments

Consumer Reports and AAA supported the proposed requirement that the FCW visual signal be presented in a location within a 10-degree cone of the driver's forward line of sight. In contrast, multiple commenters opposed the 10-degree cone requirement, some believing that the requirement could only be met using a head-up display. A majority of commenters who addressed this point requested that NHTSA consider expanding the 10-degree cone of the driver's line of sight requirement for FCW visual signal location.

FCA, Hyundai, Nissan, NADA, Rivian, and Volkswagen opposed the 10-degree cone requirement. The Alliance disagrees that the SAE J2400 information report provides adequate justification for the 10-degree requirement.

FCA thought the proposed requirement was impracticable. Rivian recommended that the FCW visual signal be presented on the top location of the driver instrument panel, in the instrument panel, or in a head-up display unless NHTSA can demonstrate that the data indicates that one location is clearly superior for driver perception. Toyota requested that the cone size be expanded to allow for suitable placement of the visual alert in areas such as the meter cluster or multi-information display, which would still be clearly visible in front of the driver.

Porsche recommended that NHTSA consider replacing the 10-degree with an allowance of up to 30 degrees, arguing that this would facilitate the use of long-established visual warning locations which it viewed as sufficient to provide the necessary cues. Multiple commenters, including Mitsubishi, the Alliance, and Honda, recommended use of a 60-degree cone requirement. Mitsubishi explained that the 60-degree value is based on a book chapter titled,

[77] ''Evaluation of Forward Collision Warning System Visual Alert Candidates and SAE J2400,'' SAE Paper No. 2009–01–0547, https://trid.trb.org/view/1430473.

Visual Fields, by R.H. Spector, et al., which states the vertical viewing angle of humans to be 60 degrees.

Agency Response

While many current vehicle models present an FCW visual signal within the instrument panel, drawing a driver's eyes downward away from the roadway in front of them to the instrument panel during a forward crash-imminent situation is likely to have a negative impact on the effectiveness of the driver's response to the FCW. NHTSA's research indicates that a visual FCW signal presented in the instrument panel can draw drivers' eye gaze downward away from the forward roadway and slow driver response to a forward crash-imminent event.[78] Further, Industry-sponsored research published in 2009 also indicates that an FCW visual signal presented in the instrument panel can slow driver response.[79]

Mitsubishi highlighted content from "Visual Fields," by R.H. Spector, et.al that states the vertical viewing angle of humans to be 60 degrees. [80] Specter's chapter specifically states that "a normal visual field is an island of vision measuring 90 degrees temporally to central fixation, 50 degrees superiorly and nasally, and 60 degrees inferiorly." Mitsubishi contended that if the FCW visual warning is displayed within this range, the driver will be able to recognize it. However, the referenced Spector visual field information relates to average humans' ability see objects presented before them and not specifically to drivers' ability to detect and quickly respond to an FCW visual signal within the potentially cluttered visual scene of a driver's-view perspective. Research sponsored by NHTSA and industry, respectively, has shown that instrument panel based visual crash warnings can draw drivers' eyes downward away from the roadway at a

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[78] DOT HS 812 191 September 2015, Evaluation of Heavy-Vehicle Crash Warning Interfaces. https://www.nhtsa.gov/sites/nhtsa.gov/files/812191_evalheavyvehiclecrashwarninterface.pdf

[79] ''Evaluation of Forward Collision Warning System Visual Alert Candidates and SAE J2400,'' SAE Paper No. 2009–01–0547, https://trid.trb.org/view/1430473.

[80] Spector RH. Visual Fields. In: Walker HK, Hall WD, Hurst JW, editors. Clinical Methods: The History, Physical, and Laboratory Examinations. 3rd ed. Boston: Butterworths; 1990. Chapter 116. PMID: 21250064.

critical time when crash avoidance action may be needed and that an FCW visual signal presented in the instrument panel can slow driver response.[81,82] Comparison to other warnings is not apt because other most other warnings do not require as immediate of a response as FCW.

As the text of SAE J2400 states, locating the FCW visual signal within a 10-degree cone could be accomplished in a top-of-dashboard location, NHTSA did not intend to require presentation of the FCW visual signal only via head-up display. To evaluate the potential difficulties associated with attempting to meet this FCW visual symbol location requirement, NHTSA gathered additional information regarding what visual angle about the driver's forward line of sight could be used to locate the FCW visual signal near the driver's forward line of sight, such as within the upper center portion of the instrument panel, without requiring substantial redesign of vehicles' instrument panels or dashboards, or require a head-up display.

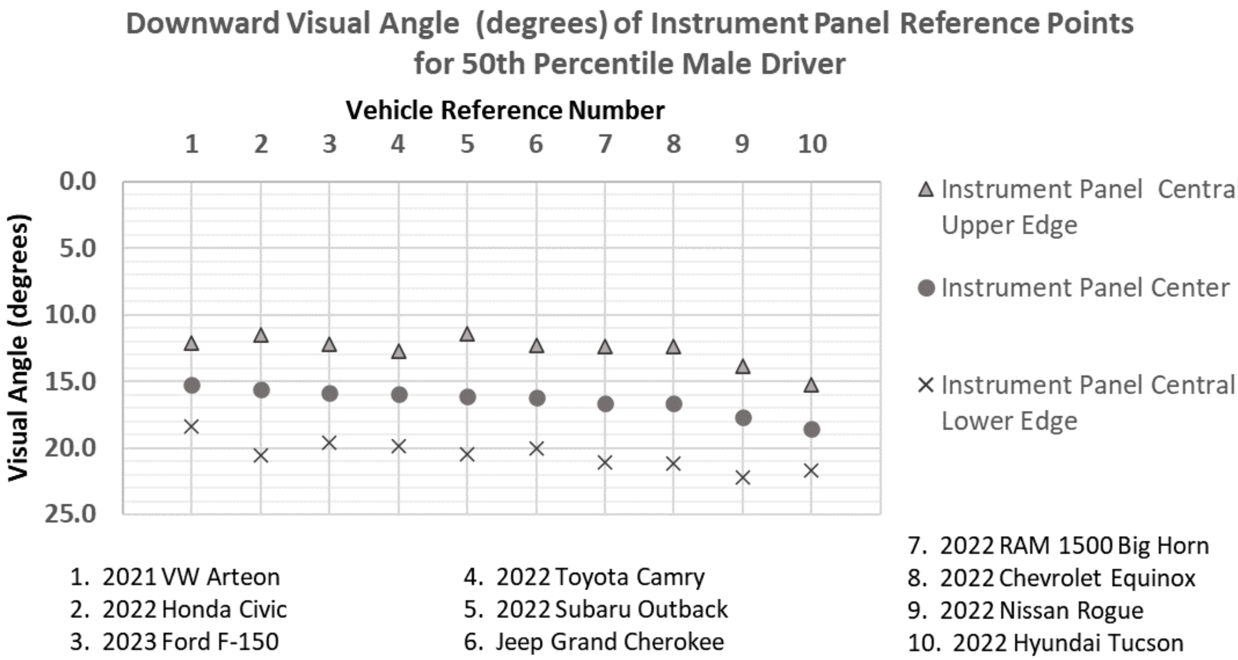
NHTSA gathered information regarding the driver's visual angle when looking at the instrument panel for a set of 10 light vehicles. Eight of the vehicles were model year 2022, one was from the 2021 model year, and one was from model year 2023. Vehicle makes examined spanned a wide range of manufacturers including Chevrolet, Ford, Honda, Hyundai, Jeep, Nissan, RAM Subaru, Toyota, and Volkswagen. The vehicles examined also spanned a range of vehicle sizes including two large pickup trucks.

NHTSA used a coordinate measuring machine to record within a single coordinate system the locations of the upper and lower extents of the active display area of each vehicle's instrument panel, as well as the left and right extents of the instrument panel. These points were used to locate the geometric center of the instrument panel. The eye midpoint location for a properly seated 50th percentile male driver was also located using an H-point machine and

[81] DOT HS 812 191 September 2015, Evaluation of Heavy-Vehicle Crash Warning Interfaces. https://www.nhtsa.gov/sites/nhtsa.gov/files/812191_evalheavyvehiclecrashwarninterface.pdf.
[82] ''Evaluation of Forward Collision Warning System Visual Alert Candidates and SAE J2400,'' SAE Paper No. 2009–01–0547, https://trid.trb.org/view/1430473.

recorded. The 50th percentile male driver size was used to represent the midpoint of the range of possible driver eye midpoint locations across all driver sizes. This full set of coordinate data was used to calculate visual angles between the eye midpoint and each of the center and upper and lower extents of the vehicles' instrument panels at their horizontal center. The plot below depicts visual angle calculation results for the instrument panel central upper edge, center point, and central lower edge for a 50th male driver's point of view.

Figure 1:



Visual angle values for the instrument panel center point for these vehicles were found to range from 15.7 to 18.5 degrees. Nine of the ten vehicles were found to have instrument panel center locations that reside within 18 degrees downward of the driver's forward horizontal line of sight. Based on these data, NHTSA believes that revising the FCW visual symbol location 10-degree requirement to an 18-degree vertical angle would permit the large majority of current vehicle designs to display a telltale-sized or larger FCW visual symbol in the upper half of the instrument panel without any structural redesign or necessity of using a head-up display. Therefore, NHTSA has decided to expand the vertical angle to 18 degrees while retaining the 10-degree horizontal angle. The 10-degree value is being retained for the horizontal angle to preserve the FCW symbol's presentation at the center of the driver's forward field of view to maximize its perceptibility.

2. AEB Requirement

a. AEB Deactivation

NHTSA discussed the issue of AEB deactivation in various circumstances, and the various ways it might become deactivated (i.e., manually or automatically). NHTSA used both "disablement" and "deactivation" in the proposal, intending that those terms mean the same thing. The NPRM proposed prohibiting manual AEB system deactivation at any speed above the proposed 10 km/h minimum speed threshold for AEB system operation. NHTSA sought comment on this and whether the agency should permit manual deactivation similar to that permitted for ESC systems in FMVSS No. 126. NHTSA also sought comment on the appropriate performance requirements if the standard permitted installation of a manually operated deactivation switch.

Regarding automatic deactivation, NHTSA stated that it anticipated driving situations in which AEB activation may not increase safety and in some rare cases may increase risk. For instance, an AEB system where sensors have been compromised because of misalignment, frayed wiring, or other partial failure, could provide the perception system with incomplete information that is misinterpreted and causes a dangerous vehicle maneuver. In instances where a light vehicle is towing a trailer with no independent brakes, or with brakes that do not include stability control functions, emergency braking may cause jack-knifing, or other dangerous outcomes. In the proposal, NHTSA stated that it was considering restricting the automatic deactivation of the AEB system generally and sought comment on providing a list of situations in which the vehicle is permitted to automatically deactivate the AEB or otherwise restrict braking authority granted to the AEB system.

In addition to these situations, NHTSA requested comment on allowing the AEB system to be placed in a nonfunctioning mode whenever the vehicle is in 4-wheel drive low or the ESC is turned off, and whenever equipment is attached to the vehicle that might interfere with the AEB system's sensors or perception system, such as a snowplow. NHTSA requested comment on the permissibility of automatic deactivation of the AEB system and under which situations the regulation should explicitly permit automatic deactivation of the AEB system.

Comments

Several commenters discussed AEB deactivation. The City of Philadelphia, the Richmond Ambulance Authority, DRIVE SMART Virginia, the National Association of City Transportation Officials (NACTO), Advocates for Highway and Auto Safety (Advocates), the Nashville Department of Transportation and Multimodal Infrastructure, and the City of Houston supported the proposed requirement to prevent AEB deactivation. In general, they stated that allowing system deactivation would diminish safety benefits.

In contrast, many commenters stated that AEB deactivation should be allowed. For example, ASC, ZF, MEMA, NADA, Mitsubishi, Porsche, Aptiv and Volkswagen suggested that the agency should follow the specific deactivation criteria under UNECE Regulation No. 152. That regulation requires at least two deliberate actions to deactivate the AEB system, and the system must default back to "on" after each ignition cycle.[83] Toyota, Porsche, and Hyundai stated that manual deactivation for AEB systems should be similar to what is allowed for ESC systems in FMVSS No. 126. Rivian stated that manual deactivation should be allowed via either a software or hardware switch.

Advocates opposed allowing deactivation of AEB systems, but they provided some suggestions for NHTSA if deactivation were allowed in narrowly tailored instances for specific

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[83] UN Regulation No 152 – Uniform provisions concerning the approval of motor vehicles with regard to the Advanced Emergency Braking System (AEBS) for M1 and N1 vehicles [2020/1597] (OJ L 360 30.10.2020, p. 66, ELI: http://data.europa.eu/eli/reg/2020/1597/oj).

applications with strong justification and supporting data. Advocates stated that any conditions allowed for automatic deactivation must not enable a means to intentionally deactivate the AEB system and suggest that any deactivation should trigger the malfunction telltale and be recorded as part of a data recording requirement. If NHTSA were to allow manual AEB deactivation, Advocates thought the process should require multiple steps while the vehicle is not moving and require drivers to engage in a deliberate and significant effort (i.e. a driver should not be able to disable AEB by pressing a single button). Advocates aligned with other commenters in suggesting that if any AEB deactivation occur, the system should default back to "on" at any new ignition cycle.

The Alliance, Honda, NADA, Porsche, and Volkswagen suggested that the agency should allow manual deactivation to mitigate consumer dissatisfaction. Honda and NADA also stated that not allowing deactivation may lead to substantially higher false positive rates, while AAA stated that allowing for automatic or manual deactivation could increase consumer acceptance and minimize the perception that the systems are overbearing. NADA also stated that AEB false positives are a significant source of consumer complaints about AEB systems and that only 59 percent of respondents to a Consumer Reports survey indicated that they were satisfied with their AEB systems. The Alliance stated that in many cases, the circumstances warranting AEB deactivation are already described in vehicle owner's manuals or other information sources, and that it supports the continuation of describing such circumstances to the user.

ASC stated that for ADAS-equipped vehicles where the primary operating responsibility belongs to the driver, AEB is an assist function and the driver should be able to deactivate the AEB system if required. ASC also stated that under extreme operating or environmental conditions, the AEB system may be outside its operating design domain and should automatically deactivate (temporarily) and that in some situations such as testing, or service, the AEB system should be able to be deactivated.

SEMA, Ford, The Alliance, Rivian, Volkswagen, and HATCI suggested that there are likely several circumstances where deactivation of the system may be needed to ensure a safe vehicle operation, including track use, off-road use, and car washes. Some specific examples suggested by commenters include the use of chains on tires for traction, towing, four-wheel drive, low traction driving scenarios, and off-roading. SEMA and Mitsubishi stated that on a vehicle towing a trailer without an independent brake system, AEB activation may cause jack-knifing or other dangerous conditions. MEMA stated that drivers of many existing vehicles can currently disable their AEB system in cases where the AEB system is predictably, but incorrectly, triggered by objects or structures.

NTEA stated that there is a need to be able to deactivate AEB when certain vocational equipment is attached in frontal areas where it intrudes into the field-of-view of an AEB system. NTEA stated that final stage manufacturers and alterers are not currently (nor foreseeably in the future) able to move/reinstall/recalibrate these systems to accommodate vocational upfits that can be in direct conflict with how these systems need to function. NTEA uses snowplows as an example of a vehicle equipment for which sensor relocation cannot accommodate AEB. NTEA stated, as an example of how provisions for deactivation could be included in the requirement, that one vehicle manufacturer has previously created a method to detect the presence of a plow blade in their electrical architecture, so that when the blade is attached, AEB is deactivated. AEB functionality resumes when the blade hardware is removed. NTEA provided examples of other front-mounted equipment such as winches, sirens and push bumpers on emergency vehicles that could cause unintended consequences with the system reaction of AEB. Further, NTEA identified operational aspects of emergency and first responder vehicles that merit more consideration for AEB deactivation.

The Alliance and Porsche stated that NHTSA should provide manufacturers with the ability to define automatic deactivation criteria. While Volkswagen stated that NHTSA should provide a list of situations where automatic deactivation is allowed it stated that this list should not be mandatory and joined the Alliance and Porsche in stating that OEM's should establish the situations where the AEB system is permitted to automatically deactivate, or otherwise restrict braking authority granted to the AEB system. HATCI did not specifically comment on the list of situations, but stated that allowing manual deactivation would provide affordances for unforeseen scenarios that industry and NHTSA have not yet contemplated which would help futureproof against situations that may not exist today. The Alliance stated that this approach introduces additional complexity in terms of demonstrating compliance with the standard. Porsche stated that providing a not "overly intrusive" deactivation warning message would be appropriate and that the range of situations in which the systems would be automatically deactivated be infrequent and of limited duration.

Finally, the Alliance also addressed whether the deactivation of ESC may cause deactivation of AEB. While not encouraged, a driver seeking to disable AEB may be left with no option but to turn both AEB and ESC systems off under NHTSA's proposal, reducing potential safety benefits from having the ESC system remain active.

Agency Response

In this final rule, NHTSA does not allow for vehicles to be equipped with a manual control whose sole functionality is the deactivation of the AEB system. NHTSA agrees with the commenters who noted concerns about diminishing the safety benefits of this rule. Harmonization alone is an insufficient justification for allowing a control to deactivate the AEB system. Commenters have not explained why there is a safety need of a dedicated deactivation control or why a dedicated deactivation control would not diminish the safety benefits of AEB. The agency also disagrees with ASC's assertion that AEB is an "assist function," and even if true, that such a description would serve as a justification for allowing a manual deactivation control.

NHTSA does not agree that any theoretical consumer dissatisfaction is one of the circumstances that justify allowing manual deactivation. AEB systems have been available on vehicles for many years. It is not reasonable to assume that there will be consumer acceptance issues due to the requirements of this final rule.

NHTSA is not persuaded by comments that suggest that not permitting deactivation would lead to substantially higher false positive rates. NHTSA recognizes that AEB false positives are a source of consumer complaints, but NHTSA does not believe AEB deactivation is the solution to the engineering challenges manufacturers with lower performing systems might face in meeting this rule's requirements.

That said, NHTSA recognizes that there are certain circumstances where deactivation may be appropriate, and the commenters raise several situations where NHTSA believes automatic deactivation would be the best approach. Examples of such a scenario include when a trailer is being towed, or when a snowplow is attached to a pickup truck. AEB activation while towing a trailer may be unsafe if the trailer does not have brakes. A snowplow may interfere with the sensing capabilities of the AEB system. In such cases, NHTSA expects that the manufacturer would automatically disable AEB functionality when interference with the sensing capabilities occurs. Using the example of towing, NHTSA expects that the manufacturer would design AEB to scan for towing connections and automatically disable AEB if it registers any.

NHTSA agrees that it is important for the AEB system to default back to "on" after each ignition cycle, except in one circumstance – in a low-range four-wheel drive configuration selected by the driver on the previous ignition cycle that is designed for low-speed, off-road driving. In that situation, NHTSA believes that reverting to the manufacturer's original default AEB setting would not be necessary. There is a similar exception for the ESC Off control.

NHTSA also agrees with the Advocates that any deactivation should trigger the malfunction telltale because consistent illumination is important to remind drivers that safety equipment (i.e., AEB) is not functioning as the driver expects. Should the OEM design its systems in a way where the AEB system would automatically deactivate when the system detects that it cannot function properly (i.e., change performance in a way that takes the AEB system out of compliance with the requirements of the standard), then the driver must be alerted of this performance issue through a telltale. This applies to partial or full disablement of the system.

NHTSA does not agree with the Alliance that restricting the installation of an “AEB off” control leaves a driver seeking to disable AEB with no option but to turn both AEB and ESC systems off. First, it is up to the manufacturer to decide if AEB is automatically turned off when ESC is turned off. Second, while it is not restricted by the FMVSS, it is the manufacturer’s choice to install an ESC off switch. Finally, the agency asserts that if a driver does use the ESC off control for the purpose of turning off AEB, the restrictions included in this final rule limit the potential safety impacts particularly once the vehicle’s ignition is turned off because AEB is required to turn back on with each ignition cycle, except when using a low-range four-wheel drive configuration.

While NHTSA understands commenters’ concerns about emergency vehicles, the Agency notes that flexibilities already exist for these vehicles, and we anticipate those flexibilities would be appropriate and sufficient to address these concerns. There are a number of ways that owners, and purchasers of emergency vehicles for official purposes, could modify their vehicles to fit the unique needs of emergency responders. Currently, manufacturers have the ability to sell upfit packages that provide the means, and instructions (upfit guides), for an emergency responder to interact with various vehicle features, including mandated safety features. A common example of these modifications involves the modification of lighting equipment and the activation of patterns which are not compliant with FMVSS No.108. While a vehicle manufacturer cannot manufacture a vehicle for sale with such lighting and activation patterns that fail to comply with FMVSS No. 108, Lamps, reflective devices, and associated equipment, an emergency responder, as the owner of a vehicle, is not prohibited from making modifications to the vehicle.[84] In addition, this final rule allows for the deactivation of AEB when ancillary systems that may affect AEB performance are activated.

In summary, NHTSA agrees with those commenters expressing opposition to broad inclusion of an on-off switch. The agency believes, as do those commenters, that the lifesaving benefits would be significantly compromised. However, some commenters noted that certain vehicles are used in unusual environments or for unique purposes, and their operation might be hampered by an AEB system that cannot be deactivated. The agency has not included on-off AEB functionality for emergency vehicles, as a broad group, as these purpose-built vehicles already have flexibilities. However, the agency believes that one other situation is appropriate for inclusion of on-off functionality—vehicles used by law enforcement.

Law enforcement has unique needs that often necessitate some differences in the configuration or functionality of their motor vehicles. The motor vehicles they purchase may be purpose-built police vehicles or unaltered vehicles available to the general public. In either case, law enforcement has a critical need to deactivate AEB when such vehicles are used in intervention maneuvers to disable a suspect's vehicle or in security escorts and processions driving in tight formation. For this reason, this final rule provides a limited exception that allows the manufacture, or the modification after sale, of vehicles that include the ability to activate and deactivate AEB for vehicles owned by law enforcement agencies.[85] Manufacturers should work to directly provide an on-off capability for verified law-enforcement-owned vehicles or make it as easy as possible for a third party to do so on behalf of law enforcement, with appropriate security safeguards, and NHTSA is committed to actively facilitating this process. Should manufacturers fail to address this important need, NHTSA may consider taking additional

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[84] In the absence of an AEB mandate, some OEMs currently facilitate deactivation for emergency responders; for example "Available Pre-Collision Assist With Pedestrian Detection - … For unique law-enforcement demands, a switch allows the feature to be temporarily disabled." https://www.ford.com/police-vehicles/hybrid-utility/, Accessed March 7th, 2024 at 10:20 AM.

[85] The agency does not have a precise estimate of the number of vehicles that may be affected by this flexibility, but notes that, when considered as part of the entire fleet, this effect is likely to be de minimis.

regulatory action. NHTSA anticipates that law enforcement vehicles resold to other than law enforcement entities will be restored to their original condition (i.e., by disabling the on-off capability).

NTEA's comment requests that NHTSA consider adding regulatory compliance pathways for upfitters. NHTSA understands NTEA's concern regarding glass replacement and the impact that has on FCW/AEB sensors. As AEB is not a new system, this is not a new issue for glass replacement upfitters. The agency is aware of glass replacement upfitters that already work with manufacturers to ensure proper sensor calibration. It is not expected that the requirements of this final rulemaking will affect their ability to continue to collaborate as they have been. NHTSA also expects that manufacturers might provide for automatic deactivation for vocationally specific equipment when it is in use, such as the snowplow example NTEA provides in its comment.

As for the equipment installed for vocational vehicles, NHTSA expects upfitters to avoid installing equipment that would result in AEB no longer working (or malfunctioning). NHTSA expects that in rare cases where no engineering solution may exist such as with snowplows, that upfitters would leave final installation of this equipment to the vehicle owners to avoid making inoperative required safety equipment. In such situations, NHTSA expects that the malfunction indicator would illuminate as a constant reminder to the driver that AEB is not working. As discussed in other sections, NHTSA believes that this consistent illumination is important to remind drivers that important safety equipment (i.e., AEB) is not functioning as the driver expects.

b. Aftermarket Modifications

SEMA stated that while the proposed rule applies to motor vehicle manufacturers and alterers of new passenger cars and light trucks, it does not specify how aftermarket vehicle modifications and alterations may impact AEB systems. SEMA stated that they seek guidance from

NHTSA on implementing FMVSS for AEB and PAEB and the legal obligations of SEMA members who produce, install, or sell aftermarket parts, as well manufacturers, installers, retailers, distributors, and independent repair shops regarding the "tampering/make inoperative" provision (49 U.S.C. 30122).

NHTSA notes that SEMA's comment invokes two separate provisions of the Safety Act because the situations of alterers and repair businesses are different. NHTSA has issued several interpretations of the obligations of both alterers and repair businesses, and the agency summarizes those key points here.[86]

An "alterer" is defined as a person who alters by addition, substitution, or removal of components (other than readily attachable components) a certified vehicle before the first purchase of the vehicle other than for resale.[87] The Safety Act and NHTSA's regulations require vehicle manufacturers certify that their vehicles comply with all applicable FMVSSs (49 U.S.C. 30112; 49 CFR part 567). NHTSA's regulations at 49 CFR 567.7 require the alterer to ensure that the vehicle, as altered, conforms to the FMVSSs affected by the alteration(s) and to certify to that effect in accordance with the same section. Alterers make this certification by affixing a permanent label to the altered vehicle identifying the alterer and the date of alteration.

In contrast, a vehicle repair business is defined as a person holding itself out to the public to repair for compensation a motor vehicle or motor vehicle equipment. Repair businesses usually work on vehicles after the time of first sale, which means that instead of complying with the certification requirements like a manufacturer or alterer, a repair business must ensure that it does not violate the Safety Act's make inoperative prohibition. The Safety Act states that a vehicle manufacturer, distributor, dealer, rental company or repair business is prohibited from

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[86] Letter to Antonio Salvetti (Dec. 29, 1994) https://www.nhtsa.gov/interpretations/10425#:~:text=An%20%22alterer%22%20is%20one%20who,such%20as%20painting%2C%20or%20by; Letter to Alan Nappier, Earl Stewart Toyota (Apr 17, 2015). https://www.nhtsa.gov/interpretations/30122-make-inoperative-alan-nappier-april-14.

[87] 49 CFR 567.3.

knowingly making inoperative any part of a device or element of design installed in or on a motor vehicle that complies with an applicable FMVSS.[88] An entity does not need to have actual knowledge that a device or element of design would be made inoperative by the entity's modification in order for that modification to violate section 30122.[89]

Additionally, section 30122 does not require repair shops to restore safety systems damaged in a collision to a new or pre-crash condition.[90] Instead, under section 30122, when any repair to a vehicle is completed, the vehicle must be returned to the customer with the safety systems capable of functioning at least as well as they were able to when the vehicle was received by the repair shop.[91]

Given the information above, NHTSA concludes the two types of entities about which SEMA is concerned both have an obligation to prevent a noncompliance with the FMVSS created by this final rule. Since NHTSA is establishing a new FMVSS with this final rule, the same rules of certification and make inoperative will apply, except for narrow circumstances for law enforcement-owned vehicles.

NHTSA is aware that many law enforcement vehicles are modified after purchase to meet the unique needs of law enforcement. Sometimes this work is completed by in-house entities, and other times, this work may be contracted out to third parties. If those third parties are the entities listed in 49 U.S.C. 30122, they are prohibited from making inoperative any system or element of design that is in compliance with a FMVSS, including this new FMVSS. To ensure that law enforcement are able to modify their vehicles to fit their unique needs, and to ensure that third-party repair businesses are capable of assisting them, NHTSA has added a make inoperative exemption in 49 CFR part 595 that permits manufacturers, dealers,and motor vehicle

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[88] 49 U.S.C. 30122.
[89] Letter to Alan Nappier, Earl Stewart Toyota (Apr. 17, 2015), https://www.nhtsa.gov/interpretations/30122-make-inoperative-alan-nappier-april-14.
[90] *See, e.g.,* http://isearch.nhtsa.gov/aiam/aiam4681.html, letter to Linda L. Conrad, January 19, 1990.
[91] Nonetheless, NHTSA strongly encourages repair shops to restore functionality to safety systems to ensure that the vehicles will continue to provide crash protection for occupants during the life of the vehicle.

repair businesses to modify a vehicle owners by a law enforcement agency to provide a means to temporarily deactivate an AEB system. This addition is complementary to the additional text added in S5.4.2.1 and discussed in the proceeding section.

c. No-Contact Requirement for Lead Vehicle AEB

The proposed performance criterion for all AEB tests involving a lead vehicle is full collision avoidance, meaning the subject vehicle must not contact the lead vehicle.

NHTSA requested comment on two alternatives to a no-contact requirement for the lead vehicle performance test requirements. The first alternative would be to permit low speed contact in NHTSA's on-track testing. The agency requested comment on the appropriateness of such a requirement, any factors to consider surrounding such a performance level, and what the appropriate reduction in speed or maximum impact speed should be. The other alternative discussed in the proposed rule was a requirement that permits the vehicle to use multiple runs to achieve the performance test requirements. This alternative is discussed in the "Permissibility of Failure" section.

Comments

In response to the NPRM, the IIHS, the Advocates, NTSB, AAA, Adasky, and Luminar, expressed support for the full collision avoidance (i.e., no-contact) requirement in all proposed AEB tests. IIHS stated that their evaluations of existing AEB systems indicated that some current systems are completely avoiding collisions at the highest speeds IIHS has tested, which is 70 km/h. Advocates stated that the vehicles are tested under nearly ideal conditions and, by requiring a no-contact condition for success, the benefits of the system will be stronger under less-than-ideal conditions in the real world. NTSB and AAA stated that the no-contact requirement is consistent with the need for safety, and potentially necessary to ensure test repeatability. Luminar stated that they were concerned that regulating some degree of contact in these scenarios presents significant concerns for test efficiency, integrity and cost related to compliance. Luminar stated that the no-contact performance is within the capability of existing technology.

Several commenters, including the Alliance, Honda, FCA, Nissan, Volkswagen, SEMA, and MEMA stated that the proposed no-contact requirement in lead vehicle AEB tests is not practicable at the proposed test speeds. Many of these commenters suggested a hybrid approach of collision avoidance at lower speeds and speed reduction at higher speeds. Multiple commenters stated that the proposed test speeds will require earlier intervention by AEB systems to meet the "no-contact" requirement, which they state will cause various unintended consequences, such as false positives due to test speeds or AEB intervention at a time where evasive steering may still be possible.

Many commenters stated that the expectation of no contact in the real world is not practical. The Alliance stated that while the research indicated that certain vehicles performed better under certain test conditions, the number of tests run, particularly at higher speeds, is insufficient to make any reliable determination as to the repeatability and reproducibility of testing and that the agency ran only one test per vehicle at each of the different speed ranges in each scenario. Many commenters also observed that no vehicle was found to have met all the proposed requirements.

Further, the Alliance described two aspects of brake performance that they suggested should be considered. First, they stated that peak deceleration capability of the vehicle is generally limited by the tire adhesion and is therefore not likely to be impacted by brake hardware changes, and performance today typically exceeds the mandated performance from FMVSS No. 135 or FMVSS No. 105. The second aspect of brake performance which the Alliance stated must be considered is the time factor to reach the target deceleration.

Honda, Nissan, and other commenters stated that the proposed test requirements do not consider the trade-off between collision avoidance through evasive steering and emergency braking, leading to increased concerns for false activations. Further, Honda stated that to meet the proposed higher speed no-contact requirements, current systems would be forced to provide braking intervention with significantly reduced recognition reliability and that current AEB systems would need to be completely redesigned.

Bosch stated that its testing shows that when the speed reaches approximately 75 km/h, there are reproducibility challenges with multi-sensor fusion of the object in time to initiate AEB and avoid the obstruction, and considerations should be made on how these requirements align with current functional safety requirements.

Volkswagen stated that they conducted an analysis using the Crash Investigation Sampling System (CISS) where data from rear-end crashes were collected from Event Data Recorder (EDR) data. The results were that there were no injuries above the Vehicle Abbreviated Injury Scale (VAIS) of 3+ in this small sample, noting that this was a non-statistically significant sample of 56 rear end crashes below a relative collision speed of 50 km/h.

MEMA stated that they agreed with the NHTSA alternate proposal for contact which, consistent with European regulations, allows low speed contact during testing. MEMA suggested a no-contact test requirement at speeds up to 25 mph (roughly 40 km/h), and a realistic speed reduction requirement above this speed (i.e., collision mitigation). Hyundai stated that a target deceleration rather than no contact should be used as the appropriate criterion for assessing AEB performance.

HATCI stated that the requirements for damageability from 49 CFR part 581 address the need to reduce severity of any impact following activation of AEB, such that reductions in fatalities and injuries are achieved without stipulating no contact. Further, HATCI stated that the part 581 bumper standard speeds do not cause damage to the vehicle or Global Vehicle Target (GVT) and are highly unlikely to cause injuries to the vehicle occupants.

Mitsubishi stated the agency should allow for maximum contact speed instead of no contact, especially for higher test speeds, as the NPRM's proposed requirement would require OEMs to fully redesign their AEB systems, including new hardware. Further, Mitsubishi stated that the benefit for systems which allow a low speed, such as a 10 km/h, impact to the rear-end of another vehicle can be considered comparable to no contact in terms of fatal or severe injury likelihood. Mitsubishi also stated that they opposed a regulatory requirement whose purpose appears to be reduction of the test burden by seeking to avoid rebuilding the strikable target when impacted. Therefore, Mitsubishi stated that they suggest 1) allowing low speed contact, 2) eliminating the higher approaching-speed test, and 3) securing reasonable headway distance, particularly with higher speed of the decelerating lead-vehicle scenarios.

FCA raised issues with whether the no-contact requirement was appropriate for vehicles with greater mass. FCA provided a graph developed from their research that suggests that as test weight went up, the overall pass (contact) rate went down.[92] FCA stated that this means one of two things: heavier vehicles installed less capable AEB systems or otherwise if all AEB systems were comparable, then the test weight of vehicle hardware could be a dominant factor in the compliant "no-contact" outcomes.

Furthermore, FCA stated that the proposed requirements that the subject vehicle under test "does not collide" is subjective. The soft coverings over both devices will have dimensional variation as they exhibit wrinkles and folds or fluttering. FCA stated that they do not understand what "not collide" means in this context. FCA suggested NHTSA investigate this concept and make a new proposal as to what "collide" means as an objective, regulatory concept.

Agency Response

This final rule adopts the full collision avoidance (i.e., no-contact) requirement proposed in the NPRM, which requires that the subject vehicle must not contact the lead vehicle in all AEB performance tests listed in the regulation. After considering all comments and for the reasons discussed below, the agency believes that the proposed no-contact requirement continues

[92] https://www.regulations.gov/comment/NHTSA-2023-0021-0999, see page 9.

to be the most appropriate. NHTSA does not believe that further investigation is necessary to determine what collide means, in the context of this rule.

No contact provides maximum safety benefits and is consistent with the Safety Act

As noted in the NPRM, one of the primary reasons for choosing the no-contact requirement in lead vehicle AEB tests is to maximize the safety benefits of the rule. Many commentors agreed with the agency's decision to obtain maximum benefits to the public. Advocates stated that allowing contact during AEB testing will lessen the strength/benefit of the rule. Similarly, NTSB stated that the no-contact requirement is consistent with the need for safety and should be mandated to obtain the best possible safety outcome. Further, AAA and NSC stated that the no-contact requirement could eliminate millions of injuries and thousands of fatalities over a five-year period. Alliance acknowledged that the alternative approaches proposed by the organization could provide meaningful safety gains (not the best benefit). As for additional benefits of the requirement, we agree with Luminar that the no-contact requirement also provides economic benefit by reducing the total cost of vehicle ownership with insurance savings.

NHTSA agrees with the commenters who stated that obtaining safety benefits is crucial for this final rule. NHTSA agrees with IIHS that some current systems are already completely avoiding collisions under the proposed lead vehicle AEB testing more than five years before this rule will take effect. One vehicle discussed in the additional research section performed very well and passed all lead vehicle AEB requirements except for only the most stringent condition under the lead vehicle decelerating scenario – satisfying the requirements in two out of five tests. Thus, the outcome of that additional confirmatory testing is encouraging and demonstrates that these requirements are practicable. The testing results provided by IIHS in their comment provide NHTSA with additional evidence that the requirements are within reach for manufacturers because the technology exists and the final rule provides sufficient lead time.

The no-contact requirement is practicable

The commenters who opposed the no-contact requirement and asserted that it is not practicable rely heavily on the 2020 testing and that no single vehicle achieved compliance in any single run. This assertion rests on misunderstandings of the applicable law and a failure to consider the trajectory of the technology and its performance.

First, no single vehicle must meet every requirement for an FMVSS to be considered practicable under the Safety Act. The Sixth Circuit in *Chrysler Corp. v. Dep't of Transp.* provided detailed analysis of the technology-forcing authority possessed by NHTSA and the legislative history that reinforces the court's conclusion.[93] The Sixth Circuit stated:

"[the] explicit purpose of the Act, as amplified in its legislative history, is to enable the Federal government to impel automobile manufacturers to develop and apply new technology to the task of improving the safety design of automobiles as readily as possible."[94] The Senate Report also states that Congress rejected the Automobile Manufacturers Association's attempt to bind the rate of innovation imposed by safety standards to the pace of innovation of the manufacturers.[95] Similarly, the House Report states that NHTSA should consider all relevant factors when considering whether a safety standard is practicable, "including technological ability to achieve the goal of a particular standard."[96] The Sixth Circuit rightly points out that there would be no need for NHTSA to consider technological ability to achieve a particular safety goal if NHTSA was limited to issuing standards that reflected the current state of

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[93] 472 F.2d 659 (6th Cir. 1972).
[94] *Id.* at 671, citing S.Rep. 1301, 89th Cong., 2d Sess., 2 U.S.Code, Cong. and Admin.News, 2709 (1966).
[95] S.Rep. 1301, 89th Cong., 2d Sess., 2 U.S.Code, Cong. and Admin.News, 2709 (1966), which states "In fact, specific efforts by the Automobile Manufacturers Association to tie the rate of innovation imposed by safety standards to the pace of innovation of the manufacturers were rejected by the House Committee on Interstate and Foreign Commerce, and the reported bill proposed that safety standards be "practicable, meet the need for motor vehicle safety, and be stated in objective terms."
[96] H.R.Rep. 1776, p. 16.

technology.[97] The court ultimately ruled that NHTSA is empowered by the Safety Act to issue FMVSS that require improvements in existing technology or that might even require development of new technology.[98]

Second, NHTSA has evidence that AEB performance improved dramatically between 2020 and 2023 model years. Considering the marked improvement in AEB system performance demonstrated in NHTSA's additional testing, NHTSA finds that manufacturers are already coming close to meeting the requirements of this final rule.

The agency disagrees with commenters that the no-contact requirement is not practicable because no vehicle in the agency's 2020 research met all lead vehicle AEB tests as presented in the NPRM. We believe that the vehicles used in the 2020 research were designed with the intention to meet the demands from the 2016 voluntary commitment and the existing U.S. NCAP. As presented in the NPRM, these programs demand a much lower level of AEB performance than those of this final rule. For example, the highest test speeds of the 2016 voluntary commitment and the NCAP are both 40 km/h (25 mph) in a lead vehicle stopped test scenario. On the other hand, the highest subject vehicle test speed of this rule for the same scenario is 80 km/h (50 mph) – much higher than that of the programs. Even though the AEB systems were designed with substantially low target performance goals, three out of eleven vehicles in the 2020 research were able to meet the no-contact requirement at the speed up to 72.4 kph (45 mph) in the lead vehicle stopped test scenario.

NHTSA conducted additional AEB research with six model year 2023 vehicles (from six different manufacturers) using the performance requirements and test procedures of this final rule.[99] The results of this additional research demonstrated that one vehicle was able to meet the

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[97] 472 F.2d at 672.
[98] *Id.* at 673.
[99] NHTSA's 2023 Light Vehicle Automatic Emergency Braking Research Test Summary, available in the docket for this final rule (NHTSA-2023-0021).

no-contact requirement at least once in all required lead vehicle AEB test conditions. Thus, the technologies needed to make the AEB systems which can meet the no-contact requirement and other performance requirements of this final rule are currently available. IIHS also observed similar results, which they assert indicate that some existing AEB systems are able to completely avoid collisions in the required lead vehicle AEB testing conditions.

Furthermore, in analyzing whether an FMVSS is objective, practicable and meets the need for motor vehicle safety, NHTSA must balance benefits and costs and consider safety as the preeminent factor in its considerations.[100] NHTSA believes that lowering the performance requirement to one that allows for contact would fail to treat safety as the preeminent factor for this final rule and otherwise be inconsistent with the goals of the Safety Act.

Increasing unintended consequences

In the comments, vehicle manufacturers and equipment suppliers expressed concern that the no-contact requirement may cause some unintended consequences, such as increasing false positive activations and taking away driver's authority at a high speed.

As for the false positives, the concern is based on a hypothetical situation that the no-contact requirement might cause a vehicle to prematurely activate the AEB system from a far distance where there is not a true risk of an imminent crash. The rationale is that the vehicle would be forced to initiate an early braking to achieve a full collision avoidance. These comments represent a combination of concerns – concerns with the no-contact requirement and concerns with the maximum speed in the testable range. This section addresses only the issue of no contact. Other related issues are addressed in the appropriate sections.

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[100] *See, e.g., Motor Vehicle Mfrs. Assn. of United States, Inc. v. State Farm Mut. Automobile Ins. Co.*, 463 U.S. 29, 55 (1983) ("The agency is correct to look at the costs as well as the benefits of Standard 208 ... When the agency reexamines its findings as to the likely increase in seat belt usage, it must also reconsider its judgment of the reasonableness of the monetary and other costs associated with the standard. In reaching its judgment, NHTSA should bear in mind that Congress intended safety to be the preeminent factor under the Motor Vehicle Safety Act.").

NHTSA does not expect that false activation would occur for well-designed systems. NHTSA recognizes that false activation could occur when an AEB system has low accuracy and reliability. As mentioned previously, we agree with Luminar and other commentors that no-contact performance is within the capability of existing technology. For example, Honda asserted that an AEB system will likely intervene improperly when the road in front of a subject vehicle is curved to the left and there is a vehicle parked on the right side of the road that causes no risk of collision. If the subject vehicle is equipped with sufficient technology to detect the shape of the road ahead, the AEB system would not improperly activate based on the mere fact that a parked vehicle appeared in the middle of AEB's field of view. There are manners in which an algorithm can assess the shape of the road. The system will also be continuously receiving more data as the vehicle gets closer.

Another technical option is having redundant systems as suggested in the Alliance's comment. Regardless of whatever technical solution manufacturers choose, NHTSA does not believe that it should lower performance to match that of poor performers. Rather, manufacturers with poorly performing vehicles should strive to resolve their systems' deficiencies so that they can perform as well as the market's better or best performing vehicles.

Additionally, while this rule imposes performance requirements for AEB systems, it does not specify how manufacturers must meet the requirements. The agency is providing maximum flexibility to manufacturers in designing AEB system for their vehicles. NHTSA recognizes that different manufacturers have different economic and practical realities that face their businesses. NHTSA principal concern is with the safety outcome and not the path that a manufacturer chooses to take to get to the required outcome. Given the various technical options, selecting technology for their AEB systems and setting the level of accuracy and reliability are at the manufacturers' discretion. At the same time, the manufacturers should be responsible for any safety-related defects in their vehicle products, in this case potential false positive activations. Therefore, we expect that vehicle and equipment manufacturers will mitigate and resolve any product defect issues including potential false activation in their AEB systems. NHTSA will continue to monitor complaints on AEB systems from the public, including those involving false activations, and will evaluate the risks they present.

NHTSA does not agree with the Alliance and other commenters that an AEB activation at a high speed may remove a safer crash avoidance option from drivers. The AEB system presumably only starts braking when the system detects an imminent crash, which is the first thing NHTSA expects a driver would do. While last-minute steering by the driver intended to avoid a crash is another possibility, NHTSA is not persuaded this is the safest option or that it is incompatible with AEB activation. A steering maneuver to avoid a crash might succeed under very limited circumstances. First, there must be another lane adjacent to the primary lane where a subject vehicle and a target vehicle are located. Second, a sufficient space must also be available in the adjacent lane. Finally, the driver must have the ability to safely maneuver a vehicle at such a high speed. Regardless, nothing in this rule specifies what an AEB system must do when a driver executes a steering maneuver to avoid a crash.

<u>Global harmonization is not possible for no contact because it unreasonably lowers the safety benefits received by the public</u>

NHTSA received comments that requested NHTSA to reject the no-contact requirement and adopt UNECE Regulation No. 152 requirements that permit low speed contact. Consistent with NHTSA's longstanding commitment to international harmonization[101] and section 24211 of BIL, NHTSA cooperates to the maximum extent practicable with respect to global harmonization of vehicle regulations as a means for improving motor vehicle safety.

NHTSA has been a leader in various international forums that impact vehicle safety for decades. The primary forum in which NHTSA engages in these activities is UNECE World

[101] https://www.federalregister.gov/documents/1994/03/08/94-5181/revision-of-the-1958-united-nations-economic-commission-for-europe-agreement-regarding-the.

Forum for Harmonization of Vehicle Regulations (WP.29). This international work is crucial to NHTSA's safety mission because it allows the agency to share its knowledge and expertise with foreign counterparts around the world, and for NHTSA to learn from its foreign counterparts. It also allows for NHTSA to advocate for standards that meet NHTSA's robust requirements and improve safety is measurable ways. Analysis of safety benefits provide NHTSA with a good understanding of the expected impact of its regulations. Such analysis is not necessarily required or conducted at WP.29.

NHTSA does not interpret section 24211 of BIL as requiring that NHTSA adopt harmonized regulations for the primary purpose of harmonization. To adopt this interpretation would be inconsistent with the text of section 24211 and the Safety Act. NHTSA interprets section 24211 as requiring NHTSA to promote safety in global forums. NHTSA believes that "as a means for improving motor vehicle safety" is intended to convey that the requirement to harmonize has the goal of improving motor vehicle safety. In situations where adopting an international or regional regulation would result in reducing motor vehicle safety, NHTSA does not believe the agency carries any obligation under the abovementioned section to adopt regulations that result in lower performance.

UNECE Regulation No. 152 was drafted by entities under an agreement to which NHTSA is not a party, and it was drafted years before NHTSA's NPRM. The testing NHTSA has conducted in support of this rule indicate that the industry has made substantial progress between 2020 and 2023 model years. NHTSA's adoption of more stringent requirements than existing UN Regulations indicates NHTSA's commitment to maximizing safety.

Variability and compliance margins

FCA's comment indicates that it is concerned both about variability and about the compliance margins it thinks may be necessary for it to ensure compliance with this rule. First, FCA commented that the no-contact requirement would force early decisions and that the NPRM did not discuss why, in multiple runs, vehicles can pass some but not all tests without contacts. From NHTSA's perspective, the variability seen in NHTSA testing is expected because the systems tested were not designed to be compliant with the proposed requirements. As NHTSA has seen through its NCAP testing, manufacturers design systems to meet whatever thresholds are set, and when they do that, their vehicles are designed to pass those tests. This suggests to NHTSA that the variability in the NHTSA testing is due to the fact that no manufacturer has designed their systems to meet all of these requirements. While NHTSA understands that industry is concerned about the stringency of the no-contact requirement, variability does not seem to be at the heart of that issue.

FCA also raised concerns about the compliance margins it believes may be necessary for its products to comply with the no-contact requirement. Compliance margins are usually manufacturer dependent due to a variety of reasons that include the fact that each manufacturer establishes a different level of organizational risk acceptance and each manufacturers' products are usually unique to that manufacturer. As stated in the FRIA accompanying this rule, different manufacturers may have differing compliance margins with which their companies are most comfortable. Differing compliance margins and overall organizational risk management practices can impact the product and costs to make that product. Manufacturers are free to choose what compliance margins make sense for their organization and their products, and NHTSA does not dictate that. NHTSA establishes a minimum level of performance and manufacturers are required to ensure that their products meet that minimum level.

<u>NHTSA's testing is sufficient to support this rule</u>

The testing conducted by the agency included the most common rear-end crash scenarios across several speeds and included a range of vehicle types and both camera and radar and camera fusion systems. In the case that the vehicle met the requirements (no contact) for a specific crash scenario and speed, testing continued at higher speeds. For the Lead Vehicle AEB testing, each vehicle was tested five to seven times for each scenario and speed combination. For the PAEB testing, each vehicle was typically tested five times for each combination of scenario, speed, and lighting condition.

In the absence of unlimited time and resources, it is not possible to test every vehicle across each combination of scenario, speed, and condition. Further, contact with a target object has the potential to compromise future test runs. Even relatively low speed impacts can result in a misalignment of forward-looking sensors, particularly those mounted behind lower trim and/or the grill. As a result, subsequent (i.e., post impact) tests may not be representative of the vehicle condition at time of first sale.

The vehicles included in the testing conducted by the agency include a variety of body styles including heavier vehicles such as SUVs and pick-up trucks. The heavier vehicles included in testing NHTSA used to support the NPRM were Ford F-150 SuperCrew, Mercedes-Benz GLC 300, Hyundai Palisade, Audi Q5, and Range Rover Sport. The vehicles that NHTSA tested also included a mix of camera only and radar and camera fused systems utilized by model year 2020/19 vehicles.

Furthermore, NHTSA performed additional confirmatory testing that included 2023 model years. This testing showed that the models tested performed even better than those in 2020, which supports NHTSA's position that this rule is not only achievable but very close to being within reach for many manufacturers. NHTSA believes that the research from 2020 and 2023 is sufficient to support this final rule.

d. No-Contact Requirement for Pedestrians

Similar to the lead vehicle AEB performance test requirements, NHTSA proposed that PAEB-equipped vehicles must completely avoid a collision with a pedestrian test mannequin during specific test track scenarios. NHTSA requested comment on the same two alternatives to a no-contact requirement for pedestrian performance test requirements.

NHTSA notes that the positions taken by commenters for both lead vehicle AEB and PAEB are substantially similar, and therefore, much of what was said in the previous section also applies. This section primarily addresses issues specific to pedestrians.

Comments

IIHS stated that their evaluations of existing PAEB systems indicated that some current systems are completely avoiding collisions in the required PAEB testing conditions. IIHS stated that they began evaluating PAEB performance in new vehicles during the day in 2019 and at night in 2022. Furthermore, they stated that IIHS's PAEB ratings are based on a mixture of the data submitted by manufacturers for verification and the results from their internal testing. As of June 2023, IIHS stated that they rated 194 model year 2023 PAEB systems tested during the day. Of those, 33 (17 percent) fully avoided the pedestrian mannequin in every test condition. IIHS further stated that of the 114 model year 2023 PAEB systems tested at night, 12 (11 percent) fully avoided the pedestrian mannequin in every test condition.

MEMA commented that full avoidance is not reproduceable at higher velocities in low light conditions and in obstructed scenes. Due to external influences, MEMA contended that it is impossible to ensure that every test run is performed under the exact same conditions in this test, which is why it cannot be guaranteed that AEB will always achieve its maximum performance.

The Alliance stated that they suggest that the agency set the requirements of the regulation with the goal of minimizing the risk of serious injury in cases where vehicle to pedestrian contact occur, while providing for more certainty in making a determination to apply the brakes for crash avoidance and mitigation. Based on available research, the Alliance stated that establishing a no-contact requirement up to 30 km/h and a residual relative speed contact threshold not to exceed 25km/h would ensure the risks of sustaining a MAIS 3+ injury is well below 10%. Further, The Alliance stated that this exceeds the acceptable injury thresholds established in NCAP (for achieving a five-star rating) as well as the recommendations of Academic Expert Group for the 3rd Global Ministerial Conference on Road Safety. The Alliance stated that the suggested hybrid approach which would maintain the no-contact requirements at vehicles speeds up to 30 km/h but permit some level of contact if an acceptable speed reduction were achieved would reduce the potential for false positives under real world conditions.

Bosch stated that they wanted to address the "no-contact" requirement in performance testing and its implications for safety systems, particularly in the context of pedestrian dummy detection and reaction. Further, Bosch stated that considering the challenge of detecting and reacting to the pedestrian dummy, there are still reservations concerning the no-contact requirement. Further, Bosch stated that they suggest that the criteria for collision mitigation systems be based on a certain amount of minimum speed reduction while considering injury-related assessments, such as the Head Injury Criteria (HIC) or similar measures (e.g., acceleration exerted on the body during crash).

Agency Response

After considering the comments, the agency has concluded that the full collision avoidance requirement in PAEB tests, as proposed in the NPRM, is most appropriate for this final rule.

First, we agree with commenters that pedestrians could suffer severe injury at any speed in the testable range. Pedestrians are particularly vulnerable when coming in contact with a vehicle of any size. This is especially true when pedestrians are stuck by larger vehicles such as SUVs and pickup trucks. NHTSA believes that the increased vulnerability of pedestrians makes it even less desirable to permit any vehicle-to-pedestrian contact within the testable range.

Second, the impracticability argument raised by Alliance, MEMA and other manufacturers is not persuasive. That argument is primarily based on the agency's 2020 PAEB research presented in the NPRM, in which no vehicle met all required PAEB performance tests. The commenters assert that this reflects that the existing AEB related technologies are not ready for the level of PAEB performance required by this rule. However, we disagree with the commentors and believe that the results of the 2020 research are not indicative of shortcomings in the overall capability of the current PAEB technology. Rather, they are systems designed to meet a lower level of performance.

The agency conducted PAEB research with six model year 2023 vehicles (from six different manufacturers) using the proposed performance requirements and test procedures.[102] The results demonstrated that at least one vehicle was able to meet all performance requirements of this final rule. To the extent others do not, NHTSA has authority to issue technology-forcing standards when it is shown, as it is here, that meeting the standard is practicable.

While the Alliance asserts that reducing impact speeds with pedestrians below 25 km/h could reduce the risk of serious injury, NHTSA believes that striking a person with a vehicle is not acceptable at any speed under any conditions. NHTSA included pedestrians in this rule because of their vulnerability and the trend of increasing pedestrian fatalities. Accordingly, we believe that retaining the no-contact requirement for the PAEB performance tests in the final rule is the most appropriate to ensure the maximum safety of the pedestrians.

e. Permissibility of Failure

As an alternative to the no-contact requirement with a single run that NHTSA proposed for lead vehicle AEB and PAEB, NHTSA sought comment on permitting the subject vehicle to use multiple test runs to achieve the performance test requirements. NHTSA provided background about how NHTSA's crash imminent braking and dynamic brake support testing within the New Car Assessment Program tests performance criteria, at the time of NPRM publication, specify that the speed reduction requirements for each test scenario must be met in at least 5 out of 7 tests runs. NHTSA stated this approach would provide a vehicle more opportunities to achieve the required performance and the agency more statistical power in characterizing the performance of the vehicle.

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[102] NHTSA’s 2023 Light Vehicle Pedestrian Automatic Emergency Braking Research Test Summary, available in the docket for this final rule (NHTSA-2023-0021).

The agency also requested comment on the number of repeated tests for a given test condition and on potential procedures for repeated tests. The agency further requested comment on the merits of permitting a vehicle that fails to activate its AEB system in a test to be permitted additional repeat tests, including a repeat test process similar to that in the recent revisions to UNECE Regulation No. 152. Finally, the agency requested comment on whether there should be additional tests performed in the event no failure occurs on an initial test for each series.

The Advocates, Forensic Rock and AAA oppose allowing repeated test trials in all test situations. Forensic Rock stated test failures should not be allowed when performing testing under ideal conditions. AAA stated that repeated tests would lead to ambiguity around whether a vehicle that has previously passed the test should be retested.

The ASC, ZF, Humanetics, MEMA, Bosch, Mitsubishi, the Alliance, Porsche, Hyundai, Aptiv, Rivian, and Volkswagen all support allowing repeated test trials. ASC, ZF, Humanetics, MEMA, Bosch, and the Alliance specifically acknowledge that testing with a 5 out of 7 passing threshold for the speed reduction tests would be appropriate. Rivian recommends running between 3 and 5 tests and averaging the speed reduction achieved with a passing grade being given to vehicles that average greater than a 50 percent speed reduction. The Alliance and Porsche also recommend that a vehicle could pass after three consecutive successful tests. ASC and ZF recommend that repeated trial testing be used at speeds of 25 mph and higher. ZF recommends that the speed reduction targets should be data driven based on speeds where there is a severely limited risk of injury to pedestrians or vehicle occupants. ZF, Porsche, Aptiv, Volkswagen and ASC also suggest the test requirements be aligned with UNECE Regulation No. 152 speed reduction requirements for daytime scenarios.

NHTSA is not including multiple test trials in this final rule. NHTSA agrees with commenters that allowing for repeated test trials, which would essentially permit a certain threshold of failures, under ideal test conditions is not acceptable. NHTSA believes that a single test run, and the expectation that a manufacturer pass all test runs if NHTSA chooses to run the same test several times, provides the performance consistency that consumers expect and safety demands. This is particularly true given that NHTSA will be conducting testing in idealized, controlled conditions when compared to real-world situations. For many years, NCAP testing and other testing around the world has permitted repeated test trials, and NHTSA believes that is appropriate for a technology that is new or being developed. However, for more mature systems with a long record of real-world use, NHTSA believes that a single test run is necessary to provide the agency the confidence that the performance it is regulating will perform as consistently as possible.

NHTSA believes it is even more important that PAEB perform in a single run with no contact due to the vulnerability of pedestrians in a vehicle-to-pedestrian crash. First, the speed ranges in which PAEB is expected to not contact a pedestrian mannequin during testing are lower than they are for lead vehicle AEB. Second, as with the no-contact provision, allowing for multiple runs is even more unacceptable for vehicle-to-pedestrian crashes because pedestrians are more vulnerable when being struck by a vehicle.

F. False Activation Requirement

NHTSA proposed to include two scenarios in which braking is not warranted. The agency proposed that AEB systems need to be able to differentiate between a real threat and a non-threat to avoid false activations. The two proposed false activation scenarios were the steel trench plate and the vehicle pass-through test scenarios.

1. Need for Requirement

NHTSA remains concerned that false activation events may introduce hard braking situations when such actions are not warranted, potentially causing rear-end crashes. The false activation tests establish only a baseline for system functionality. They are by no means comprehensive, nor sufficient to eliminate susceptibility to false activations. Rather, the tests are a means to establish minimum performance. NHTSA expects that vehicle manufacturers will design AEB systems to thoroughly address the potential for false activations. Vehicles that have excessive false positive activations may pose an unreasonable risk to safety and may be considered to have a safety-related defect. Previous implementations of other technologies have shown that manufacturers have a strong incentive to mitigate false positives and are successful even in the absence of specific requirements.

The two proposed false activation scenarios are the steel trench plate and the vehicle pass-through test scenarios. Both of these tests include acceleration pedal release and testing both with and without manual braking, similar to testing with a stopped lead vehicle. NHTSA proposed that, during each test trial, the subject vehicle accelerator pedal will be released either when a forward collision warning is given or at a headway that corresponds to a time-to-collision of 2.1 seconds, whichever occurs earlier. For tests where manual braking occurs, the brake is applied at a headway that corresponds to a time-to-collision of 1.1 seconds.

In the steel trench plate false activation scenario, a subject vehicle traveling at 80 km/h (50 mph) encounters a secured 2.4 m (7.9 ft) wide by 3.7 m (12.1 ft) long steel by 25 mm (1 in) thick ASTM A36 steel plate placed flat in the subject vehicle's lane of travel, and centered in the travel path, with its short side toward the vehicle (long side transverse to the path of the vehicle).

The pass-through test, as the name suggests, simulates the subject vehicle encountering two vehicles outside of the subject vehicle's path that do not present a threat to the subject vehicle. The test is similar to the UNECE Regulation No. 131 and UNECE Regulation No. 152 false reaction tests.[103] In the pass-through scenario, two vehicle test devices (VTDs) are positioned in the adjacent lanes to the left and right of the subject vehicle's travel path, while the lane in which the subject vehicle is traveling is free of obstacles.

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[103] UNECE Regulation No. 131 (Feb. 27, 2020), available at https://unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/2015/R131r1e.pdf; UNECE Regulation No. 152, E/ECE/TRANS/505/Rev.3/Add.151/Amend.1 (Nov. 4, 2020), available at https://unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/2020/R152am1e.pdf.

The two stopped VTDs are positioned parallel to each other and 4.5 m (14.8 ft) apart in the two adjacent lanes to that of the subject vehicle (one to the left and one to the right with a 4.5 m (14.8 ft) gap between them). The 4.5 m (14.8 ft) gap represents a typical travel lane of about 3.6 m (11.8 ft) plus a reasonable distance at which a vehicle would be stationary within the adjacent travel lanes.

Comments

ASC, MEMA, Hyundai, Volkswagen, Mitsubishi, and the Alliance for Automotive Innovation submitted comments opposing the proposed false activation tests. ASC stated that EuroNCAP does not include a false activation test because the vehicle could be programmed to pass any specific false activation test. ASC further stated that the current sensors used in vehicles do not have the same susceptibility to false activations that the proposed tests were designed to identify. Volkswagen and Hyundai questioned whether the test scenarios were comparable to real world scenarios. MEMA and the Alliance stated that testing for two specific scenarios does not entirely represent what is required to design AEB systems that accurately discriminate between actual crash-imminent situations and false triggers. As a consequence, the commenters asserted that meeting the proposed performance requirements only increases testing burdens while not providing a good indicator of the likelihood of a system producing false activations in real world driving conditions.

Advocates, Humanetics, and Consumer Reports support the proposed false activation requirements, stating that to maximize safety and consumer acceptance, false activations must be limited as much as possible through test procedures included in the final rule. In addition, these performance-based tests are a more robust solution than a document-based approach. Adasky also supported including false positive testing.

Luminar Technologies stated that it is neutral on the matter of requiring the false positive testing as proposed or demonstration of false positive measures by the manufacturer in another way. Luminar believes that false positive testing is absolutely necessary for safety and to create public trust, but understands that in some situations, especially for future autonomous vehicles, that the proposed false positive scenario may not necessarily occur in the real world.

Porsche recommends NHTSA consider aligning false activation test requirements with those that are found on the UNECE Regulation No. 152.

Agency Response

The agency has retained the two false activation requirements including the steel trench plate and the vehicle pass-through scenarios. Like many NHTSA tests, the false activation tests do not cover all the situations in the real world where false activations can occur. However, NHTSA believes that these tests add value to the rule. The steel trench place test provides protection against a known engineering challenge for some sensing technologies. Road construction sites often include steel trench plates for which vehicles will encounter in the real world. Likewise, a vehicle driven particularly in urban areas often drives between parked cars on both sides of the road.

Manufacturers must be responsible for false activations regardless of FMVSS test requirements and must engage in the precision engineering to prevent false activation and unintended consequences. The industry responsibility does not mean that NHTSA should not include aspects of performance that products must continue to meet. NHTSA believes that issuing an FMVSS with false activation prevent testing underscores the industry responsibility and works to ensure better performing systems.

The comments from MEMA and Alliance suggests a potential need for more robust false activation testing. However, it is impossible for NHTSA to test all circumstances in which false activations may occur. That is not a logical basis for having no false activation tests. The commenters did not suggest additional tests for NHTSA to consider in this final rule.

NHTSA agrees with Advocates, Humanetics, and Consumer Reports that maximizing safety and consumer acceptance are essential elements to help ensure the public receives the benefits of this technology. NHTSA agrees with Mitsubishi that ultimately protecting against the activation of AEB in situations where there is no imminent crash is the responsibility of the manufacturer. However, it is also appropriate for the FMVSS to set a minimum standard below which no vehicles should perform. While current systems may be less prone to false activations in the scenarios proposed, the scenarios represent known vulnerabilities in previous technologies. The tests ensure that performance of new technologies continue to provide the resistance to these false activation situations.

Considering Porsche's suggestion that NHTSA use the same false activation tests as the UNECE, NHTSA agrees that the curved road and turning scenarios that are part of UNECE Regulation No. 152 are relevant real-world conditions. Not all situations, however, can be tested through regulation. NHTSA is finalizing the two false activation tests it proposed because of the expected positive impacts they will have on system performance by preventing reemergence of prior performance issues and preventing other types of false activations.

2. Peak Additional Deceleration

NHTSA proposed that the AEB system must not engage the brakes to create a peak deceleration of more than 0.25g additional deceleration than any manual brake application generates (if used) in the steel trench plate false activation scenario. Similarly, NHTSA proposed that the AEB must not engage the brakes to create a peak deceleration of more than 0.25g beyond any manual braking in the pass-through test.

Comments

Consumer Reports suggested the threshold for maximum deceleration should be zero, especially under manual brake application. Consumer Reports opined that a 0.25g braking event is noticeable by passengers and could confuse or distract the driver. Consumer Reports asked that NHTSA remove any tolerance for false braking in these scenarios, or at the very least lower the threshold.

Agency Response

NHTSA is finalizing the braking criteria limit of 0.25g beyond manual braking as proposed. The agency balanced two factors in determining that a 0.25g criterion is more appropriate than using a 0.0g criterion. First, the ability to measure negative acceleration that results from the automatic application of the service brakes is difficult at low levels. As the total magnitude of deceleration increases, it is easier to establish that the service brakes are contributing as opposed to wind, tire friction, or engine drag. Second, it is unlikely that small levels of additional deceleration (less than 0.25g) could present a safety risk that could potentially lead to a crash.

3. Process Standard Documentation as Alternative to False Activation Requirements

As an alternative to the false activation requirements that were proposed, NHTSA requested comment on requiring manufacturers to maintain documentation demonstrating that robust process standards were followed specific to the consideration and suppression of false application of AEB in the real world. ISO 26262, "Road vehicles – Functional safety," ISO 21448, "Safety of the Intended Functionality (SOTIF)," and related standards, are examples of this approach. The agency requested public comment on all aspects of requiring manufacturers to maintain documentation that they have followed industry process standards in the consideration of the real-world false activation performance of the AEB system.

Comments

Advocates, Mitsubishi, the Alliance for Automotive Innovation, Honda, and FCA opposed the agency's alternative to require that manufacturers maintain technical documentation that they have followed industry process standards. Advocates and Consumer Reports stated that documentation should not be used as a replacement for testing, but as a supplement to testing. MEMA, ZF and Volkswagen supported the technical documentation option presented in the NPRM.

Mitsubishi explained as part of its opposition to technical documentation that it is impossible to predict all false-positive scenarios and be able to generate technical documentation for it. The Alliance stated such a requirement will increase the administrative burden on manufacturers with no added safety benefit. FCA and Mitsubishi stated that the suggested processes standard, like ISO 26262 or SOTIF, should not be an element of any FMVSS. FCA also stated that any FMVSS should be purely about a vehicle presented to a test site and with performance assessed according to objective criteria. FCA further stated that it is not necessary for the agency to understand how a product was developed to meet a minimum performance requirement, just that it does. Finally, FCA noted that NHTSA has other information gathering powers over industry (e.g., the current ADAS Standing General Order) and development practices or engineering methods should fall under that authority, not as part of an FMVSS.

In its support for a technical documentation requirement, ZF stated that, although they do not recommend a false activation test, they agree that efforts should be made in system design to mitigate against that risk. ZF supported some documentation to demonstrate efforts had been made in system design to prevent false activation. Volkswagen stated the most effective way to combat false positives is during the development process. Volkswagen and ZF both considered the suggested documentation requirements on measures taken against false positives to be a suitable approach.

Agency Response

After considering comments, NHTSA has opted not to include a requirement in the FMVSS that manufacturers maintain documentation of the application of process standards during AEB system development. Instead, the agency chooses to keep the false activation tests proposed and incorporate them into this final rule. NHTSA believes that performance testing of final products remains an important compliance tool for the agency.

Even though the agency is not finalizing the documentation proposal, NHTSA disagrees with commenters who asserted that this sort of documentation is not of use to the agency. The agency believes that the application of process standards in good faith is likely to increase the chances that manufacturers have created products that minimize unreasonable safety risks. NHTSA agrees that the agency has other pathways through which it could seek this sort of information, including during an inquiry into the reasonableness of a manufacturer's certification and through a defect investigation. Therefore, it is not necessary to include such a requirement in the FMVSS.

4. Data Storage Requirement as Alternative to False Activation Requirements

As another alternative to the two proposed false activation tests, NHTSA requested comment on requiring targeted data recording and storage of significant AEB activations. As an example, NHTSA considered requiring that an AEB event that results in a speed reduction of greater than 20 km/h (12 mph) activate the recording and storage of key information.

Comments

ASC, IIHS, MEMA, APCI, NTSB, and Forensic Rock supported data storage requirements. Advocates and Consumer Reports stated data storage requirements should not be used as a replacement for testing, but as a supplement to testing. ZF recommended that AEB system data be retained in some capacity by EDR systems. They stated that classification of the target that triggered the AEB activation may be useful for accident or false activation reconstruction. AAA and Rivian recommended the agency weigh how the data recording requirement would be implemented in the context of consumer privacy concerns. ASC stated its support of Event Data Recording (EDR) to assist in crash reconstruction and identification of false activation trigger factors. NTSB stated that without the data, it will be extremely challenging to determine whether and to what extent these systems were engaged during a crash. Forensic Rock stated that ensuring investigators have access to post-collision data that can objectively evaluate the performance of the AEB system in both lead vehicle and pedestrian collision scenarios is paramount and should be included in the FMVSS.

Honda, Bosch, Hyundai, Mitsubishi, the Alliance for Automotive Innovation and Volkswagen opposed requirements that would include AEB data storage. Honda stated that it was unclear as to the problem such a requirement would be meant to address. Bosch stated data recorders have limitations and are not able to determine whether a safety system's decision was reasonable, considering the provided sensor data. Hyundai stated it would entail significant burdens and unwarranted delays to this rulemaking and would provide no direct safety benefit. Mitsubishi stated a lack of objective and clear definitions of false activation indefinitely increases the data elements to record, which would require hardware reengineering. In addition, Mitsubishi stated that data is more likely to include privacy-sensitive information. The Alliance stated the agency has not provided any analysis on the technical feasibility of the proposal under consideration, nor has sufficient justification been made as to the practical utility of any data obtained as part of an information collection effort or the overall safety benefit to consumers. Volkswagen stated that to determine whether an activation was justified, camera data would be required in most cases and that storing camera data is not technically feasible for most current vehicle platforms due to processing and storage limitations of the existing architectures.

Agency Response

After considering comments, NHTSA is not including data storage as part of this FMVSS, and intends to keep the false activation tests that it proposed. NHTSA believes that the false activation tests will provide the minimum level of assurance that AEB systems will not provide unwarranted engagement. In the future, NHTSA can consider amending the EDR requirements established in 49 CFR part 563 and more broadly consider updates to vehicle data collection, event triggers for crash reconstruction, and potential gaps in performance of AEB and other safety systems. By looking at vehicle data holistically and considering the updates necessary to modernize 49 CFR part 563 and capture the information necessary for various driver assistance systems, the agency can further consider the data needs and associated burden to update the regulation to reflect the vehicle safety needs of today, current vehicle systems, and current manufacturer practices, while balancing privacy concerns.[104] Finally, regarding data manufacturers are already collecting, NHTSA has broad authority to request information from manufacturers during the course of investigations. Therefore, even absent a data recording requirement in an FMVSS or regulation, NHTSA expects that it can require manufacturers to provide the information that they are currently collecting on AEB systems.

G. Malfunction Detection Requirement

In the NPRM, NHTSA proposed that AEB systems must continuously detect system malfunctions. If an AEB system detects a malfunction that prevents it from performing its required safety function, the vehicle would illuminate a telltale that identifies (or indicates) the malfunction condition. The telltale would be required to remain active as long as the malfunction exists while the vehicle's starting system is on. NHTSA would consider a malfunction to include any condition in which the AEB system no longer functions as required by this rule. NHTSA proposed that the driver must be informed of the malfunction condition in all instances of component or system failures, sensor obstructions, or other situations that would prevent a vehicle from meeting the proposed AEB performance requirements. While NHTSA did not propose a specific telltale, NHTSA anticipates that the characteristics of the alert will provide sufficient information to the vehicle operator to identify it as an AEB malfunction.

1. Need for Requirement

The rationale behind the requirement that AEB systems continuously detect system malfunctions is that drivers would need to know when AEB is not functioning because AEB is an important safety system. NHTSA stated in the NPRM that it was considering minimum

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[104] With regard to consumer privacy, those concerns should be alleviated, at least partially, by the existence and application of the Driver Privacy Act of 2015, part of the Fixing America's Surface Transportation Act of 2015. The Driver Privacy Act assigned ownership of EDR data, as defined in 49 CFR 563.5, as the property of the owner or lessee of a vehicle. Importantly, it limits the access of EDR data to specific parties for specific purposes.

requirements for the malfunction indication to standardize the means by which the malfunction is communicated to the vehicle operator. Malfunctions of an AEB system are somewhat different than other malfunctions NHTSA has considered in the past. While some malfunctions may be similar to other malfunctions NHTSA has considered in FMVSSs because they require repair (loose wires, broken sensors, etc.), others are likely to resolve without any intervention, such as low visibility due to environmental conditions or blockages due to build-up of snow, ice, or loose debris.

Comments

Advocates, NAMIC, IIHS, MEMA and NTSB supported the proposed requirements for malfunction. NAMIC commented that it is important to include in a final rule a requirement that manufacturers notify the driver when AEB or other advanced driver assistance systems are malfunctioning or not performing as designed, and to include detailed directions for resolving the issue such as cleaning the sensor or going to a service center.

The Alliance stated that wording of the proposed malfunction requirements would likely result in excessive notifications to consumers and notifications that do not accurately communicate the status of the system. and may be misleading as to the actions required on the part of the driver to remedy the situation. The Alliance and Aptiv stated that it is not reasonable or practicable to require a manufacturer to detect changes in the roadway environment (e.g., road surface condition) or the extent to which these changes may affect the performance of a vehicle in meeting the requirements of the rule. The Alliance, Consumer Reports, and ITS America commented that malfunction failure indication should be limited to specific failures related to the hardware or software components that comprise an AEB system, not diminished performance due to environmental conditions such as heavy fog or snow.

The Alliance, NADA, and AAA recommended that NHTSA create separate definitions for “malfunction warning” and “system availability warning” to characterize these two conditions more accurately. Aptiv, Volkswagen, and Porsche suggested a warning based on

UNECE Regulation No. 152 for non-electrical failures (for example, obstructions due to weather). Bosch suggested further specification in the warning of “an appreciable time interval between each AEB system self-check.”

NTEA recommended that a compromised system function should not only warn the driver, but consider the possible prohibition of AEB activation. NTEA also provided cases where they feel sensors need self-monitoring abilities and temporary deactivation, such as a when going through a car wash or when overhead cargo is present that obstructs a portion of the forward camera’s field of view.

Agency Response

The agency agrees with commenters who state that it is necessary that AEB systems monitor system health and notify the driver when a malfunction is present. Where the agency diverges from commenters is with regard to the need to require manufacturers to provide detailed information regarding the nature of the malfunction. The primary information necessary for a driver to determine if it is safe to operate the vehicle is simply whether the AEB system is working relative to the performance requirements of this new final rule.

The agency agrees with the commenters who stated that external conditions that limit system performance (such as minute changes in the road surface construction, the presence of sand or gravel on the road surface, etc.) are not malfunctions of the system, and in some cases, it is not possible to determine the AEB system’s ability to perform. These conditions are often not readily measurable by vehicle sensors and are often temporary in nature.

NHTSA is clarifying that it did not intend to mandate that AEB perform in all environmental conditions. Rather, NHTSA requires that AEB systems function as required within the set of conditions provided in S6 of the regulatory text. The same is true for malfunction detection. NHTSA understands that there are differences between the driving environment hindering ideal AEB performance and true malfunctions of the system that likely require intervention to resolve. To give an example, snow might cause degraded performance for a variety of reasons, but a malfunction notification would not be necessary unless that snow results in deactivation of the AEB system, such as a situation when the snow obstructs the AEB sensors, causing the system to not meet the performance requirements. Alerting the driver to this type of malfunction is vital to the safe operation of the vehicle. Any notification of degraded system performance arising from any source (temporary or permanent) should end when the conditions that lead to the degradation end.

Therefore, this final rule clarifies that if the system detects a malfunction, or if the system adjusts its performance such that it will not meet the performance requirements, the system must provide the vehicle operator with a telltale notification. This requirement makes clear that if the system reduces its performance capabilities (regardless of if the reason is because of environmental conditions or for other reasons), the driver must be informed. Also, if the system is broken or a sensor is obstructed, the driver must be informed. However, if there are environmental conditions that decrease the system's ability to function (for instance decreased stopping distance) but the system has made no internal adjustments, a telltale is not required.

As for the issue of separate telltales to inform the driver of permanent and temporary malfunctions, the requirement proposed and adopted here was intended to give manufacturers flexibility in the style and nature of the driver malfunction notification. The requirements allow for different notification types for different types of degraded performance (e.g., internal malfunctions or external conditions) that degrade performance, should the manufacturer choose to do so. The manufacturer may also, at the manufacturer’s discretion, choose to use the same telltale or other notification for the different types of degraded performance. NHTSA has observed that some manufacturers currently do this and nothing in the NPRM was intended to prohibit this. This is consistent with the malfunction warning requirements in UNECE Regulation No. 152.

The agency appreciates Bosch suggesting a more specific definition, but NHTSA is not adopting the proposed definition for malfunction detection provided at this time because it is not workable for an FMVSS. For example, "appreciable time interval" is not an objective measure of timing, nor does it give manufacturers notice as to what NHTSA expects of them. Furthermore, NHTSA does not have a basis for why it would treat electrical failure conditions differently than any other type of system malfunction, as suggested by Bosch.

Regarding NTEA's suggestion that NHTSA prohibit AEB activation in the instances where a malfunction may be present, NHTSA does not believe that mandating the prohibition of AEB activation is necessary since there is no evidence that a manufacturer would permit its systems to function in a state so degraded as to present an unreasonable risk to safety.

2. Malfunction Telltale

NHTSA did not propose the specifics of the telltale but anticipated that the characteristics of the alert would provide sufficient information to the vehicle operator to identify it as an AEB malfunction, and would also be documented in the vehicle owner's manual. NHTSA requested comment on the potential advantages of specifying test procedures that would describe how the agency would test a malfunction telltale and on the related level of detail that this regulation should require. The agency also requested comment on the need and potential safety benefits of requiring a standardized appearance for the malfunction telltale and what standardized characteristics would achieve the best safety outcomes. The agency further requested comment on the use of an amber FCW warning symbol as the malfunction notification.

Comments

The Alliance and Nissan commented that specifics of a telltale for malfunction (and related system status) should be defined by the manufacturer. Nissan observed that UNECE Regulation No. 152 does not define the specific form of the malfunction telltale.

ASC suggested that the agency require an AEB malfunction telltale to be located on the vehicle's instrument panel. ASC stated that on start-up, the AEB system could run diagnostics and trigger the malfunction telltale if a failure or obstruction is detected.

However, several other commenters suggested standardization of a common malfunction telltale. ZF and MEMA suggest a telltale modeled after the ESC telltale, in an effort to better alert the driver to an AEB malfunction.

Toyota stated that an amber telltale may be appropriate, as it aligns with similar malfunction requirements, such as those in FMVSS No. 135.

IIHS commented that NHTSA should require manufacturers to notify the driver when AEB or other ADAS are malfunctioning or not performing as designed. They noted that, ideally, the notification should provide directions for resolving the issue, such as cleaning the sensor or going to a service center, noting that drivers should not be expected to troubleshoot misbehavior or malfunctions from their ADAS, especially when the malfunction introduces new risks. They provided two examples of a vehicle with a misaligned radar following a crash and a skewed camera following a windshield replacement, which did not provide an indication of malfunction or reduction of performance.

AVIA commented that for AVs, NHTSA should consider adding language that allows a malfunction detection notification to be directly communicated to the ADS itself or communicated to a remote assistant or to service personnel in the case of an AV without manually operated driving controls. They added that for an ADS-equipped vehicle with manually operated driving controls, the notification can be directly communicated to the ADS when it is engaged as well as through a telltale notification to the human operator. Zoox commented that the malfunction telltale requirement should specify that it be visible from the driver seating position and that, for vehicles without a driver seating position, the mechanism is specified by the manufacturer and provided upon request, and suggested that testing not be conducted while an equivalent notification to the telltale is active for vehicles without a driver seating position.

Agency Response

NHTSA agrees that the specifics of a telltale for malfunction should be defined in detail by the manufacturer. The agency has concerns, however, about drivers confusing a malfunction indicator that is co-located with the FCW symbol. As such, Toyota's suggestion to align the malfunction telltale with the FCW symbol may be problematic. The agency is concerned about confusing drivers, because using the same telltale could be interpreted as asking the driver to brake or as a malfunction.

NHTSA understands the positions of commenters who requested a standardized malfunction telltale. Nothing prohibits the industry from working together, such as through a standards organization, to implement a common telltale. However, NHTSA does not believe standardization is necessary at this time. Commenters did not provide sufficient evidence to demonstrate a need for a standardized malfunction indicator. Thus, NHTSA is not adding additional constraints on the telltale, in this final rule. If warranted, NHTSA would consider standardization if in the future it is determined that drivers do not adequately comprehend when an AEB malfunction has occurred.

NHTSA does not agree with ASC's suggestion of a standardized location for a telltale. FMVSS No. 101 does not provide specification for the location of any telltale except that it be visible to the driver when a driver is restrained by a seat belt. There is no evidence of a safety need for any more specific location requirement for an AEB system malfunction telltale.

As discussed in other sections, NHTSA agrees with IIHS that the driver should be notified when AEB is malfunctioning, which is the entire goal of a malfunction telltale requirement. NHTSA does not believe that it is necessary to notify drivers of the directions for resolving the issue, but that such information could be provided to drivers in the owner's manual. A driver who is driving on the street doesn't need to be told while the vehicle is moving that she needs to clean the sensor. Rather, this is diagnostic information that could be communicated through other means, like through the use of diagnostic tools accessing information in the OBD-II port.

As for the comments related to AVs, NHTSA believes it is most appropriate to address specific concerns related to AVs through other mechanisms, rather than shaping this particular

FMVSS around the needs of a very specific set of vehicles that may still have to apply for an exemption from other FMVSS. NHTSA is considering crash avoidance test procedures to facilitate the safe introduction and certification of new vehicle designs equipped with automated driving systems in a separate rulemaking.[105] NHTSA is also looking across all FMVSS to address the applicability and appropriateness of safety messaging (telltales, indicators, and warnings) in new vehicle designs without conventional driver controls.[106] Additionally, NHTSA notes that manufacturers are free to design their vehicles to have the malfunction detection notification be communicated directly to the ADS, a remote assistant or service personnel, as a redundant means of communication. Such redundancy is permissible in situations that a manufacturer believes it is necessary.

3. Sensor obstructions and testing

NHTSA proposed that the driver must be warned in all instances of malfunctions, including malfunctions caused solely by sensor obstructions. The NPRM also proposed that during track testing of the AEB system all sensors used by the system and any part of the vehicle immediately ahead of the sensors, such as plastic trim, the windshield, etc., would be free of debris or obstructions. NHTSA stated that it was considering requirements pertaining to specific failures and including an accompanying test procedure.

Comments

The Alliance stated that it is important that NHTSA define a finite set of scenarios that could be reasonably defined as a malfunction, should the agency decide to regulate in this area, to ensure that relevant scenarios are being addressed, and that other factors that may influence AEB performance are evaluated independently. Mobileye recommended performing full blockage camera/radar testing as in the Euro-NCAP Assisted Driving protocol. ZF also

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[105] https://www.reginfo.gov/public/do/eAgendaViewRule?pubId=202310&RIN=2127-AM00.
[106] https://www.reginfo.gov/public/do/eAgendaViewRule?pubId=202310&RIN=2127-AM07.

suggested testing by obstructing sensors. Rivian recommended that NHTSA adopt detailed procedures that can be performed on the test track and are representative of relatively high frequency occurrence in actual use cases. ZF commented that malfunction indicator light testing could be done by deliberately blocking for radar to simulate snow accumulation, or a piece of tape for cameras to simulate a lens blockage.

Agency Response

After considering the comments, NHTSA is not making any further specifications of failures that would be tested. As is customary with NHTSA's standards, the laboratory compliance test procedures will specify how NHTSA intends to run its compliance test regarding illumination of a malfunction telltale.

H. Procedure for Testing Lead Vehicle AEB

This section describes the lead vehicle AEB performance tests adopted by this final rule. After considering the comments to the NPRM, NHTSA has adopted the proposed procedures with a few changes. Some minor parameters and definitions were modified and various definitions were added, to clarify details of the test procedures. Additionally, to increase the practicability of running the tests, a third manual brake application controller option, a force only feedback controller, has been added. The force feedback controller is substantially similar to the hybrid controller with the commanded brake pedal position omitted, leaving only the commanded brake pedal force application.

This section responds to the comments and explains NHTSA's reasons for adopting the provisions set forth in this final rule. For the convenience of readers, a list of the test specifications can be found in the appendix A to this final rule preamble.

The lead vehicle AEB performance tests require a vehicle to automatically brake, or supplement insufficient manual braking, when tested during daylight under three specific test scenarios. The scenarios involve a stopped lead vehicle, a slower-moving lead vehicle, and a decelerating lead vehicle. The performance criterion for all AEB tests involving a lead vehicle is full collision avoidance, meaning the subject vehicle must not contact the lead vehicle.

The lead vehicle AEB tests include parameters necessary to fully define the initial test conditions in each scenario. Key test parameters for the lead vehicle AEB tests include the travel speed of both the subject vehicle and lead vehicle, the initial headway between the subject vehicle and the lead vehicle, the deceleration of the lead vehicle, and any manual brake application made to the subject vehicle. For each test run conducted under each of the scenarios, NHTSA will select the subject vehicle speed (V_{SV}), lead vehicle speed (V_{LV}), headway, and lead vehicle deceleration from the ranges specified in the standard.[107]

There will be testing under two conditions. In one condition, NHTSA will test without any manual brake application. This would simulate a scenario where a driver does not intervene at all in response to the FCW or impending collision. In the other condition, NHTSA will test with manual brake application that will not be sufficient to avoid the crash. Not only will the second condition ensure that the AEB will supplement the manual braking when needed, it also provides a way to ensure that an application of insufficient manual braking will not suppress automatic braking in circumstances where automatic braking is initiated before the manual brake application is used.

1. Scenarios

Many commenters suggested including additional scenarios in lead vehicle AEB testing.[108] Many commenters urged NHTSA to include lead vehicle AEB testing in the dark to increase the benefits of the rule. The Lidar Coalition commented that it supports testing AEB in the darkest realistic conditions possible. It stated that a test procedure in dark conditions would

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[107] In instances where an FMVSS includes a range of values for testing and/or performance requirements, 49 CFR 571.4 states, "The word any, used in connection with a range of values or set of items in the requirements, conditions, and procedures of the standards or regulations in this chapter, means generally the totality of the items or values, any one of which may be selected by the Administration for testing, except where clearly specified otherwise."

[108] These commenters included Luminar, Forensic Rock, Consumer Reports, Applied, Rivian, Advocates, Adsky and the Lidar Coalition.

evaluate AEB and PAEB technologies in the real-world scenarios where these systems are most needed because of diminished visibility. Forensic Rock state that they found differences in the performance of a specific vehicle's AEB system during the day as compared to testing under the same conditions at night and that to comprehensively evaluate the performance of AEB systems, daytime and nighttime tests should be conducted under the same closing speeds. Advocates suggested that NHTSA evaluate and present data demonstrating that the exclusion of testing lead vehicle (vehicle-to-vehicle) AEB under dark conditions is not limiting the performance level demanded by the proposed rule nor needlessly jeopardizing safety.

In response, NHTSA appreciates the interest in including additional scenarios to potentially assess AEB systems under a wider range of potential real-world situations. NHTSA does not, however, include further tests in this final rule. The decision to include a particular test scenario depends on various factors, including the safety benefit resulting from a requirement, the practicability of meeting the requirement, the practicality and safety of conducting a test, and, in accordance with E.O. 12866, the likelihood that market forces will incentivize manufacturers to provide the needed performance absent the requirement. NHTSA at present does not have sufficient supporting data to assess the need for, practicability of, or practicalities involved with adding darkness test scenarios to the lead vehicle AEB tests. This is in contrast to the PAEB test, which includes darkness test scenarios.

There is not enough data supporting a finding for a safety need for a darkness test. The test scenarios of this rule broadly represent real world situations by sampling the most common types of light vehicle rear-end crashes. In NHTSA's latest testing described earlier in this document, the agency observed that vehicle performance during the dark ambient tests were largely consistent with those produced during the daylight tests (in the absence of a regulation). The dark- compared to day-contact results observed for a given test speed were identical or nearly identical for several of the vehicles tested. Where impacts occurred, the impact speeds were very similar. Additionally, as detailed in the safety problem section of this preamble, 51 percent of rear end crash fatalities occur during daylight, and injury and property-damage-only rear-end crashes were reported to have happened overwhelmingly during daylight, at 76 percent for injury rear-end crashes and 80 percent for property-damage-only rear-end crashes.

Some data indicate that there may not be a technical need for a darkness test to reap the benefits of lead vehicle AEB in darkness. As part of this final rule, NHTSA is specifying minimum performance requirements for pedestrian avoidance in dark conditions. The agency believes that systems that can identify, and respond to, a pedestrian in the roadway at night could also possibly detect lead vehicle taillamps and other reflective surfaces that distinguish a vehicle from the surrounding visual landscape. The agency also believes a radar sensor will perform the same regardless of the lighting condition. As such, NHTSA believes an AEB system could be highly effective at classifying the rear of a lead vehicle in a dark condition, even without an explicit regulation requiring such performance. Only the daylight condition was proposed for lead vehicle AEB testing, and this sole lighting condition is maintained in this final rule.

Luminar, Forensic Rock, Consumer Reports, and Aptiv suggest the agency expand testing with additional overlaps (the measurement of deviation of the lead vehicle centerline and the subject vehicle centerline) for lead vehicle testing. Luminar stated that a 50 percent overlap in car-to-car scenario is used in both US and Euro NCAP testing and suggested that NHTSA should consider 50 percent overlap which, the commenter believed, is a common, achievable, car-to-car test scenario. Forensic Rock suggests expanding the testing to include a 25-50% overlap condition would ensure that the performance of these systems included more than just pure collinear crash scenarios.

In response, NHTSA has not included test scenarios with an overlap less than 100 percent (although a tolerance on the travel path of the subject vehicle is included). A rear-end crash as defined in the FARS database is “a collision in which one vehicle collides with the rear of another vehicle."[109] Even at the higher speeds used in testing, a change of the overlap during testing from 100 percent to 50 percent or 25 percent would result in only a marginal change in the position of the lead vehicle in the field of view of the sensors. The proposed overlap for lead vehicle AEB testing is consistent with NHTSA's NCAP test procedures for CIB and DBS, the IIHS test procedure, as well as UNECE Regulation No. 152.[110] The agency does not have the necessary information to demonstrate practicality and need for a regulation that adopts scenarios that include a broad range of overlap.

Some commenters suggest that NHTSA should consider adding additional testing scenarios from EuroNCAP, such as the head-on scenarios and left turn across path. Consumer Reports suggested NHTSA incorporate additional scenarios such as a curved travel path, scenarios involving challenges posed by environmental conditions, and circumstances in which the lead vehicle is revealed suddenly or is not aligned straight when in front of the subject vehicle.

In response, this final rule requires lead vehicle AEB systems that will prevent or mitigate rear-end crashes of light vehicles and is based on the research and other data demonstrating the efficacy and practicability of these systems. The data and technologies for test scenarios representing crashes other than a rear-end crash are not yet available to support possible inclusion in an FMVSS.

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[109] https://www-fars.nhtsa.dot.gov/Help/Terms.aspx#:~:text=Rear%2Dend%20Collision,The%20Rear%20Of%20Another%20Vehicle. Accessed November 21st, 2023 at 3:22 PM.

[110] National Highway Traffic Safety Administration (Oct., 2015), Crash Imminent Brake System Performance Evaluation for The New Car Assessment Program. Available at: https://www.regulations.gov/document/NHTSA-2015-0006-0025; National Highway Traffic Safety Administration (Oct., 2015), Dynamic Brake Support Performance Evaluation Confirmation Test for The New Car Assessment Program. Available at: https://www.regulations.gov/document/NHTSA-2015-0006-0026; Insurance Institute for Highway Safety (Oct., 2013), Autonomous Emergency Braking Test Protocol (Version I), Available at: https://www.iihs.org/media/a582abfb-7691-4805-81aa-16bbdf622992/REo1sA/Ratings/Protocols/current/test_protocol_aeb.pdf; and UN Regulation No 152 – Uniform provisions concerning the approval of motor vehicles with regard to the Advanced Emergency Braking System (AEBS) for M1 and N1 vehicles [2020/1597] (OJ L 360 30.10.2020, p. 66, ELI: http://data.europa.eu/eli/reg/2020/1597/oj).

Applied stated that NHTSA should include additional scenarios and elements through virtual testing procedures. It stated that modeling and simulation technologies allow for a vehicle to be put through a much more expansive set of testing scenarios and elements than what are possible in real-world testing and may allow to vastly increase the number of tests that can be run creating a much greater pool of data to evaluate a vehicle.

In response, while virtual test scenarios involving modeling and simulation may be employed, and are employed, by manufacturers in developing lead vehicle AEB systems, such testing is not suitable for NHTSA's compliance testing of AEB systems at this time. Virtual testing has the potential to provide many benefits and advancements to motor vehicle safety. There are challenges, however, in using virtual assessments in agency compliance tests. The agency must be assured that the virtual scenarios it was running are representative of the real world and that the test results it obtained would be the same as those obtained in tests of an actual vehicle. Neither condition currently exists. Also, virtual test environments are reliable only if they have been appropriately validated. Right now, NHTSA does not have the research available to support the development of a simulator designed for the purposes of testing compliance with this rule. Though simulation testing is a method that NHTSA is very interested in from a research perspective, it is not yet an approach that is ready for NHTSA use in compliance testing.[111]

After considering the comments, this final rule adopts the three track test scenarios, which are lead vehicle stopped, lead vehicle moving and lead vehicle decelerating, as proposed in the NPRM.

[111] There are also several practical challenges that prevent NHTSA from using virtual testing to determine compliance with the FMVSS. NHTSA's goal is to independently purchase vehicles available on the market without notification to the manufacturer (or anyone) that it is purchasing a particular vehicle. This helps make sure that the product that NHTSA is testing is one that consumers of that product would also purchase. If NHTSA were to obtain vehicles directly from manufacturers for compliance testing, NHTSA may not be as confident about the independence of its testing results. Also, AEB systems are proprietary systems. If NHTSA needs capabilities and access to the technicalities of the AEB system to conduct virtual testing, confidential business information issues may arise.

2. Subject Vehicle Speed Ranges

The proposed speed ranges were selected based on the speeds at which rear-end crashes tend to happen, while considering two primary factors. The first factor is the practical ability of AEB technology to consistently operate and avoid contact with a lead vehicle. NHTSA's 2020 and 2023 research testing indicate that the selected speed ranges for the various scenarios are within the capabilities of current production vehicles. NHTSA proposed speed ranges to ensure AEB system robustness. To illustrate, during the agency's AEB research testing, two vehicles performed better at higher speeds (48 km/h or 30 mph) than at lower speeds (40 km/h or 25 mph) in the lead vehicle stopped tests, which suggests that a range of speeds should be used in FMVSS No. 127.[112]

The second factor is the practical limits of safely conducting track tests of AEB systems. Based on the available data, a majority of fatalities and injuries from rear-end crashes occur at posted speeds up to 97 km/h (60 mph). Due to the tendency of fatalities and injuries to increase as the vehicle travel speed increases, NHTSA proposed AEB system testing at the highest speeds at which NHTSA can safely and repeatably conduct tests. If a system does not intervene as required and the subject vehicle collides with the lead vehicle test device, it should do so in a manner that will not injure test personnel or demolish the laboratory's equipment and set-up.

Comments seeking to increase testing speeds to increase potential safety benefits

Many government entities, consumer interest groups, private individuals and others suggested that NHTSA consider exploring ways to increase test speeds.[113] Many suggested lead-vehicle AEB tests above 100 km/h (~60 mph) for the stopped lead vehicle and slower-moving lead vehicle scenarios, and 80 km/h (~50 mph) for the decelerating lead vehicle scenarios. These commenters point to the increased risk of crashes as well as fatalities and serious injuries

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[112] https://www.regulations.gov/document/NHTSA-2021-0002-0002.

[113] These commenters included the cities of Philadelphia, Nashville, and Houston, the Richmond Ambulance Authority, DRIVE SMART Virginia, NACTOA, the Lidar Coalition, Consumer Reports, Forensic Rock, and Luminar.

resulting from crashes as speeds rise, and some believed that a requirement to meet higher test speeds is practicable. Forensic Rock stated that if a private accident reconstruction firm can find suitable track length to conduct high closing speed tests, NHTSA should be able to as well. NTSB stated that test scenarios be designed to best reflect real world operating conditions as NTSB investigations have shown there is a need to consider systems' performance in other crash-relevant scenarios including unusual vehicle profiles and configurations encountered in real-world conditions.

Agency Response

After considering the comments, NHTSA declines to increase the test speeds proposed in the NPRM. The agency explained in the NPRM that NHTSA proposed what it believed to be the highest practicable and reasonable testing speeds. Testing speeds are bound by important practicability matters and practical limitations, such as the safety of the testing personnel, vehicle and test equipment damage, and the repeatability of testing and test validity. Forensic Rock suggested adding equipment such as "deer/cattle guards" to the subject vehicle during testing. NHTSA believes such an approach is untenable because such equipment would still not protect testing equipment and would alter the "real-world" condition of the vehicle.

NHTSA limited the maximum test speeds for lead vehicle AEB to no more than a maximum 80 km/h (50 mph) speed differential. NHTSA is encouraged by Luminar and Forensic Rock's testing at speeds higher than the NPRM, but, with regard to Luminar's comment that the systems they tested performed at speeds up to 120 km/h, the agency's limit for the testing speed was determined based on factors including safety need and practicability, and not just on AEB performance. While NHTSA is currently researching other testing scenarios for AEB, the agency does not have the needed information regarding practicability and the need for a higher speed regulation to include a broader speed range at this time.

Comments suggesting different approaches

Several commenters suggested NHTSA should take a hybrid approach and reduce speeds for a no-contact requirement while allowing contact at a higher speed. The Alliance, Toyota and others suggested NHTSA implement a hybrid approach that maintains no-contact requirements for lower-mid-range speeds while permitting compliance if acceptable speed reductions that reduce the risk of serious injury can be achieved in higher-speed scenarios. It stated that such an approach would align with the approach implemented by other international bodies, such as UNECE Regulation No. 152, where no contact is required up to 40 km/h and various levels of maximum impact speeds are allowed from 42 km/h up to 60 km/h.[114] A number of other commenters suggested reducing the range of testing speeds and allowing contact above certain testing speeds.[115]

The Alliance stated that the hybrid approach would ensure that vehicle speeds are reduced to a level where crashworthiness features can provide an additional layer of protection for reducing the severity of occupant and pedestrian injury outcomes by lowering the overall impact speed. Volkswagen provided an analysis, which it stated is not statistically significant, which showed that vehicles on the road today can protect their occupants from severe injuries of MAIS 3+ even with collision speeds up to 50 km/h. Toyota recommended an approach that vehicle-to-lead vehicle target contact be allowed "at a speed low enough that the crash would be highly unlikely to be fatal or to result in serious injury." Honda also considered NHTSA's crash injury estimations for the risk of severe injury or fatality in frontal crashes to suggest a hybrid type approach.

Agency Response

The commenters support a hybrid approach where collision avoidance would be required only up to 42 km/h (26.1 mph) and speed reduction (a mitigated collision) permitted at speeds

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[114] https://unece. org/transport/documents/2023/06/standards/un-regulation-no-152-rev2. Other commenters supported harmonizing with UNECE Regulation No. 152, including ASC, Ford, Mitsubishi, and Nissan.
[115] These commenters included HATCI, Nissan, ZF, and Aptiv.

above 42 km/h (26.1 mph) during testing. NHTSA does not find this approach acceptable. The agency's intent is to prevent crashes at the highest practicable speeds and the proposed limits in testing speeds reflect this.

Using the speed limit as a proxy for traveling speed, the data presented earlier in this document show that about 60 percent of fatal rear-end crashes were on roads with a speed limit of 97 km/h (60 mph) or lower. That number is 73 percent for injury rear-end crashes and 78 percent for property-damage-only rear-end crashes. Out of the total rear-end crash population, only about 1 percent of fatalities, 5 percent of injuries and 7 percent of property-damage-only crashes happen where the speed limit is 40 km/h (25 mph) or less. If NHTSA were to require collision avoidance only for crashes up to 40 km/h (25 mph), in NHTSA's view only a fraction of fatalities and injuries would be avoided when so many more motorists could benefit. Such an outcome would fall short of meeting the need for safety, as meeting the proposed test speeds is practicable. As detailed in the research section, the 2023 Toyota Corolla Hybrid was able to avoid collision under all testing conditions up to the maximum proposed testing speed requirement for lead vehicle stopped and lead vehicle moving. That same vehicle, when tested for the lead vehicle decelerating scenario with a 12 m headway and 0.5g lead vehicle deceleration, was able to avoid collision in all trials when tested at 50 km/h and was able to avoid collision on two trials and incur impact speeds of approximately 5 km/h and below on the other three trials when tested at 80 km/h (50 mph). If NHTSA were not to require collision avoidance during testing at speeds up to 100 km/h (62 mph), the majority of fatal rear-end crashes would not be prevented.

NHTSA is providing a five-year lead time to push development of the technology while providing time to foster the evolution of it to achieve AEB's life-saving potential. Four out of the six vehicles tested avoided collision during agency testing at 50 km/h subject vehicle to 50 km/h lead vehicle and 12 m and the other two avoided in four out of the five trials. Considering that current AEB systems seem somewhat detuned at higher speeds because they were not designed to this requirement, the agency is encouraged that when engineered to meet this requirement, AEB will be able to avoid collision in a similar fashion as they do now under the 50 km/h condition.

The injury curves and thresholds provided by the commenters show that below 40 km/h (25 mph), there is a reduced probability of AIS3+ injury. With AEB, there is the potential to prevent the crash from occurring in the first place, i.e., to completely mitigate the risk of injury. The technology has proven capable of avoiding collisions during testing at higher speeds. With the potential of AEB technology, its rapid evolution, and the significant lead time this final rule is providing to allow for maturation and deployment of AEB, NHTSA has decided to maintain the no-contact requirement and speed limits at the levels proposed in the NPRM.

As another approach, Honda suggested to test only at what they state are worst case scenarios that pose the highest risk of injury (i.e., impact relative speed) and present the most challenging situations for AEB systems to react quickly (i.e., time to impact). Honda stated that after evaluating various combinations within the proposed headway distance and lead vehicle deceleration ranges, the worst-case scenarios are for impact relative speed of 72 km/h, time to collision (TTC) of 2.1 sec with a lead vehicle deceleration of 0.5 g, at both the 12 m and 40 m headway distances at 50 or 80 km/h.

In response, NHTSA does not believe that "worst case" scenario testing is appropriate for this standard in this final rule. In past NHTSA tests, vehicles sometimes avoided contacting the vehicle test device at higher speed tests but contacted it at lower speeds. A range of tests is necessary to better ensure satisfactory performance of the systems in the real world.

Some commenters suggest reduced speeds and repeat trials to avoid what they see as potential negative consequences

A number of commenters believed that having to meet the higher end of the proposed speed range will increase the likelihood of negative consequences. Several commenters believed that the higher end of the proposed speed range will increase the likelihood of false positives.[116] Porsche and Volkswagen stated that doubling the relative velocity at which no contact is required, as compared to UNECE Regulation No. 152, may impact the robustness of the system in real-world performance, potentially leading to increased instances of premature or unnecessary braking in the real-world. Aptiv stated that due to the possibility of false positives, NHTSA should reduce testing speeds to 50 km/h (31 mph) and allow repeat trials. Mobileye stated that the proposed requirement will necessitate hardware updates or replacement, and preferred a speed reduction requirement, based on a 2 out of 3 test runs. HATCI stated that NHTSA should follow the AEB voluntary commitment requirements.[117]

Agency Response

One reason the commenters requested lowering the upper speed range for a no-contact requirement was the concern that false activations would increase. In the NPRM, NHTSA stated that the proposed testing requirements are practicable and are intended to avoid and mitigate the most crashes. In the NPRM, NHTSA expressed that AEB systems are undergoing rapid advancement and have been able to achieve collision avoidance at higher testing speeds without major updates. Since the publication of the NPRM, NHTSA research has confirmed that a vehicle (the 2023 Toyota Corolla Hybrid) was able to avoid collision under all testing conditions up to the maximum proposed testing speed requirement for lead vehicle stopped and lead vehicle moving. That same vehicle, when tested for the lead vehicle decelerating scenario with a 12 m headway and 0.5 g lead vehicle deceleration, was able to avoid collision in all trials when tested at 50 km/h and was able to avoid collision on two trials and incur impact speeds of approximately 5 km/h and below on the other three trials when tested at 80 km/h (50 mph).

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[116] These commenters included, ASC, Mobileye, Bosch, Ford, Mitsubishi, Honda, the Alliance, Porsche, Volkswagen, HATCI, Rivian, Bosch, and Aptiv.

[117] The voluntary commitment included automatic braking system performance (CIB only) able to achieve a specified average speed reduction over five repeated trials when assessed in a stationary lead vehicle test conducted at either 19 or 40 km/h (12 or 25 mph). To satisfy the performance specifications in the voluntary commitment, a vehicle would need to achieve a speed reduction of at least 16 km/h (10 mph) in either lead vehicle stopped test, or a speed reduction of 8 km/h (5 mph) in both tests.

This vehicle's ability to pass these tests demonstrate that the proposed requirements are practicable and the technology is still evolving. As stated in the NPRM, the expectation for the tested AEB production systems (which were not designed to meet these requirements) was not that they would pass all trials; rather, it was to inform the agency on the practicability of the proposed testing speeds. The fact that a current AEB system is already capable of meeting the AEB requirements confirms the agency's assumption that current AEB systems can be further developed within the lead time provided.

Another area of concern expressed by the commenters was sensor range performance. Honda and Bosch both had concerns about requiring no contact when testing at higher speeds as current AEB systems sensor range makes it difficult for the system to discern objects far enough to achieve no contact and mitigate false positives. In previous agency testing that informed development of the NPRM, for the vehicle that performed the best—according to the publicly available information from the manufacturer—the upgrades to the AEB system from the previous generation included, among others, improved sensor range.[118] As shown by the evolution of the Toyota system, and based on the testing results from the other vehicles which also show significant advancement in collision avoidance, NHTSA is confident that current systems, given sufficient development time, can be engineered to avoid contact and mitigate false positives in a similar manner as the Toyota system.

The request for further development time was raised by the majority of industry commenters, and, as discussed later in this preamble, NHTSA agrees and is providing more time to meet this final rule. Based on the comments received, it seems that the main solution currently employed by manufacturers to mitigate false positives is to detune the system at higher speeds (consistent with current UNECE requirements). Euro NCAP, while not a regulation, employs similar testing at similar speeds as proposed in the NPRM (and adopted by this final rule), and

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[118] https://www.jdpower.com/cars/shopping-guides/what-is-toyota-safety-sense, accessed November 13, 2023.

many vehicles achieve a full score on Euro NCAP testing due to their collision avoidance capabilities. This information further reinforces NHTSA's assessment that the proposed testing speeds are practicable and deployable in the real world with sufficient lead time.

Ford stated that harsh braking to avoid high speed collisions can result in rear end collisions based on an internal controllability study with randomly selected drivers in Germany. Based on that study Ford stated there is an increase in rear end collisions resulting from AEB activation above differential speeds of 60 km/h (37.5 mph).

In response, NHTSA was unable to find this study as Ford did not provide any data on it. Thus, NHTSA was unable to evaluate the relevance of Ford's statement to the current rule. The agency observes, however, the proposed requirements do not require hasher braking than currently demonstrated by vehicles compliant with FMVSS No. 135. Further, if all vehicles were equipped with AEB systems conforming to this final rule, it is plausible that no crash would happen.

Comments about increased costs as new hardware is needed

Mobileye stated that for the stopped lead vehicle, the majority of AEB systems in vehicles today will need a new safety strategy and may need hardware updates/replacements. Therefore, Mobileye states, the assumption that all vehicles have the necessary hardware is not correct.

Agency Response

In response, NHTSA concurs that the cost estimates in the NPRM underestimated the incremental hardware costs associated with this final rule. Accordingly, this final rule has adjusted the estimates presented in the NPRM to include the costs associated with software and hardware improvements, compared to the baseline condition. Incremental costs reflect the difference in costs associated with all new light vehicles being equipped with AEB with no performance standard (the baseline condition) relative to all light vehicles being equipped with

AEB that meets the performance requirements specified in this final rule. The Final Regulatory Impact Analysis (FRIA) provides a detailed discussion of the benefits and costs of this final rule.

Comments about the effect of test speed on evasive steering

When a driver is alerted to an impending crash, the driver may manually intervene by, for example, applying the vehicle's brakes or making an evasive steering maneuver, to avoid or mitigate the crash. Several commenters believed that the agency should ensure that all final test conditions (especially at higher test speeds) would preserve steering intervention or other intentional driving behavior regarding the TTC intervention times.

A number of commenters believed that at higher testing speeds, AEB could interfere with evasive steering maneuvers.[119] Honda stated that AEB should only intervene when a collision is otherwise unavoidable and is designed to intervene as late as possible to mitigate injury and not interfere with evasive or normal driver steering maneuvers. Honda stated that differentiating between those situations where steering is more appropriate than emergency braking is critical when considering the unintended consequences of AEB. Honda believed that, under the proposed speeds, AEB intervention will be forced to occur before the driver might steer, hindering the driver's appropriate and intended response in real-world higher speed scenarios.

The Alliance stated that, based on a NHTSA study,[120] the time required to avoid impact by steering or braking are equal at approximately 35 kph and 0.61 seconds and that above 35 kph, avoidance though braking begins to require increasingly more time than steering. Drivers are generally more likely to initiate braking to avoid striking an object at speeds below 44 kph and are more likely to initiate steering to avoid impact above 44 kph. The Alliance stated that the driver will typically initiate their maneuver before 1.7 seconds TTC and therefore, any "no-contact" requirement for AEB at higher speeds will necessitate activating AEB before the driver

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[119] These commenters included ASC, Mobileye, Bosch, the Alliance, HATCI, Ford, Mitsubishi, Porsche and ITS America.
[120] *Forward Collision Warning Requirements Project Final Report - Task 1 (DOT HS 809 574) -- January 2003.*

has an opportunity to steer around the threat when a steering maneuver would be more effective. Similarly, Toyota stated that NHTSA should define a maximum speed for the lead vehicle AEB testing with no manual brake application, of no greater than 60 km/h for the "no-contact" requirement, due to the potential effect of evasive steering and the timing of AEB activation.

Agency Response

NHTSA has considered the comments but does not find the arguments relating to evasive steering compelling. AEB intervention is a last resort crash avoidance maneuver, and it does not seem reasonable to assume that a driver who is inattentive until moments before a crash will reengage and be able to perform a safe steering maneuver that would not jeopardize other traffic participants. The information provided by Honda, Toyota, and the Alliance seem to consider only the timing required for a vehicle to brake to a complete stop versus the timing of a steering maneuver, without considering any other factors. Such factors as vehicle dynamics, traffic conditions, and traffic participants all influence the safety benefit of a steering avoidance maneuver. While NHTSA does not encourage aggressive and unsafe driving behavior as shown in that example, we do note that because the test procedures involve manual braking, disengagement of AEB cannot happen solely due to brake application. Nothing in our standard, however, requires a manufacturer to suppress steering. A manufacturer, outside of the testing requirements, may elect to detune or disengage the AEB system based on an emergency steering maneuver as long as they meet all the AEB requirements.

The type of roadway (two lane, divided, interstate) is an important factor in assessing whether a steering maneuver is appropriate, as is the traffic on such roadways. It seems unreasonable to expect that, except for very specific situations such as when an adjacent lane exists and is empty, a disengaged driver could perform any type of steering maneuver safer than stopping in the lane.

In normal driving situations, rear end crashes frequently happen in heavy traffic where crash avoidance maneuvers from automatic or manual steering could cause the vehicle to either depart the road, collide with a vehicle in the adjacent lane, or, on an undivided two-lane road, cause a head-on frontal crash. Further, research referenced by Porsche in their comments shows that overwhelmingly, drivers either brake, or brake and steer, when presented with a surprise obstacle catapulted from the side.[121] In this research, when the obstacle was presented to the drivers at a TTC of 1.5s, with the adjacent lane free of obstacles and the drivers had the opportunity to avoid a collision by steering alone, 43 percent of participants attempted to avoid by braking alone. The other 57 percent of participants tried to avoid the collision by braking and steering, while no participant tried to avoid contact by steering alone.

At a TTC of 2.0 s, 46 percent of participants tried to avoid by braking alone, 38 percent by braking and steering, and 15 percent by steering alone, while at a TTC of 2.5s 72 percent of participants tried to avoid by braking only, 14 percent tried to avoid by braking and steering, and 14 percent tried to avoid by steering alone.

This research found that only at TTCs later than two seconds did drivers attempt to avoid only by steering alone, which suggests that drivers were not comfortable steering to avoid the presented object at the speed they were traveling without braking, further reinforcing the agency's assertion that braking in lane is appropriate. Looking at these results and considering that this research was performed with a surprise object catapulted from the side (which induces a preference for drivers to avoid by steering), it is clear that drivers are more inclined to brake in an emergency. Additionally, drivers brake even as they attempt a steering maneuver, which can lead to unstable vehicle dynamics. This serves to reinforce the agency's findings that a brake in the lane maneuver, even if it occurs early, before a TTC of 1.5s, is the safest, most appropriate, maneuver.

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[121] Emergency Steer and Brake Assist - A Systematic Approach for System Integration of Two Complementary Driver Assistance Systems (Eckert, Continental AG, Paper Number 11-0111), https://www-esv.nhtsa.dot.gov/Proceedings/22/files/22ESV-000111.pdf

The other situation where steering may be more appropriate, according to the commenters, is an engaged driver who consciously decides to avoid by steering. The steering avoidance maneuver by an engaged driver as shown by HATCI in their comment would still present a higher safety risk than a brake in the lane maneuver. In that example, a vehicle avoids the lead vehicle by cutting in front of a vehicle on the adjacent lane. NHTSA fails to understand how such a maneuver is safe for any of the vehicles involved, especially considering the likelihood that other vehicles would be in the adjacent lanes. A subject vehicle darting out of its lane into an adjacent lane could result in a different type of crash.

3. Headway

Comments

A key test parameter for the lead vehicle AEB tests is the initial headway[122] between the subject vehicle and the lead vehicle. Several vehicle and equipment manufacturers opposed the proposed headway conditions (12 m at 80 km/h) in decelerating lead vehicle AEB tests.[123] They stated that the proposed headway requirement is not practical because the short headway values at high relative speeds go beyond the capabilities of current AEB systems. Volkswagen, Porsche, Rivian, and others argued that the low headway conditions at high relative speeds may increase false positive rates, leading to phantom braking because earlier braking means the system looks further ahead, both in space and in time. (Hence, commenters stated, the probability for a collision is estimated at a lower accuracy value and this may lead to a false positive activation.)

Many commenters believed the 12 m proposed headway at 80 km/h is a very close following distance that would equate to an unsafe following distance in the real world and that AEB systems are not designed to account for this type of "misuse" by the driver. In addition, they believed that compliance with a no-contact requirement would require immediate

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[122] Headway refers to the distance or interval of time between vehicles moving in the same direction on the same route.
[123] These commenters included Volkswagen, Porsche, Mitsubishi, Rivian, Honda, MEMA, Bosch, and Mobileye.

emergency braking at maximum deceleration, which, the commenters stated, would result in an uncontrollable safety hazard for following traffic. Volkswagen and Porsche suggested removing the 12 m headway at the 80 km/h scenario from the decelerating lead vehicle tests and aligning with the requirements of UNECE Regulation No. 152.[124] Similarly, Mitsubishi suggested 23 m as the minimum headway because the proposed minimum headway distance (12 m) is considered close enough to issue an FCW even with minimal deceleration of the subject vehicle. MEMA and Bosch suggested a headway greater than 16 m and a time gap greater than 0.2 seconds at 80 km/h to create a more representative test scenario that resembles a constant following distance. Mobileye stated that the headway of the 12 m in decelerating lead vehicle test scenario at 80 km/h is around 0.5 s which, the commenter believed, was not realistic because research data showed that the median headway time across 10 different sites was 1.74 s.

Agency Response

The agency disagrees with Volkswagen and other manufacturers that the lower bound (i.e., 12 m) of the headway range is not practicable for the current AEB systems at a high speed (e.g., 80 km/h). NHTSA discussed in the NPRM that 4 out of 11 vehicles in the agency's 2020 AEB research met the no-contact requirement of this rule when the subject vehicle and lead vehicle were traveling at 72.4 km/h (45 mph) with an initial headway of 13.8 m (45 ft). The deceleration of the lead vehicle was 0.3 g. This research also included decelerating lead vehicle testing at 56.3 km/h (35 mph) with a deceleration rate of 0.5 g.

In the NPRM, NHTSA tentatively concluded that the current lead vehicle AEB systems would be able to meet the most stringent headway requirement (i.e., 12 m) if their perception software was properly tuned for the higher lead vehicle deceleration (0.5 g). The agency's MY 2023 AEB research supports this.[125] The test results demonstrated that one of the six vehicles

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[124] That regulation currently requires full collision avoidance up to 40 km/h relative speed between the subject and lead vehicle.

[125] NHTSA's 2023 Light Vehicle Automatic Emergency Braking Research Test Summary, available in the docket for this final rule (NHTSA-2023-0021).

was able to meet the requirements of this standard in all five trials at 80 km/h with the initial headway of 12 m and the lead vehicle deceleration of 0.5 g. Another vehicle was also able to meet the test requirements in 2 out of 5 trials for the same test speeds.

In their comment, Honda stated that the worst-case scenarios for impact relative speed (72 km/h) are accomplished with a lead vehicle deceleration of 0.5 g at the 12 m headway distance. Given the performance of these two vehicles in the most difficult testing scenario, NHTSA continues to believe that the headway specifications of this final rule – any distance between 12 m (39.4 ft) and 40 m (131.2 ft) – are within the capabilities of the AEB systems designed to comply with this final rule.

As for the potential increase of false positive rate raised by Volkswagen, Porsche and Rivian, false positive activation that causes an unreasonable risk to safety is a defect issue. Vehicle manufacturers are responsible for mitigating and resolving any defects in their vehicle products. Here, the concern is based on a hypothetical situation where a vehicle at a high speed with a small headway (e.g., 12 m) may prematurely activate the AEB system – forcing initiation of early braking – when there is not a true risk of an imminent collision. At 80 km/h (50 mph), a headway of 12 m is uncomfortably close to a crash imminent situation and the agency feels strongly that it is difficult even for an attentive driver to react properly to avoid a crash in this scenario, especially with a lead vehicle braking above 0.3g. It is up to manufacturers to design their AEB systems to deal with situations where the driver is following close to the vehicle in front of it, and the lead vehicle decelerates between 0 and 0.3 g. They must determine what is a false positive and what is an actual positive.

As for replacing the current range requirements for headway with discrete values, NHTSA disagrees with Honda and Volkswagen that the range requirements require infinite number tests and cause unreasonable test burden to manufacturers. The agency noted in the NPRM that the use of a range of potential values allows NHTSA to ensure that AEB system performance remains consistent, as conditions – in this case headway – vary within the bounds of the range. NHTSA has observed that some lead vehicle AEB systems performed well under high speed or shorter headway scenarios, but did not perform as well under lower speed or longer headway scenarios. This type of performance inconsistency is why the agency proposed a range of values, and not just discrete values.

The current range headway provides manufacturers an understanding of the performance the FMVSS requires. Manufacturers have the ability and flexibility to decide how they can certify that a given AEB system complies with the requirements contained in this final rule. This includes the number and types of tests needed to ensure that an AEB system works throughout the proposed range. The agency is providing notice of how we test a vehicle's compliance. For these reasons, NHTSA believes that the headway range requirements do not cause an unreasonable test burden.

Accordingly, NHTSA declines to amend the range of headway specifications in decelerating lead vehicle AEB tests. This final rule adopts that the headway specifications in decelerating lead vehicle AEB tests to include any distance between 12 m (39.4 ft) and 40 m (131.2 ft) as proposed in the NPRM.

4. Lead Vehicle Deceleration

The decelerating lead vehicle scenario is meant to assess the AEB performance when the subject vehicle and lead vehicle initially are travelling at the same constant speed in a straight path and the lead vehicle begins to decelerate. NHTSA's proposed lead vehicle AEB tests included parameters for the deceleration of the lead vehicle.

Honda expressed concern that the proposed rule included a broad range of parameters for lead vehicle deceleration (ranging from 0.3 to 0.5 g). It further stated that testing a theoretically infinite number of combinations within the proposed range is impractical. Honda suggested that the proposed range of deceleration values should be replaced with discrete nominal test values for lead vehicle AEB deceleration tests.

In response to Honda, NHTSA believes that the targeted average deceleration is best represented by a bounded range, rather than a discrete value, to better evaluate vehicle performance. During agency testing, NHTSA has observed vehicles that may perform well at the upper and lower bounds of a performance range, yet inconsistently perform in the middle of a performance range. The agency believes that specifying a bounded range of 0.3 g to 0.5 g will better ensure consistent performance of AEB systems in real world situations than if a discrete value were specified. Further, the test procedures of this rule provide information regarding how the agency will conduct tests. Manufacturers have the flexibility to certify the compliance of their vehicles using reasonable care, and are not required to conduct testing as the agency does if the vehicle passes when tested by NHTSA as specified in the standard. Therefore, this final rule adopts the average deceleration range proposed in the NPRM.

Humanetics commented that the provision related to “targeted deceleration” should state that the deceleration is maintained until the speed is below a target value (such as 1 km/h) and that the regulatory text “250 ms prior to coming to a stop” in proposed S7.5.3a should be replaced with “the lead vehicle speed is reduced to 1 km/h.”

NHTSA disagrees with the comment. When determining the targeted average deceleration, the agency has specified that the targeted deceleration will occur within 1.5 sec of lead vehicle braking onset, giving the lead vehicle time to reach the desired deceleration. As the vehicle comes to a stop, the acceleration profile becomes noisy and is not reflective of the actual deceleration observed through most of the test. Thus, the agency proposed that the last 250 milliseconds (ms) of the vehicle braking before coming to a stop are not used in the calculation of the targeted average deceleration. Changing this threshold to be a speed measurement, as suggested by Humanetics, would change the end of test parameter to allow for contact and would not address the noise in the deceleration as the vehicle comes to a stop. (This metric is consistent with how NCAP currently performs AEB testing.) NHTSA concludes that the metric does not need additional clarification and thus declines to replace the current time-based provision with a speed-based protocol.

5. Manual Brake Application

NHTSA proposed lead vehicle AEB performance tests that included parameters for the manual brake application made to the subject vehicle.

NHTSA received several comments from vehicle and equipment manufacturers on the provisions. Porsche and Volkswagen stated that NHTSA should provide additional clarity specific to the brake robot application, particularly regarding proposed S10 specific to the set-up and calibration of the braking robot and the rate of brake pedal application. Hyundai suggested removing the manual braking tests and replacing them by a statement in FMVSS No. 127 to the effect that, “A driver’s manual activation of the brake pedal shall not impair the operation or effectiveness of AEB.” ASC sought further clarification regarding the manual brake application profile. Humanetics believed that the tolerance was too tight in proposed S10.4 that brake pedal force is to be maintained within 10 percent of the commanded brake pedal force. Humanetics encouraged NHTSA to adopt a wider tolerance, such as allowing an applied force within 25 percent of the commanded force, while also allowing shorter duration forces (less than 200 ms) that may exceed the 25 percent tolerance.

This final rule adopts the NPRM’s proposed specifications for the manual braking conditions. It also includes a third brake control option that a manufacturer may choose.

The agency disagrees with Hyundai that the purpose of the manual braking conditions can be achieved by the suggested statement. The tests with manual braking application are different from the lead vehicle AEB tests without manual braking. First, manual braking tests are conducted at a higher range of subject vehicle speed, at any subject vehicle speed between 70 km/h (43 mph) and 100 km/h (62 mph) for both the stopped and slower-moving lead vehicle scenarios, than that of corresponding AEB tests without manual braking application. Second, the tests with manual braking application represent two different real-world situations. The first represents a driver that reacts to the FCW and re-engages in the driving task by applying the brake (although with insufficient force to prevent a collision). In this case, the vehicle must be capable of recognizing that the driver has failed to provide adequate manual braking and supplement it with automated braking force. The second represents a driver who re-engages very late in the AEB event. The test ensures that the act of late manual braking does not disrupt or disengage crash imminent braking functionality.

The language suggested by the commenter considers only this second condition and not the first. Additionally, Hyundai did not provide a metric for ensuring that this performance could be met using their proposed language. Therefore, NHTSA declines to remove the manual braking test conditions in the lead vehicle AEB tests of this final rule.

Regarding the specifications for the braking robot, the agency notes that both Porsche and Volkswagen requested more detail but neither explained the issues they faced, or what is needed in terms of additional information. Both manufacturers have experienced braking robots in other AEB testing. In the proposal, NHTSA stated that either a displacement braking controller or a hybrid braking controller (braking robot) could be used, at the manufacturer's discretion, and proposed requirements for the performance of these two styles of controllers. Additionally, the agency imposed no limitations on how manufacturers can self-certify. Thus, manufacturers, who have the best knowledge of their AEB systems, are free to choose a braking method (type of braking controller, human test driver, etc.) that best serves their needs to certify their vehicles. As Porsche recognized, various brake robots are available with different specifications. A manufacturer can easily select the one that is most appropriate for testing its AEB system. Therefore, NHTSA concludes it is unnecessary to specify a single brake controller or braking robot.

ASC sought further clarification regarding the tests that require manual brake application on the manual brake application profile. It specifically highlighted the time for driver reaction, movement of foot brake pedal application, and build system pressure. They also highlighted that 1.2 seconds after an FCW would be a typical driver response time according to Euro NCAP.

As stated in the proposal, brake pedal application onset occurs 1.0 ±0.1 second after the forward collision warning onset, thus, the driver response time is approximately one second. The agency does not have data showing that a reaction time of 1.2 is more appropriate. Specifics such as the movement of foot brake pedal application and system pressure are best not stipulated as absolutes, as they may change based off each brake system and in-vehicle brake controller. The agency believes it has provided sufficient notice for manufacturers to understand how NHTSA will test.

ASC also sought information on how the agency determines brake pedal application onset. NHTSA does not believe that specifying a minimum brake pedal displacement, along with a minimum level of force applied to the pedal is necessary. To displace the pedal at all requires a minimum amount of force. The agency believes that 11 N (2.5 lbf) of force is small enough to be easily achieved by a driver or controller, and large enough to show intent to brake. Thus, the agency is not adopting a change to the brake pedal application onset.

ASC highlighted that NHTSA had not considered braking systems using force feedback. The agency agrees that a force only feedback controller will provide another useful method of brake application. As such, the final rule includes this third brake control option that a manufacturer may choose. It is substantially similar to the hybrid controller with the commanded brake pedal position omitted, leaving only the commanded brake pedal force application. The force feedback brake pedal application applies the force that would result in a mean deceleration of 0.4 g in the absence of AEB activation.

6. Testing Setup and Completion

The NPRM proposed that the subject vehicle and lead vehicle speeds are maintained within 1.6 km/h, the travel paths do not deviate more than 0.3 m laterally from the intended travel path, and the subject vehicle's yaw rate does not exceed ±1.0 deg/s. MEMA and ASC suggested that the lane positioning requirements should be harmonized with UNECE Regulation No. 152, e.g., 0.2 m not 0.3 m permitted lateral variance. Humanetics suggested that NHTSA use more strict tolerances for the subject vehicle, to increase repeatability. Humanetics also stated that as the yaw rate is quite a noisy signal, a filter should be used for the lead and subject vehicles. Humanetics further suggested that the agency should consider currently accepted tolerances to test speeds and other test parameters in defining these FMVSS tests.

In response, NHTSA disagrees with the commenters that a tighter tolerance is needed. The agency's specification is in line with previous NHTSA testing. As for requiring a smaller tolerance for vehicle speed and providing additional tolerances for a target carrier, the agency disagrees with Humanetics that the tolerance specified is excessively large for attaining repeatable and reliable testing. NHTSA does not have any data showing that manufacturers cannot meet these tolerances, nor that the tolerances proposed induce testing failures. Additionally, requiring a tighter tolerance is not representative of expected on road conditions. Accordingly, the agency does not see value in providing tighter tolerances.

NHTSA also notes that the agency proposed tolerances for where the lead vehicle will be positioned and operated during the performance tests. NHTSA is concerned that adding more tolerances to the carrier system that drives the vehicle test device would overly constrain the testing set up. Lastly, ISO 19206-7 is in draft form and is yet to be finalized. As such, it would be premature to incorporate the document into this final rule. Given the above, the agency declines to change lane positioning requirements or adopt additional tolerancing.

Regarding test completion, the NPRM proposed that, "The test run is complete when the subject vehicle comes to a complete stop without making contact with the lead vehicle or when the subject vehicle makes contact with the lead vehicle." The Alliance stated that, for the slower-moving vehicle scenario, imposing a full braking requirement may not be appropriate if the target/lead vehicle were to continue to move (or if a stopped vehicle were to move again under real-world conditions). The commenter suggested that test completion be defined as "the instance when the subject vehicle speed is equal or less than the lead vehicle speed without making contact with the lead vehicle, or when the subject vehicle makes contact with the lead vehicle."

In response, NHTSA notes that the NPRM addressed the Alliance's concern in the proposed test procedures in proposed S7.4.4. This final rule adopts the proposed test completion criteria – "test run is complete when the subject vehicle speed is less than or equal to the lead vehicle speed" – for slower moving lead AEB tests as proposed.

Bosch suggested NHTSA consider setting parameters to define a "valid run" with respect to pedal and steering inputs to maintain tolerance on approach. Bosch stated that they encountered testing cases where an overly narrow definition of the calibration tolerances of the robot has interfered with the system reaction. Bosch also commented that, depending on the robot mode and type of vehicle brakes utilized, interference with the ADAS systems may occur. Bosch suggested the adoption of tolerances outlined in UNECE Regulation No. 152 for performance testing, with the aim of promoting standardized and realistic evaluations of automotive safety systems.

In response to Bosch's suggestion to define what a valid run is, NHTSA highlights the position and speed specifications for testing as stated in the NPRM that beginning when the headway corresponds to L_0 , the subject vehicle speed is maintained within 1.6 km/h of the test speed with minimal and smooth accelerator pedal inputs. Additionally, the subject vehicle heading is maintained with minimal steering input such that the travel path does not deviate more than 0.3 m laterally from the intended travel path and the subject vehicle's yaw rate does not exceed ±1.0 deg/s. Bosch provided no additional information as to the inadequacy of NHTSA's proposed specifications for how the lead vehicle and subject vehicle respond prior to subject vehicle braking. Additionally, Bosch did not identify specific inadequacies in the braking controllers specified for use with manual braking

As for the proposed triggering times/TTCs (related to the “beginning of tests”), the ASC stated that different test procedures in the NPRM specify different triggering times / TTCs (e.g., three (3) seconds in S7.5.2, four (4) seconds in S8.2). ASC suggested that the trigger time period be standardized for all test scenarios.

The agency disagrees with this TTC suggestion. NHTSA selected appropriate test procedures, including triggering times, for each test scenario based on its unique features. For example, a three-second triggering time in a decelerating lead vehicle AEB test (S7.5.2) is selected to provide sufficient time to align a subject vehicle with a lead vehicle and to set a proper headway between the vehicles. On the other hand, a four-second triggering time in a PAEB test (S8.2) is selected to estimate an initial headway between a subject vehicle and a pedestrian surrogate. As such, these triggering times represent unique features of two different tests. There are reasons not to standardize a triggering time to use across all lead vehicle and pedestrian AEB test scenarios.

ASC sought clarification on the accelerator pedal release process when the vehicle cruise control is active. In response, as stated in the NPRM, when cruise control is active the pedal release process is omitted as the accelerator pedal is already released. The agency expects an equivalent level of crash avoidance or mitigation regardless of whether cruise control is active.

7. Miscellaneous Comments

Mobileye stated that in some cases of target deceleration, the robot deceleration will be enough, or close enough, to avoid a collision. Mobileye stated that, in cases where the collision speed is very small, the AEB system can cause a nuisance event by a slight modification of the braking power by the driver. Mobileye suggested a more deterministic approach for these test scenarios which will result in a collision speed above 10 kph when using the robot 0.4 g deceleration.

In response, NHTSA does not specify the level of deceleration that the AEB system needs employ to safely bring the vehicle to a stop. In fact, during testing, the agency has observed that while some vehicles employ late and harsh braking as described by Mobileye, more refined AEB systems do not perform in such a manner.[126] As shown by Mobileye, to resolve the example they provided, only a slight additional deceleration, to further reduce the subject vehicle speed of 6.3 km/h, is needed to avoid the collision without harsh braking.

Bosch suggested NHTSA consider employing the term "stationary vehicle" as used in the UNECE Regulation No. 152 specification, instead of "stopped," to promote uniformity and consistency in automotive safety terminology with existing standards and specifications. Bosch believed the distinction is crucial for some AEB systems as "stopped" vehicle implies that the vehicle was in motion immediately before the sensors have detected the Vehicle Under Test (VUT). Bosch suggested using the term "stationary" instead of "stopped" to align with existing standards and avoid any potential misinterpretations about the VUT as moving.

NHTSA does not agree with Bosch that the term "stopped lead vehicle" should be amended to "stationary vehicle." The standard's test procedures clearly specify how the lead vehicle test device is placed (see, S7.3.2 of the proposed regulatory text) ("the lead vehicle is placed stationary with its longitudinal centerline coincident to the intended travel path") and does not lend itself to potential misinterpretations. The term stopped, used in this requirement, is consistent with the agency's practices in previous AEB research and in the current U.S. NCAP.

NHTSA received several comments regarding test speeds as applied to vehicles equipped with ADS. The Alliance, AVIA and Zoox suggested that compliance testing be limited to the maximum speed that an ADS-equipped vehicle can achieve within its operational design domain. AVIA commented that some ADS-equipped vehicles have top speeds below those required in the Lead Vehicle AEB Collision Avoidance test parameters, and therefore suggested modifying the test parameters such that they can be met when an ADS-equipped vehicle operates at its highest speed if that speed is lower than the originally proposed subject and lead vehicle speeds.

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[126] https://www.regulations.gov/document/NHTSA-2021-0002-0002.

Zoox commented that an ADS may "refuse" to drive at 80 km/h at a following distance of 12 m or at 80 kph between two parked cars because this behavior does not align with its more conservative driving parameters.

In response, by including a maximum speed of 90 mph in this final rule, NHTSA is not requiring that manufacturers design their vehicles to be capable of driving 90 mph. Similarly, NHTSA is not requiring that Zoox design its ADS to operate at 90 mph. Instead, NHTSA may test the vehicle at the maximum speed the vehicle can achieve in its operational design domain. However, if the speed limitation in Zoox's vehicles are solely due to ADS programming and the vehicle itself is not speed limited, then Zoox must certify compliance to all speeds up to the maximum speed its vehicles are capable of being driven. As an example, if Zoox's ADS is programmed to drive at speeds up to 45 mph, but the vehicle has functionality that would allow it to be driven at speeds up to 90 mph, then Zoox must certify that AEB operates as required by this final rule at speeds up to 90 mph.

Regarding proposed subject vehicle specifications, an anonymous commenter stated that they found some of the procedures and criteria to be unclear or confusing in the NPRM. They stated that NHTSA should provide more diagrams and figures to clarify the test procedures and criteria.

In response, NHTSA believes that the NPRM provided sufficient information to the public to understand the requirements of the proposed standard. The agency included many figures, diagrams, and tables, that highlighted and explained key information. These figures, coupled with the detailed testing scenarios and test track conditions, adequately describe the rulemaking and the performance NHTSA is requiring by issuing FMVSS No. 127.

I. Procedures for Testing PAEB

This section describes the pedestrian AEB performance tests adopted by this final rule. After considering the comments to the NPRM, NHTSA has adopted the proposed procedures tests with a few minor revisions to some parameters and definitions, to clarify details of the test procedures. Importantly, NHTSA has increased the lead time to meet the requirements by providing a five-year lead time.

This section responds to the comments and explains NHTSA's reasons for adopting the provisions set forth in this final rule. For the convenience of readers, a list of the test specifications can be found in appendix B to this final rule preamble.

The pedestrian AEB performance tests require AEB systems to provide a forward collision warning (FCW) and automatically apply the service brakes at all forward speeds above 10 km/h (6 mph) to avoid an imminent collision with a pedestrian.[127]

The test scenarios required for PAEB evaluation fall into three groups of scenarios based on how NHTSA will apply the pedestrian test device – crossing path, stationary and along path. For each test conducted under the testing scenarios, there are the following provisions within those testing scenarios: (1) pedestrian crossing (right or left) relative to an approaching subject vehicle; (2) subject vehicle overlap (25% or 50%);[128] (3) pedestrian obstruction (Yes/No); and, (4) pedestrian speed (stationary, walking, or running) (V_P).

NHTSA will select further parameters from a subject vehicle speed range (V_{SV}) and the lighting condition (daylight, lower beams or upper beams). The subject vehicle's travel path in each of the test scenarios is straight.

1. Scenarios

Request to add scenarios

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[127] The FCW and brake application need not be sequential.

[128] Overlap describes the location of the point on the front of the subject vehicle that would contact a pedestrian if no braking occurred. It refers to the percentage of the subject vehicle's overall width that the pedestrian test mannequin traverses. It is measured from the right or the left (depending on which side of the subject vehicle the pedestrian test mannequin originates).

Many commenters suggested additional scenarios in PAEB testing.[129] Commenters urged NHTSA to include test devices representative of bicyclists and other vulnerable road users (VRUs), such as motorcyclists. A number of commenters recommended expanding additional scenarios involving pedestrians, such as older adult pedestrians who may walk slower than 3 mph, persons with disabilities, a running adult from the left scenario with dark lower beam or upper beam, pedestrians crossing from both directions, or pedestrians traveling against traffic.

NHTSA is highly interested in having PAEB address more scenarios, road users, and pedestrians than the scenarios covered by this final rule. NHTSA explained in the NPRM that the agency is actively conducting research to characterize, among other matters, the performance of AEB systems in response to bicycles and motorcycles, in both daylight and darkness conditions. However, the state of knowledge is not at the point where NHTSA can proceed with including bicycle and motorcycle surrogates in the new standard at this time. To illustrate, preliminary testing discussed in the NPRM identified issues with the design of the bicycle and motorcycle surrogates and their effect on the vehicles under test, indicating a need to learn more about these devices.[130] NHTSA is continuing its research to learn more, and present and future studies may well result in efforts to define test procedures, refine the bicycle and motorcycle surrogate devices, and characterize AEB system performance for possible incorporation into the FMVSS.

NHTSA proceeded with this rulemaking because it has the information needed to support an NPRM and final rule on the pedestrian behaviors addressed by the rule. Less is known about additional pedestrian behaviors to which commenters refer. NHTSA does not have the research necessary to determine well-reasoned and practicable performance requirements for the full range of travel behaviors pedestrians employ. Because developing the technical underpinnings

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[129] These commenters included NTSB, Advocates, the League, AMA, APBP, NSC, Forensic Rock, Consumer Reports, CAS, Radian Labs, AARP, NSC, America Walks, APBP, AARP, United spinal, Radian Labs, Adasky, VRUSC, AFB, Humanetics, and PVA.

[130] This report is expected to be completed within 2024.

and assessing the feasibility of potential further countermeasures need more time, NHTSA is adopting the PAEB test procedures proposed in the NPRM as a sound first step.

Request to remove PAEB scenarios

The Alliance requested that NHTSA not include the test of the stationary pedestrian test in nighttime conditions (S8.4). The Alliance stated that an analysis of real-world data from NHTSA's FARS database showed that fewer than 5 percent of stationary pedestrian crashes occur in dark, or low light, conditions, which is substantially lower than the other scenarios evaluated in the NPRM. The Alliance stated that the complexity in designing countermeasures is increased, particularly for vision-based systems, in discerning non-moving objects that may resemble the human form in low light conditions at high speed. The Alliance expressed concerns that this requirement would force the installation of additional sensors to verify the presence of an object in the roadway. The Alliance stated that this scenario has additional cost implications and underscores that meeting the requirements of the rule is not as straightforward as the agency suggested.

Similarly, MEMA questioned if crash data support the stationary pedestrian test, because the commenter believed it is unlikely a pedestrian would be completely stationary and without movement in any real-world condition. MEMA further stated that this test increases the probability of false activation from other stationary roadside objects. MEMA suggested that the moving along path scenario addresses real-world scenarios.

In response, NHTSA declines this request to eliminate the stationary pedestrian in nighttime conditions test. The commenters addressed the size and existence of the safety problem, with the Alliance providing an analysis showing that the standing pedestrian scenario comprises 5 percent (479 lives) of unlit nighttime crashes between 2014 and 2021. The unlit nighttime testing is designed to test a worst-case scenario, where there is no appreciable light other than that generated by the vehicle to aid in the detection of a pedestrian.[131] While the stationary position of the pedestrian test mannequin adds to the challenge of the test, real pedestrians encounter these potential dual dangers of darkness and stillness every day in the real world. NHTSA testing, discussed in the NPRM, has shown that AEB performance is reduced when testing the stationary scenario as compared to the along path scenario. Given the certainty that there are pedestrians outside in the dark each day, the likelihood that they may be stationary at times and not always in motion when a vehicle approaches, and the certainty of their vulnerable status vis-à-vis the vehicle (even low-speed vehicle impacts with pedestrians can result in fatalities and serious injuries), NHTSA believes that eliminating the test would not be reasonable. This is particularly so given that meeting the requirement is practicable.[132] Further, even if the agency accepts the Alliance analysis and interprets in a similar manner "standing" as equivalent to stationary during PAEB testing, NHTSA believes that the almost 50 annual fatalities over 8 years of data lends support for adopting the proposed test.

Ford believed that some tests are redundant and requested their removal. Ford recommends the removal of daytime 50 percent overlap crossing use cases as this will be 25 percent redundant with crossing use cases, as well as removing either the in-path stationary or moving scenarios which, the commenter believed, are redundant to each other.

In response, NHTSA does not agree the tests are redundant. Testing with a 25 percent overlap is more stringent than the 50 percent overlap test, as the pedestrian is exposed to the vehicle for a shorter amount of time. However, the 50 percent overlap test assesses a different scenario than the 25 percent overlap test. In the 50 percent overlap test, the vehicle comes upon the pedestrian later in the event. NHTSA is retaining the 50 percent overlap test, and the other

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[131] NHTSA expects that this performance will also be representative of, and beneficial to, nighttime conditions where brighter ambient light conditions exist.

[132] NHTSA's 2023 testing demonstrated that six out of six vehicles were able to fully meet the stationary requirements in both daylight and upper beam nighttime scenarios. The testing showed that half of the vehicles tested also were able to fully meet the proposed requirements for the lower beam nighttime scenario.

mentioned tests, to ensure that PAEB systems are tuned to detect pedestrians across a wide and reasonable range in the roadway.

Lack of dynamic brake support (DBS) testing in PAEB scenarios

Unlike for lead vehicle AEB, NHTSA did not propose that the AEB system supplement the driver's brake input with a dynamic brake support system. This is because NHTSA believes that, due to the sudden succession of events in a potential collision between a vehicle and a pedestrian, particularly for the pedestrian crossing path scenarios, a driver is unlikely to have enough time to react to the crash imminent event, and the vehicle will brake automatically without driver input. Further, NHTSA stated that it anticipates that AEB system designs would include DBS.

Advocates commented that NHTSA should either state that manual braking alone is insufficient to interrupt the AEB functionality or include testing of DBS functionality in the PAEB scenarios. AARP commented that it is important that the PAEB system function regardless of the characteristics of the vehicle's driver, and testing should reflect predictable variations such as those that result from the characteristics of older drivers.

In response, NHTSA is declining to add a manual braking test for pedestrians in this final rule. As stated in the NPRM, NHTSA expects that manufacturers will include this functionality when approaching a pedestrian. While the agency does not test PAEB with manual brake application, it does not make any distinction as to when AEB is required based on manual brake application. Thus, an AEB system tested for manual brake application under lead vehicle AEB testing will function in the same manner when approaching a pedestrian.

The agency also decided to test PAEB only without manual brake application due to the timing of crashes involving pedestrians, as it is not realistic to expect a quick enough response from a driver when presented with a warning to mitigate a collision under the proposed testing scenarios. NHTSA testing for lead vehicle AEB is premised on data that often an engaged driver does not brake enough to avoid a collision when presented with an FCW. However, the timing of a crossing path pedestrian scenario in some cases does not afford the ability to warn a driver and wait for a driver response. This difference between the lead vehicle and pedestrian crash scenarios renders requiring a manual brake application inappropriate for PAEB.[133] As such, the agency is declining to add a manual braking test for pedestrians at this time.

Lack of 25 percent overlap for PAEB scenarios in dark conditions

Several comments suggested including PAEB performance tests with 25 percent overlap in dark conditions. Advocates requested that testing requirements at 25 percent overlap be included in the proposal, as a quarter of the vehicles tested by NHTSA in a limited study included such capability. Luminar stated the proposed PAEB testing overlap is arbitrary since the NPRM proposes PAEB testing at 25 percent overlap, but only 50 percent overlap for other scenarios, including some nighttime tests.

In response, as discussed in the NPRM, NHTSA declined to add the 25 percent overlap scenario for nighttime pedestrian AEB because it is not practicable at speeds relevant to the safety problem. The final rule has more benefits when pedestrian avoidance is tested at a more stringent and higher speed 50 percent overlap scenario.

NHTSA disagrees with Luminar that the overlap scenarios are arbitrary. UNECE Regulation No. 152 specifies the pedestrian target's positioning at the same location as a 50 percent overlap scenario. Euro NCAP also uses impact locations of 25, 50, and 75 percent.

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[133] NHTSA is also mindful that implementing similar manual braking test scenarios for PAEB as for lead vehicle AEB may increase the likelihood of false positives when the systems are driven on the road. At 60 km/h (37.3 mph) automatic braking would need to occur at a minimum distance to the pedestrian of 20.25 meters with a 0.7g stop, which is a TTC of 1.21 sec, and it takes the vehicle 2.4 sec to stop. A pedestrian traveling with a walking speed of 5 km/h (3.1 mph) would cover 3.36 meters in this time, which puts that pedestrian 3.8 meters from the center of an average vehicle in the 25 percent overlap scenario, or about 2.9 meters from the side of the vehicle. In an urban setting, this would place the pedestrian in the buffer zone between the sidewalk and the travel lane, indicating the intent to cross the street. In this scenario the pedestrian would be a further 1.38 meters away in case of a warning issued 1 second prior to the minimum TTC described above, or more with a longer warning. This would place a pedestrian outside the buffer zone and solidly on the sidewalk. Adding additional time for a forward collision warning and driver reaction time increases the likelihood of false alerts, as it becomes increase difficult to determine the pedestrian's intent the further outside the travel lane the pedestrian is. Because of this, NHTSA proposed requiring, "The vehicle must automatically apply the brakes and alert the vehicle operator such that the subject vehicle does not collide with the pedestrian test mannequin when tested using the procedures in S8 under the conditions specified in S6."

NHTSA still views testing at high speeds with a 25 percent overlap during nighttime scenarios as not practicable. The agency views setting higher speed tests for crossing path with a 50 percent overlap at night as merited and more appropriate for this final rule than specifying lower max speeds for a 25 percent overlap at night. Accordingly, NHTSA is declining to add a scenario for a high-speed test with a 25 percent overlap during nighttime condition.

Lack of turning scenarios

Several commenters recommended the inclusion of turning scenarios as part of the PAEB test requirements, i.e., expanding the testing conditions to evaluate pedestrian during right and left turns of the subject vehicle.[134] Luminar stated that turning real word traffic conditions that mimic common pedestrian encounters in which the subject's movement partially or momentarily obscured and performance of crash avoidance technology in these scenarios is achievable. Some commenters stated that turning car-to-pedestrian AEB testing is performed as part of Euro NCAP.

In response, this final rule adopts the tests as proposed based on the research and other data demonstrating the efficacy and practicability of systems meeting the crossing path, stationary and along path scenarios. The data and technologies for test scenarios representing other crashes have not been analyzed as to their merit for inclusion in a possible FMVSS (as discussed throughout this document, rear-end crashes have been analyzed).

NHTSA included pedestrian AEB in turning from the left and turning from the right as a potential regulatory alternative for a more stringent rule. While commenters pointed out that Euro NCAP and other world NCAP programs offer some turning scenarios, NHTSA does not have sufficient information to propose or finalize incorporating a turning scenario at this time. NHTSA is not selecting this alternative in this final rule, however, and will consider conducting additional research and adopting requirements for turns in a future rulemaking, as appropriate.

[134] These commenters included Forest Rock, Luminar, APBP, NSC, the Coalition, Consumer Reports, and AARP.

As discussed in the NPRM, NHTSA focused on the practicable scenarios that have the largest impact on the safety problem. While turning scenarios are responsible for around 48 percent of the total crash population for pedestrians, NHTSA crash data shows that 90 percent of fatal pedestrian-vehicle crashes, and 52 percent of the total pedestrian-vehicle crash population are covered under the standard NHTSA has developed.[135] In contrast, NHTSA data found that the turning right and turning left scenarios were found to only account for 1 percent and 4 percent of pedestrian fatalities, respectively.

2. Subject Vehicle Speed Ranges

Increase PAEB testing speeds

Comments

NHTSA received many comments requesting the agency to increase the test speed of the vehicle.[136] Commenters generally stated that since the most common speed limit for a road where a pedestrian is killed is 45 mph, PAEB testing speeds should be increased above the proposed speeds (they generally did not suggest a maximum testing speed).

Agency Response

In response, as explained in the earlier section for lead vehicle testing speeds, NHTSA has bounded the testing speeds after considering practicability and other issues. These practicability concerns include, among others, the performance that can reasonably be achieved in the lead time provided for the final rule, the safety need that can be addressed, the safety of the testing personnel, and the practicalities of conducting a test that can be run repeatably and

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[135] Mikio Yanagisawa, Elizabeth D. Swanson, Philip Azeredo, and Wassim Najm (2017, April) Estimation of potential safety benefits for pedestrian crash avoidance/mitigation systems (Report No. DOT HS 812 400) Washington, DC: National Highway Traffic Safety Administration, p xiii.

[136] These commenters included the cities of Philadelphia, Nashville and Houston, the Richmond Ambulance Authority, Drive Smart Virginia, Teledyne, the Lidar Coalition, Luminar, Consumer Reports, Forensic Rock, Luminar, COMPAL, and NACTO.

consistently without damaging lab equipment, to preserve the integrity and validity of the test data. NHTSA proposed and is adopting the highest practicable testing speeds. Accordingly, NHTSA has decided not to increase the test speeds for PAEB in this final rule. NHTSA considered, and is currently researching, other testing scenarios for PAEB, so more will be known about the future about the practicability and reasonableness of higher test speeds.

Reduce PAEB testing speeds

Comments

NHTSA received many comments from manufacturers and others requesting the agency to decrease the test speed of the vehicle.[137] Some manufacturers commented that NHTSA should permit low impact speeds when testing PAEB above certain testing speeds (when testing 30 km/h (19 mph) and above).

Like their comments on the lead vehicle speed tests, the Alliance and others suggested a hybrid approach that would permit some level of contact with the pedestrian test device for speeds above, e.g., 30 km/h (19 mph). These commenters stated that providing full crash avoidance at higher speeds may not always be practicable due to increased potential for false positives under real world conditions. Additionally, the Alliance stated that the PAEB system must have sufficient information upon which to base its decision to apply braking force. The high testing speeds and no-contact requirement may force the AEB system to be too aggressive particularly in view of what can be unpredictable movement of pedestrians in and around the roadway environment. Honda suggested when PAEB is tested between 50 km/h and 65 km/h (31 mph to 40 mph), NHTSA should allow low speed contact up to 15 km/h (9.3 mph). Honda stated that the basis for the suggested speed threshold is that according to pedestrian injury data

[137] These commenters included the Alliance, Honda, Mobileye, Mitsubishi, Porsche, Volkswagen, Nissan, Toyota, and Aptiv.

in the U.S., the risk of severe injury or fatality in pedestrian crashes below 15 km/h is highly unlikely.

The Alliance expressed concern about false positives or bad actors seeking to manipulate the AEB system into activating by imitating the act of entering the roadway environment. Mitsubishi was concerned about pedestrians who are about to jaywalk but stop due to approaching cars. The commenter stated that this behavior may lead to unnecessary activation and induce unintended consequences as current technology cannot predict pedestrian behavior with 100% accuracy. The Alliance and others stated that impact speeds of 25 km/h (16 mph) should be allowed as such impact speeds would have a reasonable safety outcome when the crash speed was mitigated from a higher speed testing. Some commenters stated that NHTSA should harmonize with UNECE Regulation No. 152, where impact speeds up to 40 km/h (25 mph) are allowed.

Agency Response

NHTSA is adopting the proposed testing speed ranges with a no-contact requirement and is not permitting repeat trials.

The commenters' main arguments in support of reducing the PAEB testing speeds are the potential increase in the likelihood of false positives due to difficulties in detecting pedestrians and classifying pedestrian action (such as intention to enter the roadway). In general, the commenters suggested allowing some level of pedestrian contact at above certain reduced speeds, ranging from 30 km/h to 50 km/h (10 mph to 31 mph), with most commenters suggesting around 40 km/h (25 mph) as the maximum speed for a no-contact requirement.

NHTSA proposed testing requirements that can be met, and that can avoid as many crashes, and mitigate as much harm, as practicable. For PAEB, NHTSA seeks to avoid crashes at the highest practicable speeds because of the vulnerability of a pedestrian in a vehicle crash. Vehicle contact with a pedestrian can be fatal or result in serious injury with potential long-term effects. NHTSA scrutinizes hybrid approaches, such as that of the Alliance, that incorporate as part of its framework the vehicle's hitting a pedestrian because the risk of injury to a pedestrian in a vehicle crash is so great. After reviewing the comments and other information, NHTSA does not believe that striking a pedestrian is an acceptable safety outcome given the availability of technologies that can prevent any kind of contact in the test scenarios.

Using the speed limit as a proxy for traveling speed, the data presented in the previous section of this document show that about 50 percent of pedestrian fatalities, and about 57 percent of injuries, occur on roads with a speed limit of 65 km/h (40 mph) or less. NHTSA believes an upper speed limit less than 65 km/h (40 mph) for a no-contact PAEB requirement would not be appropriate when test data on the performance of current vehicles show the practicability of meeting the proposed limits, particularly when more lead time is provided for the technology to evolve.

The injury curves and thresholds provided by some of the commenters show that below 25 km/h, there is a reduced probability of AIS3+ and MAIS3+ injury compared to impacts at greater speeds. However, the safety problem that PAEB can mitigate exists mainly at speeds above 40 km/h. Given that AEB, when developed to meet a no-contact requirement, could help mitigate the occurrence of pedestrian impacts up to 65 km/h (40 mph), NHTSA believes it unreasonable to set the no-contact limit at speeds at just a 40 km/h (25 mph) threshold.

As demonstrated by NHTSA testing, the technology has already proven effective at avoiding collisions at speeds up to 65 km/h (40 mph). As detailed in the research section, NHTSA found that a vehicle (the 2023 Toyota Corolla Hybrid) was able to avoid collision under all testing conditions up to the maximum proposed testing speeds requirement for all PAEB testing scenarios and speeds.[138] In addition, four of the six vehicles tested achieved collision avoidance up to the proposed maximum speeds in almost all scenarios–some even in the most

[138] NHTSA's 2023 Light Vehicle Pedestrian Automatic Emergency Braking Research Test Summary, available in the docket for this final rule (NHTSA-2023-0021).

challenging dark lower beam scenarios. Additionally, another vehicle was able to achieve collision avoidance at all tested speeds in 3 scenarios.

NHTSA believes that the practicability of meeting the PAEB requirements of this final rule is demonstrated by the test data showing the performance of the 2023 Toyota Corolla Hybrid that passed all scenarios, and that of the several other vehicles that almost passed all scenarios. These test results are even more noteworthy because the tested vehicles did not have AEB systems designed to meet the requirements of proposed FMVSS No. 127. They were not prototypes or vehicles specially engineered to the specifications of the proposed standard for research purposes. To be clear, these were production vehicles already in the marketplace. The fact that current vehicles not particularly engineered to meet the new standard's requirements could meet them as designed, or with slight modification, further demonstrates the practicability of this final rule. Because current AEB systems are already capable of meeting the AEB requirements, NHTSA's assumption is confirmed that manufacturers will be able to meet the requirements of FMVSS No. 127 with the lead time provided, without major upgrades while mitigating excessive false positives or other unintended consequences.

Several commenters also believed that repeated trials should be allowed during PAEB testing. In response, NHTSA notes that the agency does not usually incorporate repeated trials in its vehicle compliance program. NHTSA's position has been to conduct a compliance test and, if an apparent noncompliance results, the agency should pursue the matter with the vehicle manufacturer without having to run a repeated trial. NHTSA's view is that the vehicle manufacturer is responsible for certifying the compliance of its vehicles and for ensuring the basis of its certification is sufficiently robust such that each vehicle will pass the test when tested by NHTSA. The agency acknowledges that for many years, NCAP testing (and other testing around the world) has encompassed repeated test trials to populate information about AEB in the consumer information program. NHTSA took the repeated trial approach in NCAP only because it was for a technology that was new or being developed. For more mature systems with a substantial record of real-world use, a single test run is preferable. A single test approach provides the agency the confidence that the performance it is regulating will perform as consistently as possible in the real world.

Regarding the comments received relating to AEB perception,[139] pedestrian detection, and classification, the MY 2023 vehicles tested for PAEB were generally able to avoid collision in all scenarios and at the majority of higher testing speeds. These vehicles are in production and on the road, demonstrating that solutions have been engineered to the PAEB perception in the real world. The engineering solutions have also accounted for no-contact testing performance. Also, Euro NCAP, while not a regulation, employs similar testing at similar speeds as the requirements in this final rule and many vehicles achieve a full score on Euro NCAP testing due to their collision avoidance capabilities. This performance further reinforces NHTSA's assessment that meeting the testing speeds of this final rule are practicable.

Evasive steering (PAEB)

Comments

For the small overlap (25% test conditions), Porsche stated the last point to steer is much closer to the pedestrian than the last point to brake and the proposed test speeds may increase the likelihood for emergency braking engagement that may often be perceived by the customer as a false activation in scenarios where the driver is aware of the pedestrian on the road and planning to steer around them. Porsche stated that this dilemma is similar to high speed AEB for lead vehicles, but occurs at lower speeds, as small overlap pedestrian scenarios are harder to detect and predict.

Agency Response

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[139] The performance of each AEB system depends on the ability of the system to use sensor data to appropriately detect and classify forward objects. The AEB system uses this detection and classification to decide if a collision is imminent and then avoid or mitigate the potential crash. Manufacturers and suppliers of AEB systems have worked to address unnecessary AEB activations through techniques such as sensor fusion, which combines and filters information from multiple sensors, and advanced predictive models.

In response, after considering the comments, and similar to its assessment of comments regarding lead vehicle evasive steering, the agency is not persuaded that evasive steering is an acceptable avoidance maneuver during testing. As thoroughly discussed previously, such factors as vehicle dynamics, traffic conditions and traffic participants all influence the safety benefit of a steering avoidance maneuver. A steering maneuver, as an avoidance maneuver, may not be as safe as a brake-in-lane maneuver, particularly in an urban environment. In any event, like for the lead vehicle situation, a manufacturer, outside of the testing requirements, may elect to detune or disengage the AEB system based on an emergency steering maneuver as long as the vehicle meets all the AEB requirements.

3. Pedestrian Test Device Speed

Comments

AARP and ASC commented on the proposed pedestrian test device speeds. AARP suggested that NHTSA consider whether testing the adult pedestrian scenarios at a walking speed of 3.1 mph (5 km/h) is sufficient to improve safety for those who walk at slower speeds. ASC stated that IIHS, and UNECE Regulation No. 152 and No. 131, require a speed of less than or equal to 5 km/h, which is representative of a walking adult pedestrian.

Agency Response

In response, NHTSA believes that the proposed crossing path test speed of 5 km/h (3.1 mph) for walking adult scenarios reasonably addresses the safety of adult pedestrians, including those who walk at slower speeds. Higher pedestrian test device walking speeds are more challenging for AEB systems. The longer a pedestrian is in the roadway, the more time a vehicle has to identify, classify, and avoid striking the pedestrian. NHTSA proposed that tests be performed at 5 km/h (3.1 mph) and 8 km/h (5 mph), as these speeds are representative of able-bodied adults walking and running. The agency expects that manufacturers will not turn pedestrian avoidance off at pedestrian speeds below those tested but will instead design systems that detect pedestrians moving at speeds lower than 5 km/h (3.1 mph) and avoid them. Further, the agency also included in the requirements testing with stationary pedestrian test devices, so that PAEB performs under three distinct pedestrian test mannequin speed scenarios (0 km/h, 5 km/h and 8 km/h). Therefore, NHTSA declines to include additional tests with pedestrian surrogate speeds lower than 5 km/h (3.1 mph) based on the absence of a safety need to do so.

In response to ASC, NHTSA notes that the 8 km/h (5 mph) test speed is used in the pedestrian crossing from the left scenario. It is representative of an able-bodied pedestrian running. This performance test was proposed in the NPRM to ensure that pedestrian avoidance occurs in as wide a range of scenarios as is practicable. Data from NHTSA's testing of six model year 2023 vehicles showed that four of the six vehicles were able to meet the performance levels proposed in the NPRM. Based on the above, NHTSA concludes this test scenario is practical and appropriate for inclusion in the final rule. The agency also expects that if manufacturers can meet this performance for pedestrians crossing from the left at 8 km/h (5 mph), they can also avoid slower moving pedestrians, because in general the slower moving scenario poses a less demanding performance condition.

After considering the comments, the final rule adopts the 5 km/h (3 mph) speed for walking adult scenarios and the 8 km/h (5 mph) speed for running adult scenarios in crossing path PAEB tests, as proposed in the NPRM.

4. Overlap

Bosch commented on NHTSA's use of the term "overlap" in the NPRM. Overlap is a term used to describe the location of the point on the front of the subject vehicle that would make contact with a pedestrian if no braking occurred. The NPRM defined overlap as the percentage of the subject vehicle's overall width that the pedestrian test mannequin traverses. It is measured from the right or the left, depending on the side of the subject vehicle where the pedestrian test mannequin originates.

NHTSA proposed to use two overlaps for testing: a 25 percent overlap and a 50 percent overlap. The agency proposed the minimum overlap of 25 percent to allow for the test mannequin to fully be in the path of the subject vehicle. The agency also explained that the overlap determines the available time for the AEB system to detect and react when a collision with the test mannequin is imminent—a 50 percent overlap allows for more time than a 25 percent overlap. As for tolerances, the NPRM proposed that for each test run, the actual overlap would have to be within 0.15 m of the specified overlap.

Bosch did not object to the meaning of the term, the values proposed, or the tolerance provided for overlap, but suggested that NHTSA consider using the phrase "percentage of the vehicle's width," rather than "overlap." The commenter believed that the phrase accurately describes the lateral distance between the person in front of the vehicle and is terminology used by Euro NCAP. Bosch further stated that a similar approach by NHTSA would promote consistency and comparability in AEB performance evaluation across the industry.

In response, NHTSA declines to change the term "overlap." The agency believes that the term overlap used in the proposal, and "percent vehicle width" used in Euro NCAP, are synonymous and not in conflict. Furthermore, the use of "overlap" is consistent with NHTSA's use of terms in its crashworthiness regulations, NHTSA's NCAP program, and NHTSA's practices in previous PAEB research. In addition, the definition of "overlap" in S8.1.2 – the percentage of the subject vehicle's overall width –already includes the phrase put forth by Bosch.

5. Light Conditions

This final rule adopts the proposed requirements in the NPRM to specify compliance testing of AEB systems in daylight and dark conditions. The conditions ensure performance in a wide range of ambient light conditions. For daylight testing, the ambient illumination at the test site is not less than 2,000 lux. This minimum level approximates a typical roadway light level on an overcast day. The acceptable range also includes any higher illumination level including levels associated with bright sunlight on a clear day. For PAEB testing in darkness, the ambient illumination at the test site must be no greater than 0.2 lux. This value approximates roadway lighting in dark conditions without direct overhead lighting with moonlight and low levels of indirect light from other sources, such as reflected light from buildings and signage.

Comments

NHTSA received many comments to the proposed light conditions. Consumer advocacy groups and others generally support the proposed PAEB tests in daylight and darkness (with lower and upper beam) conditions.[140] NSC and GHSA emphasize that 75 to 77 percent of pedestrian fatalities occur in darkness or after dark, regardless of whether artificial lighting was present. GHSA also states that disadvantaged communities are overrepresented in pedestrian fatalities. Consumer Reports is supportive of PAEB in dark conditions based on the overrepresentation of nighttime pedestrian crashes among the total.

With respect to the use of headlamps during PAEB testing, Consumer Reports believes there does not appear to be a significant advantage of testing with the upper beams if the system already meets the requirements with the lower beams, and, that there is no guarantee that drivers will use the upper beams. In addition, Consumer Reports anticipates an increasing number of vehicles will be offered with adaptive driving beam (ABD) technology that can be used rather than lower beam and upper beams, and suggests that NHTSA's AEB tests test with ADB. Therefore, Consumer Reports suggests NHTSA replace the lower and upper beam language with language referring to the "lowest level of active illumination," or similar, and require that the system pass the test at this level of lighting. Some equipment manufacturers expressed support for the proposed PAEB tests in daylight and darkness conditions, stating that infra-red sensors would increase safety for dark lighting conditions.

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[140] These commenters included NSC, NTSB, GHSA, Consumer Reports, Forensic Rock, the Lidar Coalition, ZF, and COMPAL.

The Lidar Coalition expressed strong support for the proposed testing of PAEB in low light conditions with no overhead lighting and only lower beams activated. The commenter states that NHTSA is correctly focusing on addressing the largest portion of pedestrian fatalities on U.S. roadways. The Lidar Coalition suggests that NHTSA prioritize testing in the darkest realistic conditions possible. The commenter states that the proposed test procedure in dark conditions will evaluate PAEB technologies in the real-world scenarios where the commenter believes these systems are most needed, when the human eye falls short. The Lidar Coalition states the Insurance Institute for Highway Safety found that in darkness conditions, camera and radar based PAEB systems fail in every instance to detect pedestrians. They additionally referenced the GHSA finding that in an evaluation of roadway fatalities in 2020, 75% of pedestrian fatalities occur at night.

COMPAL supports a finding of a safety need for PAEB under dark condition and higher speeds (greater than 60 km/h (37.5 mph)), and believes that placing infrared sensors as a forward-looking sensor in PAEB testing can improve AEB functionality in challenging situations, such as testing for the crossing child obstructed scenario and the crossing adult running from the left. It states that infrared sensors should not be considered an emerging technology and that they work well in sun glare and darkness conditions and can detect a pedestrian much further than typical headlamps.

Vehicle manufacturers and equipment manufacturers generally oppose the proposed PAEB dark test conditions with only low beams because of the limited ability to illuminate pedestrians. The Alliance, Ford, Nissan, Toyota, Honda, MEMA, Mobileye and Adasky support the idea of allowing the use of the advanced lighting technology (such as ADB headlamps) if available on the model as standard equipment, or to incorporate the use of streetlights to simulate urban traffic conditions. The Alliance argues that allowing all dark lighting conditions to be tested with the advanced lighting features activated aligns with NHTSA's considerations for similar testing in the proposed NCAP upgrade and further promotes the adoption of these advanced lighting systems. Porsche states that the required nighttime PAEB performance requirements at the higher relative speeds is likely to exceed the technical capabilities of many current AEB system hardware. MEMA states that, in dark environments without streetlights, the lower beams would not be active because upper beams provide a better view, so this lower beam test is not depicting a real driving situation.

Ford and Nissan also state that the lighting requirements in FMVSS No. 108 impact feasibility and practicability in testing certain low light PAEB tests. Similarly, Honda commented that the primary sensor for detecting pedestrian targets is the camera, which relies on optical information. Honda state this exceeds the recognition capability and reliability range of current camera systems and will lead to excessive false activations.

Agency Response

After considering the comments, NHTSA has determined there is a safety need for the dark testing requirement, given the number of nighttime pedestrian fatalities and IIHS's finding that several AEB systems that performed well in daylight performed poorly in dark conditions. The agency has adopted the dark lighting requirements as proposed. However, as explained in the discussion below, NHTSA concurs that more time is needed to meet the dark lighting conditions. This final rule provides five years of lead time to do the additional engineering work needed to bring poorer performing AEB systems to a level where they can meet this final rule's requirements.

Consumer Reports commented that testing with upper beam may be redundant if the system already meets the requirements with the lower beam. While this might be true for some systems, agency testing performed for the NPRM showed inconsistent performance while testing with the upper beam.[141] In rare cases, vehicles performed better with lower beams illuminated

[141] https://www.regulations.gov/docket/NHTSA-2023-0021/document (last accessed 12/8/2023).

than with upper beam. NHTSA is adopting an upper beam test to assure the functionality of the AEB system when the driver uses the upper beam.

Forensic Rock, Lidar Coalition, COMPAL and ZF, appear to assert that all scenarios should be tested under dark and daylight condition, or that testing should be performed in the darkest realistic condition. NHTSA does not concur with that view, as the agency must consider, among other matters, the safety problem being addressed (to ensure the FMVSSs appropriately address a safety need), and the practicability and capabilities of the technology. NHTSA has assessed the tests and performance requirements adopted in this final rule to ensure each satisfies the requirements for FMVSS established in the Safety Act. Some tests did not pass NHTSA's assessment and were not proposed. To illustrate, the test results for the crossing scenarios at 25% overlap at night indicate meeting the test is impracticable at this time.[142] Similarly, the obstructed child scenario depicts a situation that very rarely occurs at night (as noted by ZF as well), so NHTSA did not propose testing for such a scenario at night as not practical or reasonable.[143]

Many commenters believe that testing should be allowed with the adaptive driving beam (ADB) active. NHTSA disagrees. NHTSA does not require ADB, whereas the lower beam and upper beam are required by the FMVSSs on the vehicle. Further, even if an ADB system were installed on the vehicle, a driver may not use it. NHTSA does not believe it appropriate to tie the life-saving benefits associated with AEB to a technology (ADB) that a driver may or may not use on a trip.

Additionally, ADB still employs the lower beam and upper beam, and merely switches automatically to the lower beam at times appropriate to do so. Thus, even if a driver has ADB operational, if the ADB reverts to a lower beam on a large portion of the beam area, in effect the operating conditions would be lower beam only, which, under the commenters' suggested

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[142] https://www.regulations.gov/docket/NHTSA-2023-0021/document.
[143] *Id.*

approach, would not have been assessed with AEB. Testing PAEB with ADB on could, under the commenters' suggested testing conditions, essentially amount to the agency only testing the upper beam condition. Such an outcome would be undesirable from a safety standpoint, as most drivers rarely use their upper beams when operating vehicles at night. IIHS test data of 3,200 isolated vehicles (where other vehicles were at least 10 or more seconds away) showed that only 18 percent had their upper beams on.[144] At one unlit urban location, IIHS data showed that upper beam use was less than 1 percent. IIHS found that even on rural roads, drivers used their upper beams less than half of the time they should have for maximum safety, on average. Testing during daylight and dark with lower beam and upper beam provides confidence that in urban dark lighted environment, PAEB will perform even with only the lower beam operational.

NHTSA understands that lower beam testing scenarios may require better lowlight cameras and may require improved recognition algorithms for the lower performing AEB systems, which is why the agency is affording manufacturers additional time to engineer such systems up to FMVSS No. 127 performance. NHTSA’s testing conducted for the NPRM indicated that the proposed PAEB dark scenarios represent ambitious, yet achievable performance criteria.[145] The latest agency research, detailed in this notice, on six model year 2023 vehicles found that in the scenario where the pedestrian is approaching from the right, five of the six vehicles tested were able to meet the performance requirements for the upper beam lighting condition, and four of the six were able to meet the lower beam lighting condition. In the scenario where the pedestrian is stationary, all vehicles were able to meet the upper beam light condition, and three of the six vehicles were able to meet the lower beam testing condition. The final nighttime scenario, with the pedestrian moving along the vehicle’s path, four vehicles met the performance requirements for the upper beam condition, and a single vehicle met the lower

[144] https://www.iihs.org/news/detail/few-drivers-use-their-high-beams-study-finds (last accessed 11/18/2023).
[145] https://www.regulations.gov/docket/NHTSA-2023-0021/document (last accessed 12/8/2023).

beam condition. The 2023 Toyota Corolla was able to avoid collision in two instances and had impact speeds of about 5 km/h or less in the other three tests.

These data indicate the practicability of meeting the PAEB tests proposed in the NPRM. Although not all manufacturers can currently certify to all dark tests, AEB technologies are evolving rapidly, with significant improvements occurring even in the last year or two of NHTSA's AEB research program. NHTSA is providing five years for further development and integration of the technology into the new vehicle fleet. The agency adopts the upper and lower beam conditions as proposed in the NPRM without change, except for providing more lead time to meet the standard's requirements.

As for Honda's concerns about the sensors that they use, i.e., cameras, NHTSA is aware of different sensor combinations capable of detecting pedestrian mannequins, as is evidenced by the higher performing vehicles identified during NHTSA testing. While Honda's current generation cameras may have recognition capability and reliability range challenges, other sensors and sensor combinations do not. NHTSA is not required to limit performance requirements to what one particular manufacturer using specific sensors is capable of doing at a given point in time. If Honda faces the challenges it describes, then software and possibly hardware updates may be necessary for Honda to meet the require performance.

6. Testing Setup

Pedestrian, Obstructed Running Child, Crossing Path from the Right

In the test of an obstructed running child crossing from the right, an obstructed child pedestrian test device moves in the vehicle's travel path from the right of the travel path. The pedestrian surrogate crosses the subject vehicle's travel path from in front of two stopped vehicle test devices (VTDs). The VTDs are parked to the right of the subject vehicle's travel path, in the adjacent lane, at 1.0 m (3 ft) from the side of the subject vehicle. The VTDs are parked one after the other and are facing in the same direction as the subject vehicle. The subject vehicle must avoid collision with the child pedestrian surrogate without manual brake input.

Comments and Agency Responses

Porsche, Volkswagen, FCA, and ASC commented on the proposed obstructed pedestrian scenario in PAEB performance tests. Porsche and Volkswagen stated that the distance between the pedestrian test dummy and the farthest obstructing vehicle is not specified in the proposed regulation (i.e., S8.3.3). The commenters believe this is critical to be defined because the level of obstruction of the child test dummy can only be defined by this distance. If multiple distances are required to reflect full and partial obstruction, then each specific test scenario should be defined.

In response, NHTSA agrees with the commenters that the proposed testing setup should have, but did not, include the distance between a pedestrian test mannequin and the obstructing vehicle device positioned further from a subject vehicle. In this final rule, NHTSA adopts the following regulatory text language to clarify the test setup for the obstructed pedestrian crossing scenario: "[t]he frontmost plane of the vehicle test device furthermost from the subject vehicle is located 1.0 ± 0.1 m from the parallel contact plane (to the subject vehicle's frontmost plane) on the pedestrian test mannequin."

ASC stated that the vehicles obstructing the mannequin should be specified. The commenter believes that due to the large size of common vehicles sold in the US (e.g., pick-ups and sport utility vehicles), specific vehicle models or types should be defined for this test configuration.

In response, the agency disagrees with ASC that NHTSA should specify models or types of the obstructing vehicles. The regulatory text specifies that two vehicle test devices are used as an obstruction in obstructed pedestrian crossing tests and the text also provides the dimensional specifications and other measurements of the vehicle test device. Therefore, the standard includes sufficient information specifying the obstructing vehicles to ensure repeatable and reproducible testing.

FCA commented that the obstruction vehicles in the research testing were a Honda Accord and Toyota Highlander and every research test used this combination of real vehicles as obstructions, but that there was no data in the NPRM or the research about how these scenarios react or correlate to the vehicle test devices proposed for the FMVSS at S8.3.3(g). FCA expressed concern that this could lead to added practicability or other concerns for the associated test condition.

In response, NHTSA highlights the additional testing performed. In this course of this testing, NHTSA evaluated using real vehicles, the 4Active vehicle test device, and the ABD test device.[146] The agency found no appreciable differences in performance between real vehicles and either vehicle test device. Thus, NHTSA believes that using the vehicle test device in the obstructed child crossing scenario is practicable and reasonable.

With respect to Bosch's suggestion that the maximum allowed travel path deviation needs to be specified as 1/8th of the subject vehicle width and not the 0.3 m allowed in the proposal, the agency agrees in general that the tolerance for the expected point of contact should be from the subject vehicle and not the lane. Thus, in the proposal, the tolerance for the expected contact point was specified as the difference between the actual overlap and the specified overlap. This tolerance was specified and is finalized independent of the vehicle's position in the lane. The NPRM's proposed regulatory text stated: "For each test run, the actual overlap will be within 0.15 m of the specified overlap." This is a tighter tolerance than Bosch suggested (1/8th of the average vehicle width is approx. 0.22 m). As such, the agency does not believe this will allow the situation Bosch proposed (where 25 percent overlap can be mistaken for a 50 percent overlap, and 50 percent overlap can be mistaken for 25 percent overlap from the left) to occur.

FCA suggested that NHTSA should consider using a standard road width and simply positioning the pedestrian mannequins across percentages of the lane, as this would be indicative of a position in the real world. FCA stated that NHTSA intended to position pedestrians

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[146] "NHTSA's 2023 Light Vehicle Automatic Emergency Braking Research Test Summary" Available in the docket for this final rule (NHTSA-2023-0021).

according to ratios derived from the overall width of each vehicle, but that this set up can be overly complicated.

NHTSA disagrees with FCA that applying mannequin positions – described as percentages of the width of a standard test lane – would simplify test procedures. First, the agency is not aware of a standard test lane specification that is universally accepted for PAEB tests, and which can represent various types of roads in the real-world. Such roads would include lanes marked by two lines on highways, lanes marked by only one line in urban residential sections, and lanes without any marking in rural areas. Second, applying a same mannequin position within the test lane for all PAEB tests could cause unnecessary confusion because it might result in different overlap scenarios for different sizes of subject vehicles. For example, a pedestrian mannequin positioned at a certain percentage of the lane width may be appropriate for a 25 percent overlap test with a full-size pickup truck. However, such positioning may result in an invalid test with a small compact car – for example, a Fiat 500 – since a mannequin at the same lateral position within the test lane may not make a contact with such a small subject vehicle. Therefore, NHTSA declines to adopt a mannequin position that is defined by lane width and not percent overlap.

J. Procedures for Testing False Activation

This section describes the false activation performance tests adopted by this final rule. These tests are sometimes referred to as “false-positive” tests. After considering the comments to the NPRM, NHTSA has adopted the proposed procedures tests with little change. This section responds to the comments and explains NHTSA’s reasons for adopting the provisions set forth in this final rule. For the convenience of readers, a list of the test specifications can be found in appendix C to this final rule preamble.

This final rule adopts the two proposed false activation testing scenarios – the steel trench plate test and the vehicle pass-through scenario. Both tests are performed during daylight. Testing is performed with manual brake application and without manual brake application. The performance criterion is that the AEB system must not engage the brakes to create a peak deceleration of more than 0.25 g additional deceleration than any manual brake application would generate (if used).

Comments

NHTSA received comments both supporting and opposing the proposed false activation tests. Commenters in favor of including the tests in FMVSS No. 127 include: Consumer Reports, Advocates, the Lidar Coalition, AAA, Bosch, Porsche, and CAS. Consumer Reports states that it is important to limit false activations to maximize safety and consumer acceptance. AAA supported the steel trench plate test, stating that it is important to ensure that increased system sensitivity does not occur at the expense of unnecessary braking. CAS suggested the addition of a third test involving a railroad crossing. The Lidar Coalition stated that false positive tests are important for evaluating both sensing modalities and perception systems, as well as the interplay between both pieces of an effective AEB and PAEB system.

NHTSA also received comments opposing inclusion of one or both of the tests. Volkswagen recommended eliminating the proposed false activation tests from the rule, believing the tests have no comparable real-world relevance. Luminar expressed similar concern about real-world similarity.

Agency Response

After considering the comments, NHTSA has decided to maintain the false positive testing scenarios for AEB proposed in the NPRM. The proposed false activation tests establish only a baseline for system functionality and are by no means comprehensive, nor sufficient to eliminate susceptibility to false activations. However, the tests are a means to establish at least a minimum threshold of performance in the standard.

NHTSA expects that vehicle manufacturers will design AEB systems to thoroughly address the potential for false activations.[147] Previous implementations of other technologies have shown that manufacturers have a strong incentive to mitigate false positives. Vehicles that have excessive false positive activations may pose an unreasonable risk to safety and may be considered to have a safety-related defect. NHTSA understands from industry comments to this rulemaking and others that industry generally designs their systems to minimize false activations.[148]

Nonetheless, NHTSA is including the false activation tests in this final rule because NHTSA has seen evidence of false activations in those scenarios and because NHTSA expects that the scenario might be particularly challenging for AEB systems. Thus, the agency does not agree to remove or add additional test scenarios or conditions to the test scenarios at this time. NHTSA is including the tests in FMVSS No. 127 to establish a reasonable minimum when it comes to false activation assessment and mitigation; the agency may add to the tests in the future if the need arises.

CR commented that a 0.25g deceleration threshold is too high, stating that a "0.25g braking event is noticeable by passengers and could confuse or distract the driver." In response, the requirement is for peak additional deceleration, not for average deceleration. In other words, the deceleration that Consumer Reports is describing would likely not meet the requirement. Consumer Reports is referring to a brief, not sustained, brake pulse, which would be noticeable. The 0.25g peak deceleration threshold was chosen as an obvious indication of external braking that is easily measurable by testing equipment.

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[147] 88 FR 38632 at 38696.

[148] In response to a 2022 NCAP Request for Comment, the Alliance stated in their comments to the 2022 NCAP notice where NHTSA requested comment on the inclusion of false positive tests in NCAP the Alliance stated that vehicle manufacturers will optimize their systems to minimize false positive activations for consumer acceptance purposes, and thus such tests will not be necessary. Similarly, in response to the same 2022 NCAP notice, Honda stated that vehicle manufacturers must already account for false positives when considering marketability and HMI. These comments are available in this docket https://www.regulations.gov/document/NHTSA-2023-0020-0001.

Bosch supported the proposed steel trench plate properties for the steel trench plate test but suggested that the orientation of the plate be accurately aligned within a tolerance, e.g., aligning the leading edge of the plate 90 degrees plus or minus 0.5 degrees to the centerline of the test vehicle.

In response, NHTSA does not agree with Bosch that a tolerance is appropriate for positioning of the steel plate, particularly such a low tolerance as 0.5 degrees. The steel plate false activation test is an established test which has been performed without a specific tolerance for the alignment of the steel plate for an extended period without any indication that the lack of a tolerance influences the outcome of the tests. Further, Bosch has not provided any data in support of their suggestion, and NHTSA does not have any data suggesting that any slight misalignment of the steel plate influences the results.

Porsche stated that they support the false positive tests with some suggested improvements. Porsche stated that they suggest modifying the pass-through test lateral distance gap in S9.3.1(b) to be in relation to the exterior of the vehicle body instead of the front wheels. Porsche also suggested adding a test matrix table to section S8.1. Volkswagen suggested that NHTSA better define the test scenarios, such as with regard to the exterior dimensions of the stationary vehicles in the pass-through gap test and whether there is a manual brake application in either test.

In response, while Porsche states that the gap between the vehicles should be measured based on the exterior of the vehicles, not the wheels, the commenter did not provide any data or reasoning for the suggestion. Volkswagen suggests that more detail should be given on the exterior dimensions of the stationary vehicles but also did not provide any supporting data or reasoning. NHTSA had evaluated these requirements when developing the NPRM and found them to be sufficient. Accordingly, the agency is not revising how the space between the vehicles is measured and how we specify the dimensions of the two stationary vehicles.

Porsche and Volkswagens both state it is unclear whether testing is to be done with and without manual brake application. In response, NHTSA notes that in the NPRM, NHTSA specifically states that it would test vehicles with and without manual application. While the agency does not believe a table is needed specifying the key parameters when testing for lead vehicle and PAEB, NHTSA agrees that the proposed regulatory text was not clear on this topic. Thus, the agency has revised the regulatory text for the steel plate and for the pass-through test to be clear that testing is conducted with manual brake application and without manual brake application.

K. Track Testing Conditions

1. Environmental Test Conditions

Lighting conditions

Under this final rule, NHTSA will test AEB systems in daylight for lead vehicle AEB and PAEB testing, as well as in darkness for PAEB testing. The light conditions ensure performance in a wide range of ambient light conditions. For all daylight testing, the ambient illumination at the test site is not less than 2,000 lux, which approximates the minimum light level on a typical roadway on an overcast day. To better ensure test repeatability, testing may not be performed while the intended travel path is such that the heading angle of the vehicle is less than 25 degrees with respect to the sun and while the solar elevation angle is less than 15 degrees. The intensity of low-angle sunlight can create sensor anomalies that may lead to unrepeatable test results.

For PAEB darkness testing, the ambient illumination at the test site must be no greater than 0.2 lux. This value approximates roadway lighting in dark conditions without direct overhead lighting with moonlight and low levels of indirect light from other sources. This darkness level accounts for the effect ambient light has on AEB performance, particularly for camera-based systems. It ensures robust performance of all AEB systems, regardless of what types of sensors are used.

Comments

NHTSA received several comments on the lighting conditions,[149] particularly the proposed ambient illumination requirement (i.e., any level at or below 0.2 lux) for darkness PAEB testing.

HATCI and others believe that NHTSA should use nighttime lighting conditions for PAEB testing that are more characteristic of urban environments. HATCI states that NHTSA would use the same specification for lower and upper beams, 0.2 lux, but that an ambient environment of 0.2 lux is extremely dark and is unlikely to be representative of real-world conditions in an urban area. HATCI stated that since 82% of the pedestrian fatalities occur in urban areas, these environmental conditions should be reflected in the test procedures. HATCI suggests that the agency should include overhead lights as it is more representative of the urban environment. The commenters state that additional lighting, including streetlights, would align lighting conditions with Euro NCAP. In contrast, AAA believes NHTSA should refrain from allowing testing under artificially bright overhead lighting for PAEB system performance requirements in darkness conditions.

Agency Response

After considering the comments submitted about the lighting conditions, NHTSA has decided to adopt the proposed lighting conditions for several reasons. First, the agency is finalizing the proposed lighting conditions because they present the most challenging, but practicable, lighting conditions for PAEB systems. Because they will be able to meet the most challenging condition, PAEB will be able to perform well in situations with more light, like roads that have streetlights. Although NHTSA agrees with commenters that 0.2 lux may not be

[149] These commenters included HATCI, MEMA, Bosch, Mitsubishi, and AAA.

representative of urban scenarios at night, the agency disagrees with HATCI, MEMA, Bosch, and Mitsubishi that testing should be conducted with lighting conditions that mimic urban areas. Testing in dark conditions, below 0.2 lux, represents the worst lighting case, where pedestrians are most at risk.[150]

Second, testing during daylight and dark with lower beams and upper beams provides confidence that in urban dark lighted environments, PAEB will perform even if the agency does not test under such a condition

In addition, the agency conducted confirmatory testing that indicates that the proposed lighting conditions represented ambitious, yet achievable conditions. The agency conducted additional research on the performance of the AEB systems of six model year 2023 vehicles when approaching a pedestrian. The darkness testing occurred with less than 0.2 lux of ambient lighting. In the scenario where the pedestrian is approaching from the right, five of the six vehicles tested were able to meet the performance requirements for the upper beam lighting condition, and four of the six were able to meet the lower beam lighting condition. In the scenario where the pedestrian is stationary, all vehicles were able to meet the upper beam light condition, and three of the six vehicles were able to meet the lower beam testing condition. The final nighttime scenario, with the pedestrian moving along the vehicle's path, four vehicles met the performance requirements for the upper beam condition, and a single vehicle met the lower beam condition. NHTSA believes that this data show that testing with the ambient light below 0.2 lux is practicable. For the above reasons, NHTSA believes the lighting conditions adopted by this final rule best ensure that PAEB systems work in all environments where pedestrians are at the highest safety risk.

[150] For the proposed PAEB testing in darkness, the ambient illumination at the test site must be no greater than 0.2 lux. This value approximates roadway lighting in dark conditions without direct overhead lighting with moonlight and low levels of indirect light from other sources, such as reflected light from buildings and signage.

As for the proposed PAEB daylight testing conditions, several sensor suppliers suggested that the agency should reconsider the sunlight glare avoidance requirement (i.e., not driving toward or away from the sun – less than 25 degrees in vertical and 15 degrees in horizontal directions). Adasky and the Lidar Coalition stated that the NHTSA should include additional real world environmental conditions, such as direct sunlight.

In response, the agency agrees with Luminar that there is a safety issue on the road when drivers operate in direct sunlight. However, the agency does not have enough test data to assess the statements from manufacturers of lidar systems (Adasky, Luminar, The Lidar Coalition) on the efficacy of LIDAR systems and potential sensor saturation by testing in direct sunlight. Additionally, NHTSA believes that, if research is warranted to assess the accuracy of the companies' assertions, that would delay this rulemaking. Thus, NHTSA declines to change the final rule as requested.

Ambient Temperature

This final rule adopts the proposed specification that the ambient temperature in the test area be between 0 Celsius (32 °F) and 40 Celsius (104 °F) during AEB testing. This ambient temperature range matches the range specified in NHTSA's safety standard for brake system performance and is representative of the wide range of conditions that AEB-equipped vehicles encounter. As explained in the NPRM, while AEB controls and sensors can operate at lower temperatures, the limiting factor here is the braking performance.

Comments

FCA commented that, given the only proposed outcome is "no contact" and passing results in the research data are often less than one meter, brake stopping performance and variation become crucial. FCA stated that because of this, testing at temperature becomes a primary concern. FCA suggested that if NHTSA believes braking performance at hot temperatures is the worst case, it should make that explanatory statement. However, if NHTSA believes braking is worst case at cold temperatures, it should assess AEB performance at the freezing point minimum temperature. Otherwise, it should limit the regulatory testing to a much more modest range to accommodate the existing data.

Agency Response

In response, NHTSA notes that FCA did not provide the testing range that it believes would be acceptable, or explain its concern about aspects of the proposed range. NHTSA believes that braking performance would be relatively unaffected by outside temperature because the procedures specify that there will be an initial braking temperature which ensures that the brakes are warm when tested, and has specified a burnishing procedure to ensure that the brakes perform consistently. The final rule specifies a testing range consistent with the ranges included in the existing braking standards applying to the vehicles subject to FMVSS No. 127. Those testing temperatures have worked well in those braking standards, and NHTSA is unaware of information indicating they would be unacceptable for this rule. Accordingly, NHTSA adopts the ambient temperature range proposed in the NPRM without change.

Wind Conditions

This final rule adopts the proposed specification that the maximum wind speed during AEB compliance testing be no greater than 10 m/s (22 mph) for lead vehicle avoidance tests and 6.7 m/s (15 mph) for pedestrian avoidance tests. Excessive wind during testing could disturb the test devices in various ways. For example, high wind speeds could affect the ability of the VTD to maintain consistent speed and/or lateral position, or could while cause the pedestrian mannequin to bend or sway unpredictably.

Comments

Bosch and Zoox are concerned with testing up to the proposed maximum wind speed. Bosch states that the testing equipment is not able to consistently maintain stability in windy conditions. Bosch and MEMA suggest using language similar to UNECE R152 which specifies testing only when there is no wind present that is liable to affect the results. Zoox suggests reducing the maximum test wind speed from 10 m/s to 5 m/s for all AEB testing.

Agency Response

NHTSA declines to adopt the suggested changes. The wind speeds included in the proposal and adopted in this final rule have long been used by the agency in AEB testing and testing of other systems in the FMVSS. As stated in the NPRM, these are the same maximum wind speeds specified for AEB tests in the agency's AEB NCAP test procedures and PAEB draft research test procedure without problems. The wind speed specified for lead vehicle avoidance tests is also in line with the maximum wind speed specified for passenger vehicles in FMVSS No. 126, "Electronic stability control systems for light vehicles." The specification has been workable for many years.

Commenters did not explain the basis for characterizing the proposed wind speeds as windy conditions, or what winds could affect test results. They provided no information showing that the proposed wind speeds would affect braking performance and test equipment stability. NHTSA believes that the UNECE R152 approach would not be helpful, as it is open-ended about wind speeds. It would not provide manufacturers with notice of the wind speeds under which the agency would test. NHTSA believes its approach of specifying the specific range of wind speeds, as opposed to leaving it open ended and undefined like UNECE R152, provides notice about the test conditions under which compliance testing would be conducted and more assurance about what NHTSA considers a valid test. The agency therefore adopts the provisions for wind speed without change.

Precipitation

NHTSA adopts the proposed specification that NHTSA will not conduct AEB compliance tests during periods of precipitation, including rain, snow, sleet, or hail. The presence of precipitation could influence the outcome of the tests because wet, icy, or snow-covered pavement has lower friction. Conducting a test under those conditions also poses risks to lab personnel. Additionally, the presence of precipitation like rain, snow, sleet, or hail, makes it much more difficult to reproduce a friction level with good precision. That is, even if NHTSA were able to run a particular test on a pavement with precipitation, replicating the same test conditions may not be possible.

Comments

Consumer Reports stated that the variation of AEB performance in different conditions is why this additional testing is needed. It noted that in its experience evaluating vehicles' wet-road braking performance, it is feasible to establish objective test procedures for conditions in which the ground is wet.

Agency Response

In response, NHTSA does not have the information necessary to demonstrate that such testing would be possible for compliance testing. NHTSA is encouraged that Consumer Reports conducts wet pavement testing because such testing can add to the agency's knowledge in this area. NHTSA encourages Consumer Reports to share more detailed information about its wet-road braking to possibly provide a foundation for future NHTSA research.

Visibility

This final rule adopts the proposed specification that AEB performance tests will be conducted when visibility at the test site is unaffected by fog, smoke, ash, or airborne particulate matter. Reduced visibility in the presence of fog or other particulate matter is difficult to reproduce in a manner that produces repeatable test results. While NHTSA considered a minimum visibility range during the development of the proposal, the agency proposed a limitation on the presence of conditions that would obstruct visibility during AEB testing. NHTSA sought comment on whether to adopt a minimum visibility range.

Comments

ASC, ZF, and MEMA supported the proposed visibility conditions for AEB testing. ASC, MEMA and ZF stated that defining minimum visibility ranges would be challenging due to current sensor performance and creating repeatable test conditions.

Other commentators requested a minimum visibility requirement and gave suggestions on how to create a minimum visibility definition. The Alliance stated that this should be objectively defined. Mobileye suggests that a minimum level of visibility could be defined as the visibility that allows a human driver to see the target within 5 seconds time to collision. Bosch and FCA states that NHTSA should establish a precise and comprehensive definition for "visibility" (e.g., that visibility will be greater than 1 km, 0.5 km, etc.). Bosch and Volkswagen state that the test must ensure that the horizontal visibility range will allow the target to be clearly observed throughout the test. Aptiv and Consumer Reports recommend adding additional testing to account for real-world conditions such as sun glare, rain, fog and smoke.

Agency Response

NHTSA adopts the provisions proposed in the NPRM without change, for the reasons provided in the proposal. The agency agrees with commenters that there may be merits to having an objective way to measure visibility, but defining a minimum visibility range that is objective is challenging, as noted by ASC, ZF, and MEMA. Bosch suggested requiring visibility be measured as greater than "X" kilometers, similar to NCAP programs,[151] and Mobileye suggested an approach.

NHTSA will further consider the pros and cons of these and other approaches and determine whether to consider them in a future rulemaking. For now, it does not appear that the commenters' requested changes to the visibility metric proposed in the NPRM present a better measurement than the limitation on the presence of conditions that would obstruct visibility. Therefore, NHTSA will adopt the provisions described in the NPRM.

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[151] Euro NCAP specifies visibility of at least 1 km (0.62 miles) and NHTSA's NCAP specifies 5 km (3.1 miles).

2. Road/Test Track Conditions

Surface

This final rule adopts the proposed specification that NHTSA will test on a dry, uniform, solid-paved surface with a peak friction coefficient (PFC) of 1.02 when measured using an ASTM F2493 standard reference test tire, in accordance with ASTM E1337-19 at a speed of 64.4 km/h (40 mph), without water delivery.[152] Surface friction is a critical factor in testing systems that rely heavily on brake system performance testing, such as AEB. The presence of moisture will significantly change the measured performance of a braking system. A dry surface is more consistent and provides for greater test repeatability.

Comments

MEMA supports the test track surface having a peak friction coefficient of 1.02. AAA recommended, based on previous testing, that there should be some tolerance allowed in terms of peak friction coefficient to allow for a greater number of closed-course facilities to be suitable for confirmation testing. FCA asked for clarification, as they see a maximum Roadway Friction Coefficient (RFC) but no mention of any minimum RFC. In addition, FCA suggested adopting a similar calculation for over speed/under speed tests within FMVSS No. 127 as in FMVSS No. 135. The Alliance commented that NHTSA should define the tolerance for the required test track surface with maximum and minimum friction coefficients. It stated that such a tolerance would ensure fairness when conducting tests across different test facilities, reduce the cost/burden associated with maintaining a test surface having a specific PFC, particularly since this value can change over time, and is consistent with NCAP's Crash Avoidance test procedures.

Agency Response

[152] ASTM E1337-19, *Standard Test Method for Determining Longitudinal Peak Braking Coefficient (PBC) of Paved Surfaces Using Standard Reference Test Tire*.

NHTSA first addressed this issue in the final rule upgrading the motorcycle brake system standard published in 2012.[153] NHTSA stated that, by specifying a single PFC, the intent is not to specify testing only on surfaces with that PFC. Rather, the intent is to set a target PFC that acts as a reference point. Manufacturers who choose to conduct on-track testing to certify their vehicles can use test surfaces with any PFC below the specified level to ensure compliance at the specified level. On the other hand, NHTSA, and laboratories conducting compliance tests, would use surfaces having a PFC at or above the target PFC to allow a reasonable margin for friction variations and other test surface variables.

This approach of specifying PFC without tolerance is consistent with how surface peak friction coefficients are specified in FMVSS No. 121, "Air Brake Systems," FMVSS No. 135, "Light Vehicle Brake Systems," and in FMVSS No. 126, "Electronic Stability Control Systems. FMVSS No. 126 mandates Electronic Stability Control (ESC) systems on light vehicles, and establishes test procedures to ensure that ESC systems meet minimum requirements. In the rulemaking that established FMVSS No. 126, NHTSA originally proposed a tolerance around the surface PFC specification, but ultimately specified a single PFC for the test surface in the final rule. The agency explained that, although the proposed tolerance was an attempt to increase objectivity, such a tolerance created the possibility of compliance tests for FMVSS No. 126 being performed on lower friction coefficient surfaces than those for other braking standards, which is not the intention. NHTSA explained that while it is unlikely that any facility has a surface with exactly that friction coefficient, compliance testing for other braking standards is performed on a surface with a PFC slightly higher than the specification, which has more adhesion and creates a margin for clear enforcement. Here, as in the ESC final rule, NHTSA will use consistent compliance test conventions across all FMVSSs when specifying surface PFC.

Slope

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[153] 77 FR 51650 (Aug. 24, 2012).

This final rule adopts the proposed specification that NHTSA's test surface will have a consistent slope between 0 and 1 percent. The slope of the road surface can affect the performance of an AEB-equipped vehicle.[154] The slope also influences the dynamics and layout involved in the AEB test scenarios.

Comments

MEMA and Bosch commented, suggesting language from FMVSS No. 135 stating that the test surface has no more than a 1% gradient in the direction of testing and no more than a 2% gradient perpendicular to the direction of testing.

Agency Response

In response, NHTSA has not made the requested change. The agency's proposed specification did not specify that this is consistent in only the direction of travel. The agency might test on a surface that is not necessarily a defined lane, so, much like with ESC testing, the surface could be 1% in the direction of travel or normal to the direction of travel.

NHTSA provides the public with information on how the agency will conduct compliance tests, but manufacturers are not required to certify their vehicles using the tests in the FMVSS. Testing on a surface that is less flat could be more stringent, and manufacturers are free to test on a more stringent surface than what the agency uses.[155] Therefore, the agency does not see a need for the suggested change.

Markings

This final rule adopts the proposed specification that, in NHTSA's tests, within 2 m of the intended travel path, the road surface can be unmarked, or marked with one, or two lines of any configuration or color, at NHTSA's option. If lines are used, they must be straight, and, in

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[154] Kim, H. et al., *Autonomous Emergency Braking Considering Road Slope and Friction Coefficient*, International Journal of Automotive Technology, 19, 1013–1022 (2018).

[155] The manufacturer must exercise due care in making its certification. While manufacturers are not required to follow the tests in the FMVSSs, manufacturers seek to ensure that their vehicles will meet the FMVSS when NHTSA tests them according to the test procedures in the FMVSSs.

the case of two lines, they must be parallel to each other and the distance between them must be from 2.7 m to 4.5 m. Vehicles equipped with AEB often are equipped with other advanced driver assistance systems, such as lane-centering technology, which detects lane lines. Those systems may be triggered by the presence of road markings, potentially leading to unrepeatable results.

Comments

In its comment, Bosch recommended including surface conditions such as grade lane markings, surrounding clearance areas, and acceptable target object specifications to enhance the accuracy and reliability of the testing process in each scenario. Zoox recommended specific markings for the regulation. It suggests text stating: "The road surface within 2 m of the intended travel path is marked with two solid lines (yellow on the left, white on the right) that are straight, parallel to each other, and at any distance from 2.7 m to 4.5m." Zoox believes that, in the scenarios prescribed and with the variety of permissible lane markings, an ADS may drive around the obstruction instead of stopping in lane. It recommends specifying lane markings consistent with the Manual on Uniform Traffic Control Devices (MUTCD).

Agency Response

NHTSA disagrees with the recommendation by Bosch and Zoox to change the lane marking specifications for the compliance test. Fully marking the lane would simulate a vehicle traveling on new, well-marked roadways, which reduces the representativeness of test of the real-world. Lane markings across the country vary in terms of existence, quality, and placement. Many rural roads have little to no lane markings, older roads may have degraded or missing lane markings, and even new roadways may have lane markings that are not yet present. The provision that states that NHTSA has flexibility in how the lanes are marked puts manufacturers on notice that they must consider all roadway types when designing their AEB system, not just road with newly marked lines. The most commonly encountered lane marking colors are white and yellow; however, there are areas where vehicles may encounter other colors. The MUTCD states that markings are to be yellow, white, red, blue, or purple. Less common situations include E-ZPass lanes that are marked with purple/white lane markings. In general NHTSA does not believe that lane markings/colors have a technical effect on AEB performance, however specifying that lane lines used may be any color ensures that AEB performance will not vary based on lane marking color faded color.

NHTSA believes it is important to the real-world efficacy of AEB systems that AEB be designed to consider a wide variety of lane markings that it is reasonable to assume the systems may encounter in the real world. NHTSA is concerned that reducing the types of lane markings they need to consider would work against NHTSA's goals of ensuring the robustness of AEB systems and the safety benefits AEB can attain. Therefore, the agency will adopt the provisions described in the NPRM without change.

Subject Vehicle Conditions

This final rule adopts the proposed specification about the subject vehicle conditions during testing relating to the following topics: AEB initialization, tires, subject vehicle brakes, fluids and propulsion battery charge, user adjustable settings, headlamps and subject vehicle loading. Where the agency received no comments a particular topic, it is not discussed below. All proposals are adopted for the reasons discussed in the NPRM.

AEB System State and Initialization

In the NPRM, NHTSA proposed that testing not be conducted if the AEB malfunction telltale is illuminated or any of the sensors used by the AEB systems are obstructed. NHTSA proposed that AEB systems would be initialized before each series of performance tests to ensure the AEB system is in a ready state for each test trial. This is because the electronic components of an AEB system, including sensors and processing modules, may require a brief interval following each starting system cycle to reset to their default operating state. It also may be necessary for an AEB-equipped vehicle to be driven at a minimum speed for a period of time prior to testing so that the electronic systems can self-calibrate to a default or baseline condition, and/or for the AEB system to become active.

The proposed initialization procedure specifies that, once the test vehicle starting system is cycled on, it will remain on for at least one minute and the vehicle is driven at a forward speed of at least 10 km/h (6 mph) before any performance trials commence. This procedure also ensures that no additional driver actions are needed for the AEB system to be in a fully active state.

In its comment, Porsche suggested that vehicles should be brought to operating temperature before testing is begun. NHTSA disagrees with this suggestion for several reasons. First, it is NHTSA's position that the AEB system should be functional regardless of the vehicle's operating temperature because to choose otherwise could lead to unnecessary and concerning real-world limitations. The agency believes that specifying that the vehicle will be started and running for at least one minute prior to test initiation is more than sufficient for the manufacturer to have a functional AEB system. In the real world, vehicles often travel at the speeds proposed shortly after the driver powers the vehicle on. NHTSA requires brakes, lights, and crashworthiness devices, like seat belts and air bags, to work when the vehicle is turned on. In the same manner, the vehicle must meet FMVSS No. 127 when turned on. NHTSA is providing a brief initiation state for the AEB system to reset to a default operating state, but extending that state to the period suggested by Porsche would be contrary to the need for safety.

NHTSA believes the one-minute initiation period is generous in the context of the FMVSSs. There is a risk that drivers will not wait a minute to start driving. These drivers likely expect all vehicle system, especially safety systems, to be ready to operate once the vehicle is turned on. Porsche did not provide sufficient justification for its suggestion to extend that time. Based on these the above factors, NHTSA is not accepting Porsche's suggestion.

MEMA, Volkswagen, Porsche, and Bosch commented that the agency should adopt the pre-test conditioning process from UNECE Regulation No. 152 where, if requested by the manufacturer, the vehicle can be driven a maximum of 100 km (62.1 miles) to initialize the sensor system.

NHTSA also disagrees with this suggestion for the reasons discussed in the previous paragraph. This suggestion presents issues similar to those flagged in the previous paragraph, namely that the system should be available and functioning as soon as possible after vehicle start up and that a failure to do that could be very confusing to drivers and result in a failure to provide the safety benefits it should. For the reasons explained in this section, this final rule adopts the provisions proposed in the NPRM without change.

Brake Burnishing

To maximize test repeatability, this final rule adopts the proposed specification that subject vehicle brakes be burnished prior to AEB performance testing according to the specifications of either S7.1 of FMVSS No. 135, Light vehicle brake systems, which applies to passenger vehicles with GVWR of 3,500 kilograms or less, or to the specifications of S7.4 of FMVSS No. 105, which applies to passenger vehicles with GVWR greater than 3,500 kilograms. Since AEB capability relies upon the function of the service brakes on a vehicle, it is reasonable and logical that the same pre-test conditioning procedures that apply to service brake performance evaluations should also apply to AEB system performance evaluations.

Comments

In comments, MEMA, Volkswagen, Porsche, and Bosch suggest that the agency adopt the pre-test conditioning process from UNECE Regulation No. 152 in that the vehicle can undergo a series of brake activations to burnish the brake system.

Agency Response

In response, NHTSA agrees with commenters that properly burnishing the brake system is important, but NHTSA does not believe that it must adopt this aspect of UNECE Regulation No. 152 to accomplish that. NHTSA believes that the proposed brake burnishing procedures that are consistent with both FMVSS No. 135 and FMVSS No. 105 properly burnish the brake system, depending on the test vehicle's GVWR. Additionally, commenters did not provide NHTSA with any evidence that the brake burnishing procedures the agency proposed are improper for burnishing brakes or are otherwise unacceptable for any reason. NHTSA is not adopting the changes and will adopt the provisions proposed in the NPRM without change.

Brake Temperature

This final rule adopts the proposed specification that the subject vehicle service brakes be maintained at an average temperature between 65°C (149°F) and 100°C (212°F) measured as an average of the brakes on the hottest axle. This temperature range, which is the same as the range specified in FMVSS No. 135, is important for consistent brake performance and test repeatability.

Comments

In comments, MEMA, Volkswagen, Porsche, and Bosch suggest that NHTSA adopt the pre-test conditioning process from UNECE Regulation No. 152, specifically, that the average temperature of the service brakes on the hottest axle should be between 65-100 degrees C prior to each test run. Zoox also recommends that the hottest axle on the service brakes should be between 65-100 degrees C prior to testing, and that the agency should use FMVSS No. 135 as a guide for warming the vehicle brakes.

Agency Response

In response, NHTSA points out that the commenters refer to initial brake temperatures tested according to the procedure in FMVSS No. 135, and appear to be supporting NHTSA's proposed provisions notwithstanding reference to UNECE Regulation No. 152. The procedure in FMVSS No. 135 more rigorously specifies how and where temperature is measured than the equivalent in UNECE Regulation No. 152. NHTSA concurs and is adopting the provisions as proposed in the NPRM

User Adjustable Settings

This final rule adopts the proposed specification that NHTSA may test user adjustable settings such as engine braking, regenerative braking, and those associated with FCW, at any available setting state. Furthermore, adaptive and traditional cruise control may be used in any selectable setting during testing. The agency may test vehicles with any cruise control or adaptive cruise control setting to make sure that these systems do not disrupt the ability of the AEB system to stop the vehicle in crash imminent situations. However, for vehicles that have an ESC off switch, NHTSA will keep ESC engaged for the duration of the test.

Comments

In its comments, HATCI stated that NHTSA should test the vehicles using the default settings to represent real-world driving conditions because HATCI's research indicates that consumers do not typically change the settings. Bosch commented that the regenerative brakes add too much variability to the vehicle performance. Therefore, Bosch stated that the regenerative braking feature of a car, if equipped with one, should be overridden for the duration of AEB testing. AAA expressed concern that the proposal to allow vehicle testing with any cruise control setting would introduce too many variables into the testing scenario. AAA recommended the agency test all vehicles with the latest AEB setting and/or test all vehicles with and without the cruise control activated.

Agency Response

The purpose of the "any" user adjustable parameter is to ensure that driver-activated settings do not negatively impact AEB performance. NHTSA seeks to avoid a situation where use of a setting reduces the requisite performance of AEB when tested according to the parameters of S7, S8, and S9. NHTSA also sought to incorporate the word "any" into the standard to make clear that NHTSA has wide latitude to adjust the settings in a compliance test, in accordance with 49 CFR 571.4. That section states: "The word *any,* used in connection with a range of values or set of items in the requirements, conditions, and procedures of the standards or regulations in this chapter, means generally the totality of the items or values, any one of which may be selected by the Administration for testing, except where clearly specified otherwise."

NHTSA did not receive any comments indicating that the agency's approach to ensure AEB performance would be problematic. Vehicle manufacturers will have to assure that their designs do not negative affect the performance of AEB and may have more of a certification burden to assure such performance. The burden is reasonable, though, to assure that AEB systems work properly when other systems are engaged. Therefore, the agency is adopting the provisions proposed in the NPRM without change.

Loading

This final rule adopts the proposed specification that NHTSA will load the subject vehicle with not more than 277 kg (611 lbs.), which includes the sum of any vehicle occupants and any test equipment and instrumentation. The agency proposed this specification for load because tests of the fully loaded vehicles are already required and conducted under exiting FMVSSs, such as FMVSS No. 135, "Light vehicle brake systems," to measure the maximum brake capacity of a vehicle.

Comments

NHTSA received comments from MEMA and ASC recommending that the agency harmonize with procedures of UNECE R151 and R152, and Euro NCAP. Those procedures specify a maximum load of 200 kg.

Agency Response

In response, NHTSA declines to adopt the suggested change. NHTSA derives the subject vehicle load of 277 kg (611 lbs.) from agency testing, which uses the provision in NHTSA's NCAP test procedures. Most, if not all, vehicle manufacturers are familiar with NCAP's procedures and have designed their vehicles in accordance with them. As explained in the NPRM, the stopping performance of a fully loaded vehicle is already assessed under FMVSS No. 135. Commenters supporting the UN Regulations maximum load of 200 kg gave little technical support or rationale as to why that maximum load was preferred to the 277 kg proposed load. It is not apparent to NHTSA whether or the degree to which the 77 kg difference would change the test results. Therefore, given the information available to the agency, NHTSA is adopting the proposal.

L. Vehicle Test Device

This final rule adopts specifications for a VTD to be used for compliance testing for the lead vehicle requirements. The GVT is a full-sized harmonized surrogate vehicle developed to test crash avoidance systems. To ensure repeatable and reproducible testing that reflects how a subject vehicle would be expected to respond to an actual vehicle in the real world, the VTD specified in this final rule will be used as a lead vehicle, pass through vehicle, and obstructing vehicle during testing. This final rule adopts all the specifications in the NPRM.

This final rule specifies that the vehicle test device is based on certain specifications defined in ISO 19206-3:2021, "Road vehicles-Test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions – Part 3: Requirements for passenger vehicle 3D targets."[156] The vehicle test device is a tool that NHTSA will use in compliance tests to measure the performance of AEB systems required by FMVSS No. 127.

1. General Description

In the NPRM, NHTSA provided background on the agency's purpose and rationale for proposing the VTD.[157] The VTD provides a sensor representation of a passenger motor vehicle. The rear view of the vehicle test device contains representations of the vehicle silhouette, a rear window, a high-mounted stop lamp, two taillamps, a rear license plate, two rear reflex reflectors, and two tires.

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[156] https://www.iso.org/standard/70133.html. May 2021.
[157] 88 FR 38632 at 38705.

NHTSA received several comments on the proposed test device, all of which were generally supportive. Bosch, AAA, Rivian, the Alliance, and Ford all generally supported use of the proposed GVT across all AEB systems. AAA stated that the GVT is easy to use and provides versatility that allows for the evaluation of many realistic vehicle interaction. Rivian recommended NHTSA align the GVT device with the device used by Euro NCAP.

Forensic Rock, on the other hand, recommends higher speed targets that can withstand high closing speed tests with minimal damage to the vehicles. In response, NHTSA will continuously monitor the development of AEB technologies and test devices associated with system performance. If a need arises for new test devices, NHTSA can assess and respond to the situation at that time.

2. Definitions

The proposal defined a "vehicle test device" as a test device that simulates a passenger vehicle for the purpose of testing AEB system performance and defined a vehicle test device carrier as a movable platform on which a lead vehicle test device may be attached during compliance testing.

Bosch recommended the definition of "vehicle test device" be changed to "a test device with the appearance and radar characteristics that, together with the vehicle test device carrier, simulates a passenger vehicle for the purpose of testing automatic emergency brake system performance."

In response, NHTSA has considered the difference in the proposed definition for the "vehicle test device" and the definition suggested by Bosch and believes there to be no utility difference. The definition suggested by Bosch contains two areas of distinction from that of the proposed rule. First, Bosch suggested adding the phrase "with the appearance and radar characteristics." While the specifications contain appearance and radar characteristics, such details are not needed within the definition to fulfill the purpose of a definition, which is to provide clarity as to what items are included and excluded from the term. The agency has decided to keep the definition broad and specify the technical details in the body of the regulation.

Second, the definition suggested by Bosch provides that only the combination of the vehicle test device and the vehicle test device carrier represent a passenger vehicle. While the specifications provide details of the carrier device, those details are minimal and are primarily designed to minimize the carrier's appearances. One limitation of Bosch's suggestion would be that only the combination of the vehicle test device and the carrier would be usable for testing at a definition level. Not all tests require movement of the vehicle test device and as such, these tests could be conducted without a carrier (provided that the vehicle test device meet the specifications without the carrier). Considering that the appearance of the carrier is to be minimal, such flexibility of testing provides advantages for compliance testing. Accordingly, the agency is finalizing the definition of vehicle test device as proposed in the NPRM.

3. Sideview Specification

NHTSA proposed to establish specifications applicable to only the rear-end of the vehicle test device. The proposal sought comment on whether the specifications for the vehicle test device should include sides of the vehicle, as well as the rear-end, and proposed potentially including the specifications from ISO 19206-3:2021.

Comments

Advocates, MEMA, ZF, and Bosch all support specification of sideview, so the AEB can address cross traffic in the future. MEMA and ZF also recommend angled rear view (30 degrees, for example) representing a vehicle making a right-hand turn. Advocates suggested that any shortcomings established with specifications of rear view should also be addressed by NHTSA for side view. Bosch stated that for test cases in which the sides of the vehicle are within the signal detection of the radars and/or sensors, the sides need to be included.

Agency Response

In response, NHTSA is not adopting turning scenarios or other scenarios where the side of the vehicle test device is critical to the outcome of the test. All lead vehicle scenarios, with the single exception of the false activation pass-through test, align the subject vehicle with the vehicle test device longitudinally along each centerline. Similar to the pass-through test, the obstructed pedestrian test that utilizes the vehicle test device aligns the subject vehicle with vehicle test device longitudinally, with offsetting centerlines. Thus, no tests finalized in this final rule are dependent on the side view characteristics of the vehicle test device. If, in the future, tests are added that include side view interactions, the agency will consider additional specifications to the vehicle test device. For this final rule, the agency has finalized the rear-view characteristics only and has not added any view characteristics other than 180 degrees.

4. Field Verification Procedure

The NPRM did not specify in-the-field verifications be performed to assess whether the radar cross section falls within the acceptability corridor throughout the life of the device. NHTSA sought comment regarding the adoption of the optional field verification procedure provided in ISO 19206-3:2021, Annex E, Section E.3.

Comments

Bosch commented in support of the utilization of the optimal field verification procedure provided in ISO 19206-3:2021, Annex E, Section E.3, and further suggests the inclusion of suitable parts of the Annex C.

Agency Response

In response, the field verification procedure is not included in this final rule. NHTSA testing has shown that the radar cross section of a new GVT and a "used" GVT manufactured by at least one company fall consistently within the specified corridor incorporated by reference from ISO 19206-3:2021.[158] The field verification procedure alone does not fully demonstrate that the vehicle test device is within the specifications outlined in this rule. Accordingly, while the agency may informally use the field verification test to provide a general indication of the state of the vehicle test device, such a procedure is not appropriate for the test procedure.

5. Dimensional Specification

NHTSA proposed that the rear silhouette and the rear window be symmetrical about a shared vertical centerline and that representations of the taillamps, rear reflex reflectors, and tires also be symmetrical about the surrogate's centerline. Further, the license plate representation was proposed to have a width of 300 ± 15 mm and a height of 150 ± 15 mm, and be mounted with a license plate holder angle within the range described in 49 CFR 571.108, S6.6.3.1. Lastly, NHTSA proposed that the VTD representations be located within the minimum and maximum measurement values specified in columns 3 and 4 of Table A.4 of ISO 19206-3:2021 Annex A. The tire representations are to be located within the minimum and maximum measurement values specified in columns 3 and 4 of Table A.3 of ISO 19206-3:2021 Annex A. Additional clarification of terms was included in the NPRM stating that "rear light" means "taillamp," "retroreflector" means "reflex reflector," and "high centre taillight" means "high-mounted stop lamp."

Comments

In their comments, Ford, Porsche, and FCA all agree with NHTSA that the vehicle test device should be based on specifications defined in ISO 19206-3:2021. AAA and Adasky, alternatively, suggests that NHTSA re-assess the proposed requirement to be consistent with subcompact and compact cars, given the increased popularity of larger crossovers, SUVs, and light-duty trucks. Adasky recommends that the influences of hood height and A-pillar be included in the vehicle test device property definition.

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[158] Assessing the Effect of Wear on Vehicle Test Device Radar Return Characteristics, available in the docket for this final rule (NHTSA-2023-0021).

Agency Response

In response, NHTSA has adopted the specification as proposed. Most commentors agreed with the use of ISO 19206-3:2021, which NHTSA proposed as appropriate in the NPRM. The agency does not have information to support adopting a change at this time. The agency would also point out that including the hood height and A pillar is unnecessary for front to rear crashes because they are not visible from the rear of the test device, which is the orientation for all tests.

6. Visual and Near Infrared Specification

NHTSA proposed that the vehicle test device rear representation colors be within the ranges specified in Tables B.2 and B.3 of ISO 19206-3:2021 Annex B. The proposal also specified that the infrared properties of the vehicle test device be within the ranges specified in Table B.1 of ISO 19206-3:2021 Annex B for wavelengths of 850 to 950 nm when measured according to the calibration and measurement setup specified in paragraph B.3 of ISO 19206-3:2021 Annex B. Lastly, NHTSA proposed that the rear reflex reflectors, and at least 50 cm^2 of the taillamp representations, of the vehicle test device be grade DOT-C2 reflective sheeting as specified in 49 CFR 571.108, S8.2.

NHTSA received no comments on this proposal. The agency has adopted the provision for the reasons provided in the NPRM.

7. Radar Reflectivity

NHTSA proposed that the radar cross section of the vehicle test device is to be measured while attached to the carrier (robotic platform). NHTSA also proposed that the radar reflectivity of the carrier platform be less than 0 dBm^2 for a viewing angle of 180 degrees at a distance of 5 to 100 m, when measured according to the radar measurement procedure specified in C.3 of ISO 19206-3:2021 Annex C for fixed-angle scans. The proposal also stated that the rear bumper area, as shown in Table C.1 of ISO 19206-3:2021 Annex C, contributes to the target radar cross section. NHTSA proposed that the radar cross section be assessed using a radar sensor that operates at 76 to 81 GHz and has a range of at least 5 to 100 m, a range gate length smaller than 0.6 m, a horizontal field of view of 10 degrees or more (-3dB amplitude limit), and an elevation field of view of 5 degrees or more (-3dB amplitude). The proposal stated that a minimum of 92 percent of the filtered data points of the surrogate radar cross section for the fixed vehicle angle, variable range measurements be within the radar cross section boundaries defined in SectionC.2.2.4 of ISO 19206-3:2021 Annex C for a viewing angle of 180 degrees when measured according to the radar measurement procedure specified in C.3 of ISO 19206-3:2021 Annex C for fixed-angle scans. Lastly, the proposed rule stated that between 86 to 95 percent of the vehicle test device spatial radar cross section reflective power be within the primary reflection region defined in Section C.2.2.5 of ISO 19206-3:2021 Annex C, when measured according to the radar measurement procedure specified in Section C.3 of ISO 19206-3:2021 Annex C using the angle-penetration method.

Comments

In their comments, ZF and ASC both consider the tolerance of +/- 10dBm^2 to be quite high. ZF noted that information derived might be misleading (e.g., object classification). In addition, ZF, ASC, Mobileye, and MEMA recommend including acceptable Radar Cross Section (RCS) ranges for the rear and the side of the VTD. While ZF, ASC, and MEMA suggest using the same RCS corridor values as specified in ISO 19206-3:2021, Mobileye suggests setting the bars at the lower RCS values (e.g., -10dBsm for VRU, 0dBsm or below for motorcycle). Mobileye also suggests including lateral edge errors as critical metrics because identifying the lateral edges of the object lowers risk of false association with camera or other sensors. Bosch recommends amending the radar reflectivity specifications because, “The radar reflectivity of the carrier platform alone is less than 0 dBm^2 for a viewing angle of 180 degrees and over a range of 5 to 100 m when measured according to the radar measurement procedure specified in Section C.3 of ISO 19206-3:2021 Annex C for fixed-angle scans.”

Agency Response

The agency disagrees with the suggested revision to the radar reflectivity for the carrier, as the carrier radar characteristics are important when attached to the VTD, not the carrier by itself for the purposes of testing AEB. Testing the carrier alone fails to take into account the actual interface between the VTD and the carrier system.

Regarding the RCS range, the agency believes that both values are needed to set appropriate bounds of what is acceptable RCS for the VTD to match real world vehicles. The vehicle tests using two different sensors documented in the ISO 19206-3:2021 Figure C.17 and C.18 show that the vehicles tested varied within +/- 10dBm^2. Thus, permitting the vehicle test device to vary within this tolerance provides real-world application for the various vehicles on the road. In addition, lateral error tolerances are included in the test set-up specifications.

NHTSA is not adding turning scenarios to this proposal, and therefore the agency believes that side presentation specifications are not needed. NHTSA is finalizing the radar reflectivity specifications for the vehicle test device as proposed in the NPRM.

8. List of Actual Vehicles

In addition to the vehicle test device specifications, NHTSA sought comment on specifying a set of real vehicles to be used as vehicle test devices in AEB testing. NHTSA also sought comment on the utility and feasibility of safely conducting AEB tests with real vehicles, such as through removing humans from test vehicles and automating scenario execution, and how laboratories would adjust testing costs to factor in the risk of damaged vehicles. Additionally, NHTSA sought comments on the merits and potential need for testing using real vehicles, in addition to using a vehicle test device, as well as challenges, limitations, and incremental costs of such.

Comments

Advocates and Bosch both generally support the development of a list of possible real vehicles that could be used for testing in addition to the GVT. While Bosch suggests that NHTSA reference the relevant parts of ISO 19206-3:2021 if using a set of real vehicles, Advocates recommend that NHTSA consider the most frequently registered vehicles in the US over some lookback period with an established timeline.

In contrast, Rivian, Alliance, ASC, ZF, and MEMA all oppose using real vehicles. ZF, MEMA, and ASC state high cost and risk of injury to human subjects in performing high-speed AEB tests. ASC and ZF added that the advantages of testing with real vehicles compared to soft vehicle targets is not clear. Furthermore, ZF and MEMA mention that the tests that involve a soft target could serve as a real vehicle test if combined with documentation provided by the OEM.

The Alliance notes test repeatability and reproducibility challenges due to potential differences in vehicles selected for testing and that repairs may be expensive and time-consuming if contact occurs. It also notes that the current GVT is correlated to real world vehicles through collaborative global government/industry testing and verification. Rivian stated that using representative test devices, as opposed to real vehicles, reduces test burdens on manufacturers and poses lesser risk of injury if AEB fails to avoid a crash during the test procedure. ASC and ZF believe that vehicles with AEB systems should be able to detect a wide range of vehicles and suggests that if NHTSA decides to develop its own, more US-fleet representative GVT target, then it should be compliant with the ISO standard.

Agency Response

NHTSA agrees that the VTD specifications provide sufficient flexibility in appearance that creating a list of vehicles for testing is not likely to increase the safety impacts of the rule. NHTSA also agrees that there are concerns over the cost of testing with real vehicles, and, that there are potential safety risks to test operators. NHTSA believes that the GVT is representative of a genuine vehicle,[159] and does not believe that the increased costs of adding a documentation requirement for manufacturers to show this is warranted at this time. Accordingly, the agency is not adopting a list of real vehicles for testing at this time.

M. Pedestrian Test Devices

This final rule adopts specifications for two pedestrian test devices to be used for compliance testing for the PAEB requirements. The two pedestrian test devices each consist of a test mannequin and a motion apparatus (carrier system) that positions the test mannequin during a test. NHTSA's specifications for pedestrian test mannequins represent a 50th percentile adult male and a 6- to 7-year-old child. NHTSA has incorporated by reference specifications from three ISO standards.

1. General Description

The Adult Pedestrian Test Mannequin (APTM) provides a sensor representation of a 50th percentile adult male and consists of a head, torso, two arms and hands, and two legs and feet. The Child Pedestrian Test Mannequin (CPTM) provides a sensor representation of a 6- to 7-year-old child and consists of a head, torso, two arms and hands, and two legs and feet. The arms of both test mannequins are posable but will not move during testing. The legs of the test mannequins will articulate and will be synchronized to the forward motion of the mannequin.

In the NPRM, NHTSA provided background on the agency's purpose and rationale for proposing the test devices and the history of the devices and their use,[160] including previous NHTSA *Federal Register* notices that have solicited input from the public on test procedures that

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[159] Overall, the AEB system sensors interpret the SSV appears to sensors as a genuine vehicle. Nearly all vehicle manufacturers and many suppliers have assessed how the SSV appears to the sensors used for their AEB systems. The results of these scans have been very favorable. 80 FR 68615, NCAP RFC, Docket No. NHTSA–2015–0006.
[160] 88 FR at 38702.

include the use of these pedestrian test devices either in current or past form (i.e., articulated vs. non-articulated legs).

NHTSA received many comments on the proposal, all of which were generally supportive. Commenters generally supported the use of the ISO 19206-2:2018 mannequins as these are already validated and readily available. SAE noted that its mannequin prototypes had limited testing in the test track and deferred to NHTSA's understanding of the new standard to know which pedestrian mannequin would be most appropriate for the regulation. The commenters also supported harmonizing with international standards, such as UNECE Regulation No. 152, as a baseline for mannequin specifications, and with ISO 19206-2:2018 regarding the PAEB mannequins.

In response, NHTSA is adopting the relevant parts of ISO 19206-2:2018 and ISO 19206-4:2020, as specified in the NPRM. ISO 19206 has a larger body of research testing to support its test devices than SAE J3116, and using ISO 19206 is consistent with international standards like UNECE Regulation No. 152.

For the mannequin carrier system, Bosch suggested adoption of the ISO 19206-7 specifications and test hardware to specify the carrier system used to move the pedestrian test mannequin. Bosch further recommended revising the definitions of the adult and child mannequins to refer to the carrier systems. NHTSA is declining to make these changes. Because ISO 19206-7 is still in draft form, NHTSA believes it is premature to consider it for adoption. Regarding the carrier system, it is a modular system designed to move the child and adult test mannequins. As such, NHTSA believes that the definition of the carrier system should lie outside the definition of either mannequin. It is also more appropriate to specify how the carrier system can affect sensor representations of the mannequins, rather than specify it as part of a mannequin.

The American Foundation for Blind (AFB) recommended NHTSA use the most inclusive and effective mannequins that will reduce road injuries and deaths among people with disabilities, including women, adults with short stature, and cyclists. Some commenters suggest that NHTSA use pedestrian test mannequins using mobility assistive devices, such as wheelchairs (motorized and non-motorized), walkers, motorized scooters, or canes.

In response, NHTSA is interested in additional pedestrian test devices outside of the child and adult pedestrian test mannequins, including those that reflect the broad diversity among the American public. At this time, however, there is a need for more development, research, and testing for pedestrian test mannequins that are using mobility assistive devices. NHTSA intends to monitor the progress of these devices as they are developed and standardized, for possible inclusion in the standard at a future date.

2. Dimensions and Posture

The APTM and the CPTM have basic body dimensions and proportions specified in ISO 19206-2:2018. All commenters responding to the proposed dimensions agreed with the proposal. The agency is adopting the proposal for the reasons provided in the NPRM.

A number of commenters responded to NHTSA's question asking whether use of the 50^{th} percentile adult male test mannequin would ensure PAEB systems will react to small adult females and other pedestrians other than mid-size adult males. Consumer Reports (CR) supported NHTSA's proposal to use a pedestrian test mannequin representing a 50^{th}-percentile adult male and one representing a six- to seven-year-old child, stating it is critical to use both mannequins in PAEB testing to account for a range of human proportions. The commenter believed it is especially important to use the child mannequin to provide adequate protection for children and other shorter individuals, particularly from impacts involving large vehicles that have tall hoods or that otherwise have limited frontal visibility.

Several commenters (Advocates, AARP, ZF, Consumer Reports, and MEMA) suggested including an adult female mannequin and the child mannequin in all tests. NHTSA is unaware of any standards providing specifications for a 5^{th} percentile adult female test mannequin, or of any consumer information programs testing with such a device.

The Alliance stated that the proposed child and adult test devices should provide a reasonable assessment across a broad spectrum of occupant sizes.[161] AAA recommended not including the child test mannequin for all testing scenarios, as this would increase testing burdens. AAA suggested that, as an alternative, NHTSA could test some scenarios with the smaller SAE pedestrian test mannequin.

After reviewing the comments, NHTSA is satisfied that the currently proposed pedestrian test mannequins provide a reasonable representation of the pedestrian crash population for purposes of issuing this final rule. In its comment to the NPRM, IIHS stated that evidence does not demonstrate that current PAEB systems are tuned only to the adult male mannequin. This rulemaking does not expand the mannequins used in new FMVSS No. 127, or expand how the child dummy is used, because NHTSA does not have the body of research necessary to support such changes for this final rule.

FCA noted that there are no dimensional tolerances on the pedestrian test device. In response, NHTSA's testing has not shown an issue with the dimensions specified in the NPRM. Further, the locational bounds of the pedestrian test mannequin are specified in the individual test scenarios. Thus, the agency is not adopting additional tolerances on the dimensional specification of the pedestrian test mannequins. SAE responded to NHTSA's comment on shoe height, stating that the overall mannequin height on the sled is representative of the overall height of real pedestrians with shoes.

3. Visual Properties

The mannequins will have specified features for the depictions of hair, skin tone, clothing, and the like. The features are specified in the ISO standards incorporated by reference into FMVSS No. 127 by this final rule. The incorporated ISO standards provide needed

[161] The Alliance supported using a child test mannequin in daytime scenarios only, and not also in the nighttime scenario. NHTSA discussed this comment in separate section.

specifications for these features, but they also allow NHTSA to harmonize with specifications for test mannequins in use by Euro NCAP.

Because specifications for test mannequin skin color are not found in ISO 19206-2:2018, NHTSA is incorporating by reference the bicyclist mannequin specifications for color and reflectivity found in ISO 19206-4:2020, "Road vehicles – test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions—Part 4: Requirements for bicyclists targets." Although this standard provides requirements for bicyclist test devices, NHTSA is referencing it for color and reflectivity for the prescribed adult and child test mannequins because the specifications are workable for use with the ISO standard for pedestrian test devices. NHTSA is specifying that the test mannequins be of a color that matches a specified range of skin colors representative of very dark to very light complexions. The mannequins must also have standardized properties that represent hair, facial skin, hands, and other features, and must have a standardized long-sleeve black shirt, blue long pants, and black shoes.

Commenters (AARP, Safe Kids Worldwide (SKW), Safe Kids in Autonomous Vehicles Alliance (SKAVA), Luminar, and private citizens) supported NHTSA's effort to ensure PAEB detect pedestrians of all skin colors. The agency agrees with the commentors that sensors should detect skin tones other than light skin tones.

Luminar did not support the white face, black shirt, and blue pants on mannequins. While NHTSA understands that the commenter would like to see testing outside of the specifications identified in the NPRM, the agency does not have the body of knowledge necessary to objectively specify clothing outside of the black shirt and blue pants. Furthermore, commenters did not provide data demonstrating that current PAEB systems do not already detect a wide array of skin tones. The proposal includes a range of colors (based on ISO 19206-4_2020 standard) for skin, face, and hands. NHTSA encourages manufacturers to consider designing their systems to detect all pedestrians, including those wearing various clothing colors.

4. Radar Properties

The radar reflectivity characteristics of the pedestrian test device approximates that of a pedestrian of the same size when approached from the side or from behind. Radar cross section measurements of the pedestrian test mannequins must fall within the upper and lower boundaries shown in Annex B, section B.3, figure B.6 of ISO 19206-2:2018 when tested in accordance with the measure procedure in Annex C, section C.3 of ISO 19206-2:2018.

In response to Bosch, this final rule adopts the newer ISO 19206-3:2021 instead of ISO 19206-2:2018 in determining the upper and lower boundaries for an object for radar cross-section measurements. The proposed procedure in Annex C, section C.3 of ISO 19206-2:2018 is specific for pedestrian targets; however, recent testing performed by the agency indicates that the three position measurement specified in Annex C, section C.3 of ISO 19206-3:2021 provides more reduction in multi-path reflections and offers more accurate radar cross section values. This testing confirms the recommendation from Bosch to adopt the measurement procedure in Annex C, section C.3 of ISO 19206-3:2021. Therefore, the agency is adopting the new version of the ISO standard.

5. Articulation Properties

This final rule adopts the proposal that the legs of the pedestrian test device be in accordance with, and as described in, Annex D, section D.2 and illustrated in Figures D.1, D.2, and D.3 of ISO 19206-2:2018. For the test scenarios involving a moving pedestrian, the legs of the pedestrian test mannequin will articulate to simulate a walking motion. A test mannequin that has leg articulation when in motion more realistically represents an actual walking or running pedestrian. For test scenarios involving a stationary pedestrian, the legs of the pedestrian test mannequin remain at rest (i.e., simulate a standing posture).

Commenters to this issue supported the pedestrian test mannequin with articulation characteristics. The Alliance agreed that mannequins equipped with articulate moving legs are more representative of actual pedestrians than mannequins with stationary legs. While agreeing with the NPRM, Aptiv noted that even when people are standing next to a road, they move in some way (e.g., body micro-movement) and so NHTSA may want to add some upper body movement to the stationary pedestrian test mannequin. Porsche supported the adoption of articulated dummies, explaining that the articulated motion is required because of the "micro doppler" effect, which is an important consideration for radar sensors.

NHTSA has adopted the proposal for the articulation properties of the legs. The agency is not adding pedestrian micro-movement to the articulation requirements as there are currently no consensus standards available for pedestrian micro-movement and NHTSA does not testing experience with mannequins of that type.

6. Comments on Thermal Characteristics

In addition to the characteristics specified in the proposal presented in the NPRM, NHTSA requested comments on whether test mannequins should have thermal characteristics. Several commenters[162] responding to the NPRM discussed the merits of thermal characteristics in the pedestrian test mannequins. Owl AI and Teledyne explained that thermal imaging can capture infrared radiation emitted by pedestrians in the 8-14μm (long wave) band, which allows for pedestrians to be easily distinguished from other objects. AAA supported inclusion of thermal specifications, especially for nighttime testing.

NHTSA currently does not have the body of research necessary to develop test protocols that support the inclusion of thermally active pedestrian test mannequins but concurs this matter may be a topic for future consideration. NHTSA will continue to monitor the development of thermally active pedestrian test mannequins so that the agency can explore their use in the future.

[162] Commenters included Advocates, Adasky, Owl AI, Teledyne, and AAA.

N. Miscellaneous Topics

Advocates, ZF, AAA, Rivian, Volkswagen, AARP, the National Associations of Mutual Insurance Companies, and ASC suggested a requirement that vehicle manufacturers provide information in owners' manuals and elsewhere describing how the AEB system works, and its capabilities and its limitations. SEMA suggested a requirement that specific information such as diagnostic codes and calibration information be shared with consumers, MEMA suggested web links to information, and NADA suggested using a QR code on the Monroney label. SEMA also requested that NHTSA provide a system of information about AEB to aftermarket suppliers.

In contrast, the Alliance and Hyundai opposed new information requirements about AEB, suggesting that information is already provided in the absence of a regulation. Additionally, the Alliance stated it is unaware of the safety impacts of providing AEB information to consumers.

This final rule has not adopted additional information requirements. The agency concludes that the primary safety impacts from AEB is the functionality itself. While information regarding the capabilities and limitations of the AEB system may be generally useful, AEB as required by this rule is a last second intervention system. Thus, a driver's basic driving technique should not change based on the capabilities or even the existence of AEB (aside from heeding the warning of the malfunction indicator to attend to a problem with the AEB system).

FCA believed that the proposed requirements overly focus performance on the vehicle's braking system and not on the output of the sensing and perception capacity of the AEB system. FCA further stated that it could be possible to focus the regulatory requirement solely onto the AEB system (i.e., the sensors and perception system) by defining a perception mandate for output signals for time to warn or the BRAKE! Command. FCA further asserted that this output could be derived from fleet averages, equations of motion, and that as vehicle performance improves, the timing could be revised accordingly.

In response, NHTSA declines FCA's suggestion to directly regulate the sensing and perception systems directly instead of the ability of the entire system to avoid crashes. This

FMVSS is created with important safety goals in mind to address significant safety problems that this technology can resolve. For this rule, the safety problems are rear-end crashes and crashes involving pedestrians struck by the front of a vehicle. The performance requirements (avoiding contact with a lead vehicle and pedestrian) address this safety problem in an effective and expeditious manner. They are solidly supported and informed by data from years of agency and industry research, the voluntary commitment and NCAP, substantial collaborative work between entities, and NHTSA's close monitoring of AEB development and maturation. A new approach specifying a particular time to collision based on the information from the perception system is not supported by the current stated of knowledge and would take years to research and develop.

FCA commented that NHTSA did not provide a baseline or compliance assessment of the front lighting equipment installed in the research vehicles, so manufacturers are unaware of the performance level of the lighting relative to the FMVSS No. 108 range. For example, the vehicles may have been equipped with optional lighting packages within the product lineup, which may have enhanced performance. FCA also noted that lighting was not included in the technical assessment or economic analysis in the proposal. FCA expressed that NHTSA should have knowledge regarding the high cost of modern lighting systems and importantly, how much lead time would be needed to develop them, and that performance requirements should not prohibit otherwise compliant lighting systems. Finally, it stated that if improved lighting is mandatory for AEB nighttime performance objectives, FMVSS No. 108 should be reconfigured in a separate rulemaking.

In response, NHTSA's performance-oriented approach in this final rule directly addresses the safety problem while providing manufacturers the most flexibility in designing vehicles to meet FMVSS No. 127. Improved lighting is not a requisite of the final rule. A manufacturer may choose to create a robust perception system that initiates braking sooner, have a lesser performing perception system and equip the vehicle with robust brakes, have a high performing headlighting system to help achieve the performance required, or implement another means of meeting the standard. Because FMVSS No. 127 is a performance standard, manufacturers decide what countermeasures makes the most sense for them to meet the standard, and the marketplace can continue to drive innovation while achieving positive safety outcomes.

O. Effective Date and Phase-In Schedule

NHTSA proposed that all requirements be phased in within four years of publication of a final rule. Under the proposal, all AEB-equipped vehicles would be required to meet all requirements associated with lead vehicle AEB within three years. NHTSA also proposed that all PAEB-equipped vehicles would be required to meet all daylight test requirements for PAEB within three years. For PAEB performance in darkness, NHTSA proposed lower maximum test speed thresholds that would have to be met within three years for some specified test procedures. Under the proposal, all vehicles would be required to meet the minimum performance requirements with higher darkness test speeds four years after the publication of a final rule. Small-volume manufacturers, final-stage manufacturers, and alterers would be provided an additional year of lead time for all requirements.

NHTSA requested comments on the proposed lead time for meeting the proposed requirements, and how the lead time can be structured to maximize the benefits that can be realized most quickly while ensuring that the standard is practicable.

Comments

In general, manufacturers, suppliers, and industry advocacy groups asserted that more time is needed to meet the performance requirements in the NPRM. In contrast, safety advocates and municipalities requested that the proposed requirements be implemented sooner.

More specifically, the Alliance cited concerns over the practicability of no contact, the NPRM’s underestimation of the software and hardware changes needed to facilitate crash avoidance at higher speeds, and the complexity of addressing false positives all within a short lead time. They expressed that it cannot be known whether systems can achieve the proposed requirements through software upgrades until a comprehensive system review, analysis, and synthesis has been performed by manufacturers. Further, they expressed that the proposed timeline could disrupt vehicle developments already underway as it may require revisiting previous hardware and software design decisions and redesigning systems expected to impact or be impacted by the AEB/PAEB system. In addition, they stated that existing vehicle electrical architectures may not be capable of handling the additional or upgraded sensors, additional communication bandwidth and processing power to upgrade the vehicle ADAS system to the proposed level of performance.

The Alliance, Mitsubishi, Honda, and Nissan proposed a compliance date starting seven years or more after the issuance of a final rule for large volume manufacturers, and the Alliance suggested an additional four years for small volume manufacturers. The Alliance proposed an alternative compliance schedule that begins five years after the issuance of a final rule but noted that this would not address the outstanding technical issues and unintended consequences that they outlined in their comments.

Volkswagen and Porsche suggested a phased-in compliance process where a certain percentage of the fleet would be required to comply over a period of several years until 100 percent of the fleet was required to comply with the final rule. The Alliance and Nissan suggested that if the agency considered its proposal to harmonize with UNECE Regulation No. 152, compliance could occur sooner. Porsche and Volkswagen suggested that compliance with UNECE Regulation No. 152 could be considered for end-of-production lines or as part of a phase-in.

Bosch recommended a stepwise regulatory timeline, observing that speeds up to 60 km/h are achievable as proposed in the NPRM, but additional time would be necessary for testing at higher speeds. Mobileye suggested a similar approach.

Advocates stated that the agency should require a more aggressive schedule for compliance given the baseline inclusion of the components for AEB systems in new vehicles. In addition, Advocates stated that they oppose any further extension of the proposed compliance dates in the NPRM. The NTSB encouraged NHTSA to consider reducing the timeline for the rule's effective dates to expedite deployment as some manufacturers may be able to achieve some of the performance requirements immediately. Consumer Reports suggested that all requirements, other than darkness pedestrian avoidance requirements, be effective no later than one year after issuing a final rule. For darkness pedestrian avoidance requirements, Consumer Reports stated that NHTSA should set the compliance timeline at no more than two years after publication of a final rule. NAMIC and IIHS stated that, based on recent IIHS test data, manufacturers have made dramatic progress in PAEB programs in a short time, and recommended a one-year phase-in. Finally, NACTO, Richmond Ambulance Authority, DRIVE SMART Virginia, the city of Philadelphia, the city of Houston, and the Nashville DOT recommended that NHTSA have the higher speed pedestrian avoidance tests in dark conditions required on the same timeline as the daytime scenarios.

Agency Response

The agency finds the arguments for additional lead time compelling. For the reasons discussed below, this final rule requires that manufacturers comply with all provisions of this final rule at the end of the five-year period starting the first September 1 after this publication, or September 1, 2029. Most vehicles sold today do not meet all of the requirements set forth in this final rule, and many may not be easily made compliant with all of the requirements established in this final rule. While NHTSA recognizes the urgency of the safety problem, NHTSA also recognizes that the requirements of this final rule are technology-forcing. The agency believes that the requirements are crucial in ensuring the safety in the long run, but we are extending the schedule to avoid significantly increasing the costs of this rule by requiring that manufacturers conduct expensive equipment redesigns outside of the normal product cycle. Because of the normal product development cycle, it is likely that there will be significant market penetration of complying systems as they are developed prior to the effective date of this rule.

While some commenters suggested that the proposed lead time is practicable if the agency reduced the stringency of this final rule's requirements, such an approach would result in a substantial decrease in the expected benefits of this rule in the long run. A lead time of five years provides manufacturers with the ability to fully integrate the AEB system into vehicles in line with the typical design cycle in many cases. Such a process permits manufacturers to fully design systems that minimize the false activations that industry has expressed concern about, yet still provide the level of performance required by this rule. NHTSA believes a five-year lead time fully balances safety considerations, the capabilities of the technology, and the practical need to engineer systems that fully comply with this final rule.

Note that as discussed in the Regulatory Flexibility Act section of the document, NHTSA is giving certain small manufacturers and alterers an additional year of lead time to comply with this rule.

Safety Act

Under 49 U.S.C. 30111(d), a standard may not become effective before the 180th day after the standard is prescribed or later than one year after it is prescribed, unless NHTSA finds, for good cause shown, that a different effective date is in the public interest and publishes a reason for the finding. A 5-year compliance period is in the public interest because most vehicles will require upgrades of hardware or software to meet the requirements of this final rule. To require compliance with this standard outside of the normal development cycle would significantly increase the cost of the rule because vehicles cannot easily be made compliant with the requirements of this final rule outside of the normal vehicle design cycle.

IV. Summary of Estimated Effectiveness, Cost, and Benefits

The requirements specified in this final rule for Lead Vehicle AEB address rear-impact crashes. Between 2016 and 2019, an average of 1.12 million rear-impact crashes involving light vehicles occurred annually. These crashes resulted in an annual average of 394 fatalities, 142,611 non-fatal injuries, and approximately 1.69 million property-damage-only vehicles (PDOVs).

In specifying the requirements for Lead Vehicle AEB, the agency considered the number of fatalities and non-fatal injuries resulting from crashes that could potentially be prevented or mitigated given the current capabilities of this technology. As a result, the requirements specified for Lead Vehicle AEB consider the need to address this safety issue by ensuring that these systems have sufficient braking authority to generate speed reductions that can prevent or mitigate real-world crashes.

The requirements specified in the final rule for PAEB address crashes in which a light vehicle strikes a pedestrian. Between 2016 and 2019, an average of approximately 23,000 crashes that could potentially be addressed by PAEB occurred annually. These crashes resulted in an annual average of 2,642 fatalities and 17,689 non-fatal injuries.

In specifying the requirements for PAEB, the agency considered the number of fatalities and non-fatal injuries resulting from crashes that could potentially be prevented or mitigated given the current capabilities of this technology. As a result, the requirements specified for PAEB consider the need to address this safety issue by ensuring that these systems have sufficient braking authority to generate speed reductions that can prevent or mitigate real-world crashes with pedestrians.

The target population for the lead vehicle AEB analysis includes two-vehicle, rear-end light vehicle crashes and their resulting occupant fatalities and non-fatal injuries. FARS is used to obtain the target population for fatalities and CRSS is used to obtain the target population for property-damage-only crashes and occupant injuries. The target population includes two-vehicle light-vehicle to light-vehicle crashes in which the manner of collision is a rear-end crash and the first harmful event was a collision with a motor vehicle in transport. Further refinement includes limiting the analysis to crashes where the striking vehicle was traveling straight ahead prior to the collision at a speed less than 90.1 mph (145 km/h) and the struck vehicle was either stopped, moving, or decelerating.

Table 23: Light Vehicle to Light Vehicle Target Population

Light Vehicle to Light Vehicle Target Population	Crashes	PDOVs	Injuries						Fatalities
			MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	MAIS 1-5	
All Conditions	1,119,470	1,692,678	130,736	9,364	1,942	256	57	142,611	394

The target population for the PAEB analysis considered only light vehicle crashes that included a single vehicle and pedestrian in which the first injury-causing event was contact with a pedestrian. The area of initial impact was limited to the front of the vehicle, specified as clock points 11, 12, and 1, and the vehicle's pre-event movement was traveling in a straight line.

These crashes were then categorized as either the pedestrian crossing the vehicle path or along the vehicle path. The crashes are inclusive of all light, road surface, and weather conditions to capture potential crashes, fatalities, and injuries in real world conditions. Data elements listed as "unknown" were proportionally allocated, as needed.

Table 24: Target Population of Pedestrian Fatalities and Non-Fatal Injuries

Light Vehicle to Pedestrian Target Population	Injuries						Fatalities
	MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5	MAIS 1-5	
All Scenarios	13,894	3,335	1,541	300	75	19,511	2,508
Crossing Path	12,637	3,087	1,442	284	71	17,522	2,083
Along Path	1,257	248	98	16	4	1,622	425

A. Benefits

As a result of the requirements for Lead Vehicle AEB and PAEB specified in this final rule, we estimate that 362 fatalities and more than 24,000 non-fatal MAIS 1-5 injuries will be mitigated over the course of one vehicle model year's lifetime.

Table 25: Summary of Benefits: Estimated Quantified Benefits for Non-Fatal Injuries and Fatalities Mitigated

Injury Severity	Lead Vehicle AEB	PAEB	Total

MAIS 1	18,449	2,089	20,538
MAIS 2	2,575	401	2,976
MAIS 3	536	153	689
MAIS 4	71	23	94
MAIS 5	18	6	24
Total MAIS 1-5	21,649	2,672	24,321
Fatal	124	238	362

MAIS - Maximum Abbreviated Injury Scale

B. Costs

The agency estimated the incremental costs associated with this final rule, which has been adjusted from the estimates presented in the NPRM to include the costs associated with software and hardware improvements, compared to the baseline condition. Incremental costs reflect the difference in costs associated with all new light vehicles being equipped with AEB with no performance standard (the baseline condition) relative to all light vehicles being equipped with AEB that meets the performance requirements specified in this final rule.

As common radar and camera systems are used across Lead Vehicle AEB and PAEB systems, functionality can be achieved through upgraded software for most of the affected vehicles. Therefore, the agency accounts for the incremental cost associated with a software upgrade for all new light vehicles. Although the majority of new light vehicles would be able to achieve the minimum performance requirement without adding additional hardware to their current AEB systems, a small percentage would need to add either an additional camera or radar. Based on the prevalence of mono-camera systems in our test data and in NCAP reporting data, as well as a discussion with Bosch, this analysis estimated that approximately five percent of new light vehicles would require additional hardware.[163] Therefore, in addition to software costs, the

[163] Ex Parte Docket Memo and Presentation_Bosch, available at: https://www.regulations.gov/document/NHTSA-2023-0021-1058.

agency also accounts for the incremental cost for five percent of new light vehicles would add additional hardware (radar) to their existing AEB systems in order to meet the requirements specified in this final rule. Taking into account both software and hardware costs, the total annual cost associated with this final rule is approximately $354.06 million in 2020 dollars.

Table 26: Summary of Incremental Costs

Category	Percentage of New Light Vehicles Impacted	Total Annual Cost (Millions)
Software	100%	$282.20
Hardware	5%	$71.86
Total		**$354.06**

C. Net Impact

The Benefits associated with this final rule, which are measured in fatalities prevented and non-fatal injuries reduced, were converted into equivalent lives saved. Under this final rule, the cost per equivalent life saved ranges from $0.55 million and $0.68 million. Therefore, the final rule is considered to be cost-effective. To calculate net benefits, both measures must be represented in commeasurable units. Therefore, total benefits are translated into monetary value. When discounted at three and seven percent, the net benefits associated with the final rule are $7.26 billion and $5.82 billion, respectively. Furthermore, when discounted at three and seven percent, the benefit cost ratios associated with the final rule are 21.51 and 17.45, respectively. Therefore, this final rule is net beneficial. Overall, the agency's analyses indicate that society will be better off as a result of the final rule.

Table 27: Calculation of Monetized Benefits

MAIS Level	Non-Fatal Injuries and Fatalities Mitigated	Comprehensive Cost of Injuries	Monetized Benefits (Billions)
MAIS 1	20,538	$66,071	$1.36
MAIS 2	2,976	$504,776	$1.50
MAIS 3	689	$2,172,806	$1.50

MAIS 4	94	$3,825,873	$0.36
MAIS 5	24	$6,414,626	$0.15
Fatal	362	$11,937,313	$4.32
Total			**$9.19**

Note: Values may not sum due to rounding.

Table 28: Discounted Monetized Benefits (Billions)

Monetized Benefits	Discount Rate		Discounted Monetized Benefits
$9.19	3%	0.8285	$7.61
	7%	0.6721	$6.18

Table 29: Summary of Net Benefits (Millions)

Total Cost	Monetized Benefits		Net Benefits	
	3%	7%	3%	7%
$354.06	$7,614.86	$6,177.36	$7,260.80	$5,823.31

V. Regulatory Notices and Analyses

Executive Orders 12866, 13563, and 14094 and DOT Regulatory Policies and Procedures

The agency has considered the impact of this rulemaking action under Executive Order (E.O.) 12866, E.O. 13563, E.O. 14094, and the Department of Transportation's regulatory procedures. This rulemaking is considered “(3)(f)(1) significant” and was reviewed by the Office of Management and Budget under E.O. 12866, “Regulatory Planning and Review,” as amended by E.O. 14094, "Modernizing Regulatory Review." It is expected to have an annual effect on the economy of $200 million or more. NHTSA has prepared a regulatory impact analysis that assesses the cost and benefits of this rule, which has been included in the docket listed at the beginning of this rule. The benefits, costs, and other impacts of this rule are summarized in the final regulatory impact analysis.

Regulatory Flexibility Act

The Regulatory Flexibility Act of 1980, as amended, requires agencies to evaluate the potential effects of their proposed and final rules on small businesses, small organizations, and small governmental jurisdictions. The Small Business Administration's regulations at 13 CFR part 121 define a small business, in part, as a business entity "which operates primarily within the United States." (13 CFR 121.105(a)). No regulatory flexibility analysis is required if the head of an agency certifies that the rule will not have a significant economic impact on a substantial number of small entities. The SBREFA amended the Regulatory Flexibility Act to require Federal agencies to provide a statement of the factual basis for certifying that a rule will not have a significant economic impact on a substantial number of small entities.

NHTSA has considered the effects of this final rule under the Regulatory Flexibility Act.

The RIA discusses the economic impact of the rule on small vehicle manufacturers, of which NHTSA is aware of 12. NHTSA believes that this rule would not have a significant economic impact on these manufacturers. The vehicles produced by manufacturers listed in RIA can roughly be grouped into three classes: (1) luxury/ultra-luxury vehicles; (2) alternative electric vehicles; and (3) modified vehicles from other manufacturers. For luxury/ultra-luxury vehicles, any potential incremental compliance costs would not impact demand. Similarly, we would expect alternative electric vehicles to offer amenities meeting or exceeding the established market alternatives, including effective AEB and PAEB systems. Lastly, regarding final stage manufacturers, NHTSA is aware that these manufacturers buy incomplete vehicles from first-stage manufacturers. Then these vehicles are modified from larger manufacturer stock that would already be compliant. Therefore, there would be no incremental compliance costs.

As noted in the NPRM, much of the work developing and manufacturing AEB system components would be conducted by suppliers. Although the final certification would be made by the manufacturer, the NPRM proposed allowing for one additional year for small-volume manufacturers to comply with any requirement. That approach is similar to the approach we have taken in other rulemakings in recognition of manufacturing differences between larger and smaller manufacturers. As the countermeasures are developed, AEB suppliers would likely supply larger vehicle manufacturers first, before small manufacturers. In the proposed rule, NHTSA recognized this and maintained the agency's position that small manufacturers need additional flexibility, so they have time to obtain the equipment and work with the suppliers after the demands of the larger manufacturers are met.

The difference between the proposal and what is finalized in this rule is that NHTSA is no longer pursuing different lead-times based on the technology or phase-in schedules. Rather, the agency is providing all manufacturers with two extra years of lead time for lead vehicle AEB and one extra year of lead time for the most stringent requirements for PAEB (i.e., 5 years of lead time regardless of technology). The rule adopts a 5-year lead time for all requirements and all manufacturers to ensure that the public attains lead vehicle AEB and PAEB safety benefits as soon as practicable. Small volume manufacturers would not have to comply for six years due to the additional year provided to them.

This rule may also affect final stage manufacturers, many of whom would be small businesses. While it is NHTSA's understanding that final stage manufacturers rarely make modifications to a vehicle's braking system and instead rely upon the pass-through certification provided by a first-stage manufacturers, as with small-volume manufacturers, final stage manufacturers would be provided with one additional year to comply with any requirement.

NHTSA received comments on the Regulatory Flexibility Act analysis included in the NPRM. One commenter asserted that NHTSA did not adequately consider the additional burden for small volume manufacturers and the unique design characteristics that would present additional compliance challenges for small manufacturers. The unique design considerations include low ground clearance, bumper characteristics that would require mounting radar very close to the ground, thereby requiring additional engineering to manage increased sensor signal noise, the general shape of the bumper, and the materials used for the bumper. This commenter said that the combination of these factors raises the risk of false positives and/or angular distortion of the target object in vertical and horizontal plane. Another commenter raised concerns about the engineering challenges faced by manufacturers of "SuperCars" and concern that these manufacturers would revert to seeking exemptions instead of pursuing FMVSS compliance.

In response to these comments, NHTSA notes that it has extended the lead time for all manufacturers to 5 years in this final rule. As proposed, final stage manufacturers and small-volume manufacturers would receive an additional year to comply, thus giving those entities 6 years to comply with this final rule. NHTSA believes that 6 years is sufficient time for even the smallest manufacturers to design and conform their products to this FMVSS, or seek an exemption if they have grounds under one of the bases listed in 49 CFR part 555.

I certify that this final rule would not have a significant economic impact on a substantial number of small entities. Additional information concerning the potential impacts of this rule on small entities is presented in the RIA accompanying this rule.

National Environmental Policy Act

The National Environmental Policy Act of 1969 (NEPA)[164] requires Federal agencies to analyze the environmental impacts of proposed major Federal actions significantly affecting the quality of the human environment, as well as the impacts of alternatives to the proposed action.[165] The Council on Environmental Quality (CEQ) directs Federal agencies to prepare an environmental assessment for a proposed action "that is not likely to have significant effects or when the significance of the effects is unknown."[166] When a Federal agency prepares an environmental assessment, CEQ's NEPA implementing regulations require it to (1) "[b]riefly provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact;" and (2) "[b]riefly discuss the purpose and need for the proposed action, alternatives . . ., and the environmental impacts of the proposed action and alternatives, and include a listing of agencies and persons consulted."[167]

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[164] 42 U.S.C. 4321-4347.
[165] 42 U.S.C. 4332(2)(C).
[166] 40 CFR 1501.5(a).
[167] 40 CFR 1501.5(c).

This section serves as NHTSA's Final Environmental Assessment (EA). In this Final EA, NHTSA outlines the purpose and need for the rulemaking, a reasonable range of alternative actions the agency considered through rulemaking, the projected environmental impacts of these alternatives. NHTSA did not receive any comments on the Draft EA.

Purpose and Need

This final rule sets forth the purpose of and need for this action. In this final rule, NHTSA is adopting a new FMVSS to require AEB systems on light vehicles capable of reducing the frequency and severity of both lead vehicle rear-end (lead vehicle AEB) and pedestrian crashes (PAEB). As explained earlier in this preamble, the AEB system improves safety by using various sensor technologies and sub-systems that work together to detect when the vehicle is in a crash imminent situation, to automatically apply the vehicle brakes if the driver has not done so, or to apply more braking force to supplement the driver's braking, thereby detecting and reacting to an imminent crash with a lead vehicle or pedestrian. This final rule promotes NHTSA's goal to reduce the frequency and severity of crashes described in the summary of the crash problem discussed earlier in the final rule, and advances DOT's January 2022 National Roadway Safety Strategy that identified requiring AEB, including PAEB technologies, on new passenger vehicles as a key Departmental action to enable safer vehicles. This final rule also responds to a mandate under the Bipartisan Infrastructure Law (BIL) directing the Department to promulgate such a rule.

Alternatives

NHTSA considered four regulatory alternatives for the proposed action and a "no action alternative." Under the no action alternative, NHTSA would not issue a final rule requiring that vehicles be equipped with systems that meet minimum specified performance requirements, and manufacturers would continue to add AEB systems voluntarily. However, because the BIL directs NHTSA to promulgate a rule that would require that all passenger vehicles be equipped with an AEB system, NHTSA cannot adopt the no action alternative. Alternative 1 considers requirements specific to lead vehicle AEB only. Alternative 2 includes the lead vehicle AEB requirements in Alternative 1 and a requirement in which PAEB is only required to function in daylight conditions. Alternative 3, the selected alternative, considers requirements for lead vehicle AEBs and PAEB requirements in both daylight and darkness conditions. Alternative 4 considers a more-stringent requirement in which PAEB would be required to provide pedestrian protections in turning scenarios (no change to the lead vehicle AEB requirements in the final rule).

NHTSA also considered other options, including the International Organization for Standardization (ISO) standards, SAE International standards, the Economic Commission for Europe (ECE) standards, test procedures used by NHTSA's New Car Assessment Program (NCAP) and Euro NCAP, which are described above in this preamble and accompanying appendices. In the final rule, NHTSA incorporates aspects of the test procedures and standards mentioned here, but departs from them in numerous and significant ways.

Environmental Impacts of the Proposed Action and Alternatives

This final rule is anticipated to result in the employment of sensor technologies and sub-systems on light vehicles that work together to sense when a vehicle is in a crash imminent situation, to automatically apply the vehicle brakes if the driver has not done so, and to apply more braking force to supplement the driver's braking if insufficient. This final rule is also anticipated to improve safety by mitigating the number of fatalities, non-fatal injuries, and property damage that would result from crashes that could potentially be prevented or mitigated because of AEB. As a result, the primary environmental impacts[168] that could potentially result from this rulemaking are associated with: greenhouse gas emissions and air quality, socioeconomics, public health and safety, solid waste/property damage/congestion, and

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[168] NHTSA anticipates that this rulemaking would have negligible or no impact on the following resources and impact categories, and therefore has not analyzed them further: topography, geology, soils, water resources (including wetlands and floodplains), biological resources, resources protected under the Endangered Species Act, historical and archeological resources, farmland resources, environmental justice, and section 4(f) properties.

hazardous materials. Consistent with CEQ regulations and guidance, this EA discusses impacts in proportion to their potential significance. The effects of the final rule that were analyzed further are summarized below.

Greenhouse Gas Emissions and Air Quality

NHTSA has previously recognized that additional weight required by FMVSS could potentially negatively impact the amount of fuel consumed by a vehicle, and accordingly result in greenhouse gas emissions or air quality impacts from criteria pollutant emissions. Atmospheric greenhouse gases (GHGs) affect Earth's surface temperature by absorbing solar radiation that would otherwise be reflected back into space. Carbon dioxide (CO_2) is the most significant greenhouse gas resulting from human activity. Motor vehicles emit CO_2 as well as other GHGs, including methane and nitrous oxides, in addition to criteria pollutant emissions that negatively affect public health and welfare.

Additional weight added to a vehicle, like added hardware from safety systems, can cause an increase in vehicle fuel consumption and emissions. An AEB system requires the following hardware: sensing, perception, warning hardware, and electronically modulated braking subsystems.[169] As discussed in the preamble and the RIA, NHTSA anticipates that under the no action alternative and Alternatives 1–3, the majority of vehicles subject to the rulemaking would already have all of the hardware capable of meeting the requirements by the effective date of a final rule. For all alternatives, NHTSA assumes that manufacturers will need time to build code that analyses the frontal view of the vehicle (*i.e.,* manufacturers would need to upgrade the software for the perception subsystem) in a way that achieves the requirements of this final rule. Furthermore, approximately five percent of vehicles would add additional hardware such as a

[169] Automatic actuation of a vehicle's brakes requires more than just technology to sense when a collision is imminent. In addition to the sensing system, hardware is needed to apply the brakes without relying on the driver to depress the brake pedal. The automatic braking system relies on two foundational braking technologies — electronic stability control to automatically activate the vehicle brakes and an antilock braking system to mitigate wheel lockup. Not only do electronic stability control and antilock braking systems enable AEB operation, these systems also modulate the braking force so that the vehicle remains stable while braking during critical driving situations where a crash with a vehicle or pedestrian is imminent.

camera or radar. In addition to those costs, Alternative 4 includes an assumption that two cameras would be added; however, based on weight assumptions included in studies cited in the RIA, that weight impact would be minimal. The incremental weight associated with a stereo camera module is 785 g (1.73 lbs.) and for the entire camera and radar fused system is 883 g. (1.95 lbs.). NHTSA has previously estimated that a 3–4-pound increase in vehicle weight is projected to reduce fuel economy by 0.01 mpg.[170] Accordingly, Alternatives 1–3 would not have any fuel economy penalty for 95 percent of vehicles subject to the rulemaking because no hardware would be added. The potential impact on fuel economy for those five percent that would add an additional hardware would be negligible as it would potentially be under a pound when considering half the weight of either the stereo camera module or camera and radar fused system or under two pounds based on the stereo camera module. Similarly, Alternative 4 would potentially have a negligible fuel economy penalty as the potential incremental weight would be under two pounds based on the stereo camera module.

Pursuant to the Clean Air Act (CAA), the U.S. Environmental Protection Agency (EPA) has established a set of National Ambient Air Quality Standards (NAAQS) for the following "criteria" pollutants: carbon monoxide (CO), nitrogen dioxide (NO_2), ozone, particulate matter (PM) less than 10 micrometers in diameter (PM_{10}), PM less than 2.5 micrometers in diameter ($PM_{2.5}$), sulfur dioxide (SO_2), and lead (Pb). The NAAQS include "primary" standards and "secondary" standards. Primary standards are intended to protect public health with an adequate margin of safety. Secondary standards are set at levels designed to protect public welfare by accounting for the effects of air pollution on vegetation, soil, materials, visibility, and other aspects of the general welfare. Under the General Conformity Rule of the CAA,[171] EPA requires a conformity determination when a Federal action would result in total direct and indirect

[170] Final Regulatory Impact Analysis, Corporate Average Fuel Economy for MYs 2012-2016 Passenger Cars and Light Trucks, Table IV-5 (March 2010).
[171] Section 176(c) of the CAA, codified at 42 U.S.C. 7506(c); To implement CAA section 176(c), EPA issued the General Conformity Rule (40 CFR part 51, subpart W and part 93, subpart B).

emissions of a criteria pollutant or precursor originating in nonattainment or maintenance areas equaling or exceeding the emissions thresholds specified in 40 CFR 93.153(b)(1) and (2). the General Conformity Rule does not, however, require a conformity determination for Federal "rulemaking and policy development and issuance," such as this action.[172] Therefore, NHTSA has determined it is not required to perform a conformity analysis for this action.

Socioeconomics

The socioeconomic impacts of the rulemaking would be primarily felt by vehicle manufacturers, light vehicle drivers, passengers, and pedestrians on the road that would otherwise be killed or injured in light vehicle crashes. NHTSA conducted a detailed assessment of the economic costs and benefits of establishing the new rule in its RIA. The main economic benefits come primarily from the reduction in fatalities and non-fatal injuries (safety benefits). Reductions in the severity of motor vehicle crashes would be anticipated to have corresponding reductions in costs for medical care, emergency services, insurance administrative costs, workplace costs, and legal costs due to the fatalities and injuries avoided. Other socioeconomic factors discussed in the RIA that would affect these parties include software and some hardware costs and property damage savings. Overall, Alternative 1 is anticipated to have societal net benefits of $3.40 to $4.28 billion, Alternative 2 is anticipated to have societal net benefits of $4.23 to $5.30 billion, Alternative 3 (the selected alternative) is anticipated to have societal net benefits of $5.82 to $7.26 billion, and Alternative 4 is anticipated to have societal net benefits of $4.18 to $5.73 billion. The RIA discusses this information in further detail.

Public Health and Safety

The affected environment for public health and safety includes roads, highways and other driving locations used by all light vehicle drivers, other drivers, passengers in light vehicles and other motor vehicles, and pedestrians or other individuals who could be injured or killed in

[172] 40 CFR 93.153(c)(2)(iii).

crashes involving the vehicles regulated by the proposed action. In the RIA, the agency determined the impacts on public health and safety by estimating the reduction in fatalities and injuries resulting from the decreased crash severity due to the use of AEB systems under the four action alternatives. Under Alternative 1, it is expected that the addition of a less stringent requirement that only specifies requirements for lead vehicle AEB would result each year in 314 to 388 equivalent lives saved. Under Alternative 2, it is expected that the less-stringent requirement, in which PAEB is only required to function in daylight conditions, would result each year in 384 to 473 equivalent lives saved. Under Alternative 3 (the selected alternative), it is expected that the regulatory option would result each year in 517 to 638 equivalent lives saved. Finally, under Alternative 4, it is expected that the addition of more stringent requirements in which PAEB would be required to provide pedestrian protections in turning scenarios would result each year in 555 to 684 equivalent lives saved. The RIA discusses this information in further detail.

Solid Waste/Property Damage/Congestion

Vehicle crashes can generate solid wastes and release hazardous materials into the environment. The chassis and engines, as well as associated fluids and components of automobiles and the contents of the vehicles, can all be deemed waste and/or hazardous materials. Solid waste can also include damage to the roadway infrastructure, including road surface, barriers, bridges, and signage. Hazardous materials are substances that may pose a threat to public safety or the environment because of their physical, chemical, or radioactive properties when they are released into the environment, in this case as a result of a crash.

NHTSA's rulemaking is projected to reduce the amount and severity of light vehicle crashes, and therefore may reduce the quantity of solid waste, hazardous materials, and other property damage generated by light vehicle crashes in the United States. The addition of an AEB system may also result in reduced damage to the vehicles and property, as well as reduced travel delay costs due to congestion. This is especially the case in “property-damage-only” crashes, where no individuals are injured or killed in the crash, but there may be damage to the vehicle or whatever is impacted by it. NHTSA estimates that based off data from 2016–2019 alone, an average of 1.12 million rear-impact crashes involving light vehicles occurred annually. These crashes resulted in an annual average of 394 fatalities, 142,611 non-fatal injuries, and approximately 1.69 million PDOVs.

Less solid waste translates into cost and environmental savings from reductions in the following areas: (1) transport of waste material, (2) energy required for recycling efforts, and (3) landfill or incinerator fees. Less waste will result in beneficial environmental effects through less GHG emissions used in the transport of it to a landfill, less energy used to recycle the waste, less emissions through the incineration of waste, and less point source pollution at the scene of the crash that would result in increased emissions levels or increased toxins leaking from the crashed vehicles into the surrounding environment.

The addition of an AEB system may also result in reduced post-crash environmental effects from congestion. As discussed in the RIA, NHTSA's monetized benefits are calculated by multiplying the number of non-fatal injuries and fatalities mitigated by their corresponding "comprehensive costs." The comprehensive costs include economic costs that are external to the value of a statistical life (VSL) costs, such as emergency management services or legal costs, and congestion costs. NHTSA has recognized that motor vehicle crashes result in congestion that has both socioeconomic and environmental effects. These environmental effects include "wasted fuel, increased greenhouse gas production, and increased pollution as engines idle while drivers are caught in traffic jams and slowdowns."[173] NHTSA's monetized benefits therefore include a quantified measure of congestion avoidance. NHTSA did not calculate congestion effects specifically for each regulatory alternative; however, because comprehensive costs are a discrete

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[173] Blincoe, L. J., Miller, T. R., Zaloshnja, E., & Lawrence, B. A. (2015, May). The economic and societal impact of motor vehicle crashes, 2010. (Revised) (Report No. DOT HS 812 013). Washington, DC: National Highway Traffic Safety Administration.

cost applied to non-fatal injuries and fatalities at the same rate, we can conclude that there are increasing benefits associated with fewer crashes, and specifically decreased congestion, as the monetized benefits increase across regulatory alternatives. To the extent that any regulatory option for AEB results in fewer crashes and accordingly higher monetized benefits, there would be fewer congestion-related environmental effects.

NHTSA has tentatively concluded that under the agency's rulemaking, the economic benefits resulting from improved safety outcomes, property damage savings, fuel savings, and GHG reductions would limit the negative environmental impacts caused by additional solid waste/property damage due to crashes because of the crashes that will be avoided due to the requirements of this rule. Similarly, while the potential degree of hazardous materials spills prevented due to the reduction of crash severity and crash avoidance expected from the rulemaking has not specifically been analyzed in the RIA or final rule, the addition of the AEB system is projected to reduce the amount and severity of light vehicle crashes and may improve the environmental effects with respect to hazardous material spills. While the RIA does not specifically quantify these impact categories, in general NHTSA believes the benefits would increase relative to the crashes avoided and would be relative across the different alternatives. The RIA discusses information related to quantified costs and benefits of crashes, and in particular property damage due to crashes, for each regulatory alternative in further detail.

Cumulative Impacts

In addition to direct and indirect effects, CEQ regulations require agencies to consider cumulative impacts of major Federal actions. CEQ regulations define cumulative impacts as the impact "on the environment that result from the incremental [impact] of the action when added to . . . other past, present, and reasonably foreseeable actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions."[174] NHTSA notes that the public health

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[174] 40 CFR 1508.1(g)(3).

and safety, solid waste/property damage/congestion, air quality and greenhouse gas emissions, socioeconomic, and hazardous material benefits identified in this EA were based on calculations described in the RIA, in addition to other NHTSA actions and studies on motor vehicle safety as described in the preamble. That methodology required the agency to adjust historical figures to reflect vehicle safety rulemakings that have recently become effective. As a result, many of the calculations in this EA already reflect the incremental impact of this action when added to other past actions.

NHTSA's and other parties' past actions that improve the safety of light vehicles, as well as future actions taken by the agency or other parties that improve the safety of light vehicles, could further reduce the severity or number of crashes involving light vehicles. Any such cumulative improvement in the safety of light vehicles would have an additional effect in reducing injuries and fatalities and could reduce the quantity of solid and hazardous materials generated by crashes. To the extent that this rule may have some minimal impact on fuel economy for the small percentage of vehicles where additional hardware may be required, NHTSA would consider that impact when setting maximum feasible fuel economy standards."[175]

Agencies and Persons Consulted

This preamble describes the various materials, persons, and agencies consulted in the development of the final rule. NHTSA invited public comments on the contents and tentative conclusions of the Draft EA. No public comments addressing the Draft EA were received. Furthermore, none of the public comments that were received addressed any issues related to the human environment that would be relevant to the Final EA.

Finding of No Significant Impact

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[175] 49 U.S.C. 32902(f), which states that we consider the effect of other motor vehicle standards of the Government on fuel economy in the max feasible discussion.

Although this rule is anticipated to result in additional FMVSS requirements for light vehicle manufacturers, AEB systems have already largely been introduced by manufacturers voluntarily. The addition of regulatory requirements (depending on the regulatory alternative) to standardize the AEB systems in all vehicle models is anticipated to result in negligible or no fuel economy and emissions penalties (*i.e.,* five percent of vehicles would require additional hardware, but the added weight is negligible), increasing socioeconomic and public safety benefits as the alternatives get more stringent, and an increase in benefits from the reduction in solid waste, property damage, and congestion (including associated traffic level impacts like reduction in energy consumption and tailpipe pollutant emissions) from fewer vehicle crashes across the regulatory alternatives.

Based on the Final EA, NHTSA concludes that implementation of any of the alternatives considered for the proposed action, including the selected alternative, will not have a significant effect on the human environment and that a "finding of no significant impact" is appropriate. This statement constitutes the agency's "finding of no significant impact," and an environmental impact statement will not be prepared.[176]

Executive Order 13132 (Federalism)

NHTSA has examined this rule pursuant to Executive Order 13132 (64 FR 43255, August 10, 1999) and concluded that no additional consultation with States, local governments, or their representatives is mandated beyond the rulemaking process. The agency has concluded that this rule will not have sufficient federalism implications to warrant consultation with State and local officials or the preparation of a federalism summary impact statement. The rule does not have "substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government."

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[176] 40 CFR 1501.6(a).

NHTSA rules can preempt in two ways. First, the National Traffic and Motor Vehicle Safety Act contains an express preemption provision: When a motor vehicle safety standard is in effect under this chapter, a State or a political subdivision of a State may prescribe or continue in effect a standard applicable to the same aspect of performance of a motor vehicle or motor vehicle equipment only if the standard is identical to the standard prescribed under this chapter. 49 U.S.C. 30103(b)(1). It is this statutory command by Congress that preempts any non-identical State legislative and administrative law addressing the same aspect of performance. The express preemption provision described above is subject to a savings clause under which compliance with a motor vehicle safety standard prescribed under this chapter does not exempt a person from liability at common law. 49 U.S.C. 30103(e). Pursuant to this provision, State common law tort causes of action against motor vehicle manufacturers that might otherwise be preempted by the express preemption provision are generally preserved. However, the Supreme Court has recognized the possibility, in some instances, of implied preemption of such State common law tort causes of action by virtue of NHTSA's rules, even if not expressly preempted. The second way that NHTSA rules can preempt is dependent upon there being an actual conflict between an FMVSS and the higher standard that would effectively be imposed on motor vehicle manufacturers if someone obtained a State common law tort judgment against the manufacturer, notwithstanding the manufacturer's compliance with the NHTSA standard. Because most NHTSA standards established by an FMVSS are minimum standards, a State common law tort cause of action that seeks to impose a higher standard on motor vehicle manufacturers will generally not be preempted. If and when such a conflict does exist – for example, when the standard at issue is both a minimum and a maximum standard – the State common law tort cause of action is impliedly preempted. *See Geier v. American Honda Motor Co*., 529 U.S. 861 (2000).

Pursuant to Executive Orders 13132 and 12988, NHTSA has considered whether this rule could or should preempt State common law causes of action. The agency's ability to announce its conclusion regarding the preemptive effect of one of its rules reduces the likelihood that preemption will be an issue in any subsequent tort litigation. To this end, the agency has examined the nature (i.e., the language and structure of the regulatory text) and objectives of this rule and finds that this rule, like many NHTSA rules, would prescribe only a minimum safety standard. As such, NHTSA does not intend this rule to preempt state tort law that would effectively impose a higher standard on motor vehicle manufacturers. Establishment of a higher standard by means of State tort law will not conflict with the minimum standard adopted here. Without any conflict, there could not be any implied preemption of a State common law tort cause of action.

Executive Order 12988 (Civil Justice Reform)

When promulgating a regulation, section 3(b) of Executive Order 12988, "Civil Justice Reform" (61 FR 4729, February 7, 1996) requires that Executive agencies make every reasonable effort to ensure that the regulation: (1) Clearly specifies the preemptive effect; (2) clearly specifies the effect on existing Federal law or regulation; (3) provides a clear legal standard for affected conduct, while promoting simplification and burden reduction; (4) clearly specifies the retroactive effect, if any; (5) adequately defines key terms; and (6) addresses other important issues affecting clarity and general draftsmanship under any guidelines issued by the Attorney General. This document is consistent with that requirement.

Pursuant to this Order, NHTSA notes that the preemptive effect of this rulemaking is discussed above in connection with Executive Order 13132. NHTSA notes further that there is no requirement that individuals submit a petition for reconsideration or pursue other administrative proceeding before they may file suit in court.

Executive Order 13045 (Protection of Children From Environmental Health and Safety Risks)

Executive Order 13045, "Protection of Children from Environmental Health and Safety Risks," (62 FR 19885; April 23, 1997) applies to any proposed or final rule that: (1) Is determined to be "economically significant," as defined in E.O. 12866, and (2) concerns an environmental health or safety risk that NHTSA has reason to believe may have a disproportionate effect on children. If a rule meets both criteria, the agency must evaluate the environmental health or safety effects of the rule on children, and explain why the rule is preferable to other potentially effective and reasonably feasible alternatives considered by the agency.

This rule is not expected to have a disproportionate health or safety impact on children. Consequently, no further analysis is required under Executive Order 13045.

Congressional Review Act

The Congressional Review Act, 5 U.S.C. 801 et. seq., as added by the Small Business Regulatory Enforcement Fairness Act of 1996, generally provides that before a rule may take effect, the agency promulgating the rule must submit a rule report, which includes a copy of the rule, to each House of the Congress and to the Comptroller General of the United States. NHTSA will submit a report containing this rule and other required information to the U.S. Senate, the U.S. House of Representatives, and the Comptroller General of the United States prior to publication of the rule in the *Federal Register*. Because this rule meets the criteria in 5 U.S.C. 804(2), it will be effective sixty days after the date of publication in the *Federal Register*.

Paperwork Reduction Act (PRA)

Under the PRA of 1995, a person is not required to respond to a collection of information by a Federal agency unless the collection displays a valid OMB control number. There are no "collections of information" (as defined at 5 CFR 1320.3(c)) in this rule.

National Technology Transfer and Advancement Act

Under the National Technology Transfer and Advancement Act of 1995 (NTTAA) (Pub. L. 104-113), all Federal agencies and departments shall use technical standards developed or adopted by voluntary consensus standards bodies, using such technical standards as a means to carry out policy objectives or activities determined by the agencies and departments. Voluntary consensus standards are technical standards (e.g., materials specifications, test methods, sampling procedures, and business practices) developed or adopted by voluntary consensus standards bodies, such as the International Organization for Standardization and SAE International. The NTTAA directs us to provide Congress, through OMB, explanations when we decide not to use available and applicable voluntary consensus standards.

NHTSA is incorporating by reference ISO and ASTM standards into this rule. NHTSA considered several ISO standards and has opted to use ISO 19206-3:2021 to specify the vehicle test device and a combination of ISO 19206-2:2018 and ISO 19206-4:2020 to specify the test mannequins. NHTSA is incorporating by reference ASTM E1337-19, which is already incorporated by reference into many FMVSSs, to measure the peak braking coefficient of the testing surface.

NHTSA considered SAE International Recommended Practice J3087, "Automatic emergency braking (AEB) system performance testing," which defines the conditions for testing AEB and FCW systems. This standard defines test conditions, test targets, test scenarios, and measurement methods, but does not provide performance criteria. There is considerable overlap in the test setup and conditions between this rule and the SAE standard including the basic scenarios of lead vehicle stopped, slower moving, and decelerating. This SAE recommended practice is substantially similar to the existing NCAP test procedures and this rule.

NHTSA also considered SAE International Standard J3116, "Active Safety Pedestrian Test Mannequin Recommendation," which provides recommendations for the characteristics of a surrogate that could be used in testing of active pedestrian safety systems. As proposed, NHTSA incorporates the ISO standard because the ISO standard specifications are more widely adopted than the SAE Recommended Practice.

In appendix B of the NPRM's preamble, NHTSA described several international test procedures and regulations the agency considered for use in this rule. This rule has substantial technical overlap with UNECE Regulation No. 131 and UNECE Regulation No. 152. This rule and the UNECE regulations both specify a forward collision warning and automatic emergency braking. Several lead vehicle AEB scenarios are nearly identical, including the lead vehicle stopped and lead vehicle moving scenarios. The pedestrian crossing path scenario specified in UNECE Regulation No. 152 is also substantially similar to this rule. As discussed in the preamble, this rule differs from the UNECE standards in the areas of maximum test speed and the minimum level of required performance. This rule uses higher test speeds and a requirement that the test vehicle avoid contact, both of which are more stringent than the UNECE regulations and more reflective of the safety need in the United States. NHTSA expects that this approach would increase the repeatability of the test and maximize the realized safety benefits of the rule.

Incorporation by Reference

Under regulations issued by the Office of the Federal Register (1 CFR 51.5), an agency, as part of a proposed rule that includes material incorporated by reference, must summarize material that is proposed to be incorporated by reference and discuss the ways the material is reasonably available to interested parties or how the agency worked to make materials available to interested parties. At the final rule stage, regulations require that the agency seek formal approval, summarize the material that it incorporates by reference in the preamble of the final rule, discuss the ways that the materials are reasonably available to interested parties, and provide other specific information to the Office of the Federal Register.

In this rule, NHTSA incorporates by reference six documents into the Code of Federal Regulations, ASTM E1337-19, *Standard Test Method for Determining Longitudinal Peak Braking Coefficient (PBC) of Paved Surfaces Using Standard Reference Test Tire*, is already incorporated by reference elsewhere in 49 CFR part 571. ASTM E1337 is a standard test method for evaluating peak braking coefficient of a test surface using a standard reference test tire using a trailer towed by a vehicle. NHTSA uses this method in all of its braking and electronic stability control standards to evaluate the test surfaces for conducting compliance test procedures.

NHTSA also incorporates by reference SAE J2400 *Human Factors in Forward Collision Warning System: Operating Characteristics and User Interface Requirements*, into part 571. SAE J2400 is an information report intended as a starting point of reference for designers of forward collision warning systems. NHTSA incorporates this document by reference solely to specify the location specification and symbol for a visual forward collision warning.

NHTSA incorporates by reference four ISO standards into 49 CFR part 596. The first of these standards is ISO 3668:2017(E), *Paints and varnishes – Visual comparison of colour of paints*. This document specifies a method for the visual comparison of the color of paints against a standard. This method will be used to verify the color of certain elements of the pedestrian test mannequin NHTSA will use in PAEB testing. Specifically, NHTSA will use these procedures to determine that the color of the hair, torso, arms, and feet of the pedestrian test mannequin is black and that the color of the legs are blue.

NHTSA incorporates by reference ISO 19206-2:2018(E), *Road vehicles – Test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions – Part 2: Requirements for pedestrian targets*. This document addresses the specification for a test mannequin. It is designed to resemble the characteristics of a human, while ensuring the safety of the test operators and preventing damage to subject vehicles in the event of a collision during testing. NHTSA references many, but not all, of the specifications of ISO 19206-2:2018, as discussed earlier in the preamble of this rule.

NHTSA also incorporates by reference ISO 19206-3:2021(E), *Test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions — Part 3: Requirements for passenger vehicle 3D targets*. This document provides specification of three-dimensional test devices that resemble real vehicles. Like the test mannequin described in the prior paragraph, it is designed to ensure the safety of the test operators and to prevent damage to subject vehicles in the event of a collision during testing. NHTSA references many, but not all, of the specifications of ISO 19206-3:2021, as discussed earlier in the preamble of this rule.

Finally, NHTSA incorporates by reference ISO 19206-4:2020(E), *Road vehicles – test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions—Part 4: Requirements for bicyclists targets*. This standard describes specifications for bicycle test devices representative of adult and child sizes. NHTSA will not use a bicycle test device during testing for this final rule. Rather, this standard is incorporated by reference solely because it contains specifications for color and reflectivity, including skin color, that NHTSA is applying to its pedestrian test mannequin.

All standards incorporated by reference in this rule are available for review at NHTSA's headquarters in Washington, DC, and for purchase from the organizations promulgating the standards (see 49 CFR 517.5 for contact information). The ASTM standard presently incorporated by reference into other NHTSA regulations is also available for review at ASTM's online reading room.[177]

Unfunded Mandates Reform Act

The Unfunded Mandates Reform Act of 1995 (Public Law 104-4) requires agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditures by States, local or tribal governments, in the aggregate, or by the private sector, of more than $100 million annually (adjusted annually for inflation with base year of 1995). Adjusting this amount by the implicit gross domestic product price deflator for 2021 results in an estimated current value of $165 million (2021 index value of 113.07 / 1995 index value of 68.60 = 1.65). The assessment may be included in conjunction with other assessments, as it is for this rule in the RIA.

A rule on lead vehicle AEB and PAEB is not likely to result in expenditures by State, local or tribal governments of more than $100 million annually. However, it is estimated to result in the estimated expenditure by automobile manufacturers and/or their suppliers of $354

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[177] https://www.astm.org/products-services/reading-room.html. .

million annually (estimated to be an average of approximately $23 per light vehicle annually). This average estimated cost impacts reflects that the estimated incremental costs depend on a variety of lead vehicle AEB hardware and software that manufacturers plan to install (in vehicles used as "baseline" for the cost estimate). The final cost will greatly depend on choices made by the automobile manufacturers to meet the lead vehicle AEB and PAEB test requirements. These effects have been discussed in the RIA developed in support of this final rule.

The Unfunded Mandates Reform Act requires the agency to select the "least costly, most cost-effective or least burdensome alternative that achieves the objectives of the rule." As an alternative, the agency considered a full-vehicle dynamic test to evaluate the capability of lead vehicle AEB and PAEB systems to prevent crashes or mitigate the severity of crashes. Based on our experience on conducting vehicle tests for vehicles equipped with lead vehicle AEB and PAEB where we utilize a reusable surrogate target crash vehicle and test mannequins instead of conducting the test with an actual vehicle as the target, we determined that full vehicle-to-vehicle crash tests can have an undesired amount of variability in vehicle kinematics. Unlike vehicle-to-vehicle tests, the lead vehicle AEB and PAEB tests with a surrogate target vehicle is conducted in a well-controlled test environment, which results in an acceptable amount of variability. In addition, the agency's lead vehicle AEB and PAEB tests with surrogate target vehicle and pedestrian were able to reveal deficiencies in the system that resulted in inadequate system capability in detecting and activating the brakes. Therefore, we concluded that a full vehicle-to-vehicle test would not achieve the objectives of the rule.

In addition, the agency evaluated data across a broad range of test scenarios in an effort to identify the maximum range of test speeds at which it is feasible for test vehicles to achieve a no-contact result. The range of feasible speeds for no contact identified in the review was specified as the mandated range in the rule. Thus, there are no alternative test procedures available that would improve the ability of manufacturers to achieve no-contact results. In turn, the agency concluded that lead vehicle AEB and PAEB systems designed to meet the no-contact requirement at speeds outside the ranges specified in the rule would not achieve the objectives of the rule.

Executive Order 13609 (Promoting International Regulatory Cooperation)

The policy statement in section 1 of E.O. 13609 states, in part, that the regulatory approaches taken by foreign governments may differ from those taken by U.S. regulatory agencies to address similar issues and that, in some cases, the differences between the regulatory approaches of U.S. agencies and those of their foreign counterparts might not be necessary and might impair the ability of American businesses to export and compete internationally. The E.O. states that, in meeting shared challenges involving health, safety, labor, security, environmental, and other issues, international regulatory cooperation can identify approaches that are at least as protective as those that are or would be adopted in the absence of such cooperation, and that international regulatory cooperation can also reduce, eliminate, or prevent unnecessary differences in regulatory requirements. NHTSA requested public comment on the "regulatory approaches taken by foreign governments" concerning the subject matter of this rulemaking. NHTSA received many comments expressing that NHTSA should either align or adopt existing international regulations. As discussed above, while NHTSA has adopted aspects of these regulations, it has rejected others because of the stringency of the regulations due to the reasons discussed in further detail in various parts of the preamble and National Technology Transfer and Advancement Act section.

Severability

The issue of severability of FMVSSs is addressed in 49 CFR 571.9. It provides that if any FMVSS or its application to any person or circumstance is held invalid, the remainder of the part and the application of that standard to other persons or circumstances is unaffected. It expresses NHTSA's view that, even with invalidated portions or applications disregarded, remaining portions and applications can still function sensibly.

Regulation Identifier Number

The Department of Transportation assigns a regulation identifier number (RIN) to each regulatory action listed in the Unified Agenda of Federal Regulations. The Regulatory Information Service Center publishes the Unified Agenda in April and October of each year. You may use the RIN contained in the heading at the beginning of this document to find this action in the Unified Agenda.

VI. Appendices to the Preamble

A. Appendix A: Description of the Lead Vehicle AEB Test Procedures

Stopped Lead Vehicle

Test Parameters

The stopped lead vehicle scenario consists of the vehicle traveling straight ahead, at a constant speed, approaching a stopped lead vehicle in its path. The vehicle must be able to avoid contact with the stopped lead vehicle. The testing is at any subject vehicle speed between 10 km/h and 80 km/h with no manual brake application and between 70 km/h and 100 km/h with manual brake application.

Test Conduct Prior to FCW onset

Prior to the start of a test, the lead vehicle is placed with its longitudinal centerline coincident to the intended travel path and with no specific limitations on how a subject vehicle may be driven prior to the test start. As long as the specified initialization procedure is executed, a subject vehicle may be driven under any conditions including any speed and direction, and on any road surface, for any elapsed time prior to reaching the point where a test trial begins.
As the subject vehicle approaches the rear of the lead vehicle, beginning when the headway corresponds to L_0, the subject vehicle speed is maintained within 1.6 km/h of the test speed with minimal and smooth accelerator pedal inputs. Furthermore, beginning when the headway corresponds to L_0, the subject vehicle heading is maintained with minimal steering input such that the subject vehicle travel path does not deviate more than 0.3 m laterally from the intended

travel path and the subject vehicle's yaw rate does not exceed ±1.0 deg/s. The purpose of these test tolerances is to assure test practicability and repeatability of results.

Test Conduct After FCW onset

During each test, the subject vehicle accelerator pedal is released in response to the FCW. The procedure states that the accelerator pedal is released at any rate and is fully released within 500 milliseconds for subject vehicles tested without cruise control active. The accelerator release procedure ensures consistent release of the accelerator and assures test repeatability. The accelerator pedal release can be omitted from tests of vehicles with cruise control actively engaged because there is no driver input to the accelerator pedal in that case. The AEB performance requirements are the same for vehicles with and without cruise control engaged, and AEB systems must provide an equivalent level of crash avoidance or mitigation regardless of whether cruise control is active.

For testing without manual brake application, no manual brake application is made until one of the test completion criteria is satisfied. For tests that include manual brake application, the service brakes are applied at 1.0 ± 0.1 second after FCW.

Test Completion Criteria

Any test is complete when the subject vehicle comes to a complete stop without making contact with the lead vehicle or when the subject vehicle makes contact with the lead vehicle.

Slower-Moving Lead Vehicle

Test Parameters

The slower-moving lead vehicle scenario involves the subject vehicle traveling straight ahead at constant speed, approaching a lead vehicle traveling at a slower speed in the subject vehicle path. NHTSA will test at the same two subject vehicle speed ranges as the stopped lead vehicle scenario depending on the manual brake application. The lead vehicle speed is 20 km/h.

Test Conduct Prior to FCW Onset

Prior to the start of a test trial the lead vehicle is propelled forward in a manner such that the longitudinal center plane of the lead vehicle does not deviate laterally more than 0.3m from the intended travel path.

As the subject vehicle approaches the rear of the lead vehicle, beginning when the headway corresponds to L_0, the subject vehicle speed is maintained within 1.6 km/h of the test speed with minimal and smooth accelerator pedal inputs. Furthermore, beginning when the headway corresponds to L_0, the subject vehicle and lead heading are to be maintained with minimal steering input such that the subject vehicle travel path does not deviate more than 0.3 m laterally from the intended travel path and the subject vehicle's yaw rate does not exceed ±1.0 deg/s.

Test Conduct After FCW onset

Similar to the stopped lead vehicle test, the subject vehicle accelerator pedal is released in response to the FCW. The procedure states that the accelerator pedal is released at any rate and is fully released within 500 milliseconds for subject vehicles tested without cruise control active. The accelerator pedal release can be omitted from tests of vehicles with cruise control actively engaged due to the lack of driver input to the accelerator pedal.

For testing without manual brake application, no manual brake application is made until one of the test completion criteria is satisfied. For testing with manual brake application, the service brake application occurs at 1.0 ± 0.1 second after FCW onset.

Test Completion Criteria

Any test run is complete when the subject vehicle speed is less than or equal to the lead vehicle speed without making contact with the lead vehicle or when the subject vehicle makes contact with the lead vehicle.

Decelerating Lead Vehicle

Test Parameters

The decelerating lead vehicle scenario is meant to assess the AEB performance when the subject vehicle and lead vehicle initially are travelling at the same constant speed in a straight path and the lead vehicle begins to decelerate. NHTSA tests under two basic setups for this scenario, one where both the subject vehicle and lead vehicle initial travel speed ($V_{SV} = V_{LV}$) is 50 km/h and another where both vehicles travel at 80 km/h. For both testing speeds, NHTSA tests with, and without, manual brake application, at any headway between 12 m and 40 m and at any lead vehicle deceleration between 0.3 g and 0.5 g.

Test Conduct Prior to Lead Vehicle Braking Onset

Up to 3 seconds prior to the start of a test trial there are no specific limitations on how a subject vehicle may be driven. Between 3 seconds prior and the lead vehicle braking onset, the lead vehicle is propelled forward in a manner such that the longitudinal center plane of the lead vehicle does not deviate laterally more than 0.3m from the intended travel path. During this same time interval, the subject vehicle follows the lead vehicle at the testing headway distance between 12 m and 40m. While the subject vehicle follows the lead vehicle from 3 seconds prior and lead vehicle brake onset, the subject vehicle and lead vehicle speeds are maintained within 1.6 km/h and their travel paths do not deviate more than 0.3 m laterally from the centerline of the lead vehicle. The speed is to be maintained with minimal and smooth accelerator pedal inputs and the and yaw rate of the subject vehicle may not exceed ±1.0 deg/s.

Test Conduct After Lead Vehicle Braking Onset

The lead vehicle is decelerated to a stop with a targeted average deceleration of any value between 0.3g and 0.5g. The targeted deceleration magnitude is to be achieved within 1.5 seconds of lead vehicle braking onset and maintained until 250 ms prior to coming to a stop. Similar to the lead vehicle tests, during each test trial, the subject vehicle accelerator pedal is released in response to the FCW and fully released within 500 milliseconds.

In the same manner as the slower lead vehicle tests, when testing without manual brake application, no manual brake application is made until one of the test completion criteria is satisfied. For testing with manual brake application, the service brake application occurs at 1.0 ± 0.1 second after FCW onset.

Test Completion Criteria

Any test run is complete when the subject vehicle comes to a complete stop without making contact with the lead vehicle or when the subject vehicle makes contact with the lead vehicle, similarly to the stopped lead vehicle tests.

Headway Calculation

For the scenarios where the headway is not specified (stopped lead vehicle and slower lead vehicle) the headway (L_0), in meters, providing 5 seconds time to collision (*TTC*) is calculated. L_0 is determined with the following equation where V_{SV} is the speed of the subject vehicle in m/s and V_{LV} is the speed of the lead vehicle in m/s:

$L_0 = \mathrm{TTC}_0 \times (V_{SV} - V_{LV})$

$TTC_0 = 5.0$

Travel Path

The intended travel path is the target path for a given test scenario and is identified by the projection onto the road surface of the frontmost point of the subject vehicle located on its longitudinal, vertical center plane. The subject vehicle's actual travel path is recorded and compared to the intended path.

The intended subject vehicle travel path is coincident with the center of a test lane whenever there are two edge lines marking a lane on the test track surface. If there is only one lane line (either a single or double line) marked on the test track, the vehicle path will be parallel to it and offset by 1.8 m (6 ft) to one side (measured from the inside edge of the line).

Subject Vehicle (Manual) Brake Application Procedures

Subject vehicle brake application is performed through either displacement or hybrid feedback at the manufacturer’s choosing. The subject vehicle brake application procedures are consistent with the manual brake applications defined in NHTSA’s NCAP test procedures for

DBS performance assessment.[178] The procedure is to begin with the subject vehicle brake pedal in its natural resting position with no preload or position offset.

Displacement Feedback Procedure

For the displacement feedback procedure, the commanded brake pedal position is the brake pedal position that results in a mean deceleration of 0.4 g in the absence of AEB system activation. The mean deceleration is the deceleration over the time from the pedal achieving the commanded position to 250 ms before the vehicle comes to a stop. The pedal displacement controller depresses the pedal at a rate of 254 mm/s ±25.4 mm/s to the commanded brake pedal position. The standard allows for the pedal displacement controller to overshoot the commanded position by any amount up to 20 percent. In the event of an overshoot, it may be corrected within 100 ms. The achieved brake pedal position is any position within 10 percent of the commanded position from 100 ms after pedal displacement occurs and any overshoot is corrected.

Hybrid Brake Pedal Feedback Procedure

For the hybrid brake pedal feedback procedure, the commanded brake pedal application is the brake pedal position and a subsequent commanded brake pedal force that results in a mean deceleration of 0.4 g in the absence of AEB system activation. The hybrid brake pedal application procedure follows the displacement application procedure, but instead of maintaining the achieved brake pedal displacement, the controller starts to control the force applied to the brake pedal (100 ms after pedal displacement occurs and any overshoot is corrected). The hybrid controller applies a pedal force of at least 11.1 N and maintains the pedal force within 10 percent of the commanded brake pedal force from 350 ms after commended pedal displacement occurs and any overshoot is corrected, until test completion.

Force Feedback Procedure

For the force feedback procedure, the commanded brake pedal application is the brake pedal force that results in a mean deceleration of 0.4 g in the absence of AEB system activation. The mean deceleration is the deceleration over the time from when the commanded brake pedal force is first achieved to 250 ms before the vehicle comes to a stop. The force controller achieves the commanded brake pedal force within 250 ms. The application rate is unrestricted. The force controller may overshoot the commanded force by up to 20 percent. If such an overshoot occurs, it is corrected within 250 ms from when the commanded force is first achieved. The force controller applies a pedal force of at least 11.1 N from the onset of the brake application until the end of the test.

B. Appendix B: Description of the PAEB Test Procedures

Test Parameters

The PAEB performance tests require a vehicle to avoid a collision with a pedestrian test device by applying the brakes automatically under certain test-track scenarios during daylight and darkness (with lower beam and with upper beams activated). Similar to the lead vehicle AEB performance test requirements, NHTSA adopted a no-contact requirement as a performance metric. The test scenarios for PAEB evaluation fall into three groups of scenarios based on the actions of the pedestrian test device – crossing path, stationary and along path. For each test conducted under the testing scenarios, NHTSA adopted the following options within those testing scenarios: (1) pedestrian crossing (right or left) relative to an approaching subject vehicle, (2) subject vehicle overlap (25% or 50%), (3) pedestrian obstruction (Yes/No), and (4) pedestrian speed stationary, walking, or running(V_P). Further parameters when approaching a pedestrian are selected from a subject vehicle speed range (V_{SV}) and the lighting condition (daylight, lower beams or upper beams). As opposed to lead vehicle AEB track testing, manual brake application by the driver is not a parameter of the test scenarios for PAEB.

Similarly to the lead vehicle AEB testing, NHTSA specifies that the travel path in each of the test scenarios be straight. For PAEB testing, the intended travel path of the subject vehicle is a straight line originating at the location corresponding to a headway of L_0.

NHTSA specifies that if the road surface is marked with a single or double lane line, the intended travel path be parallel to, and 1.8 m from the inside of the closest line. If the road surface is marked with two lane lines bordering the lane, the intended travel path is centered between the two lines.

For each PAEB test run, the headway (L_0), in meters, between the front plane of the subject vehicle and a parallel contact plane on the pedestrian test mannequin providing 4.0 seconds time to collision (*TTC*) is calculated. L_0 is determined with the following equation where V_{SV} is the speed of the subject vehicle in m/s and $V_{P\text{-}y}$ is the component of speed of the pedestrian test mannequin in m/s in the direction of the intended travel path:

$$L_0 = \mathrm{TTC}_0 \times (V_{SV} - V_{P\text{-}y})$$

$$\mathrm{TTC}_0 = 4.0$$

Overlap describes the location of the point on the front of the subject vehicle that would make contact with the pedestrian test mannequin (PTM) if no braking occurred and is the percentage of the subject vehicle's overall width that the pedestrian test mannequin traverses. It identifies the point on the subject vehicle that would contact a test mannequin within the subject vehicle travel path if the subject vehicle were to maintain its speed without braking, and it is measured from the right or the left (depending on the side of the subject vehicle where the pedestrian test mannequin originates).

Pedestrian Crossing Path

Test Parameters - Unobstructed from the Right

The unobstructed crossing path from the right scenario consists of the subject vehicle traveling straight at a constant speed towards the adult PTM, which enters its travel path (perpendicular to the vehicle's travel path) from the right side of the vehicle. The subject vehicle must be able to avoid contact with the pedestrian test mannequin crossing its path. NHTSA specifies testing the unobstructed crossing path scenario from the right with a 25% and 50% overlap during daylight and a 50% overlap for darkness with independent tests with the lower and upper beams activated. The subject vehicle testing speed is any speed between 10 km/h and 60 km/h, while the PTM speed is 5km/h.

Pedestrian Test Mannequin - Unobstructed from the Right

An adult PTM is used for this scenario and NHTSA specifies that the PTM is to be secured to a moving apparatus so that it faces the direction of motion at 4.0 ± 0.1 m to the right of the subject vehicle's intended travel path. The PTM's leg articulation is to start on apparatus movement and stops when the apparatus stops. The PTM speed is 5 km/h.

Test Parameters - Unobstructed from the Left

The unobstructed crossing path from the left scenario consists of the subject vehicle traveling straight at a constant speed towards the adult PTM, which enters its travel path (perpendicular to the vehicle's travel path) from the left side of the vehicle. The subject vehicle must be able to avoid contact with the pedestrian test mannequin crossing its path. NHTSA will test the unobstructed crossing path scenario from the left with a 50% overlap during daylight. The subject vehicle testing speed is any speed between 10 km/h and 60 km/h, while the PTM speed is 8 km/h.

Pedestrian Test Mannequin – Unobstructed from the Left

An adult PTM is used for this scenario, and NHTSA specifies that the PTM be secured to a moving apparatus so that it faces the direction of motion at 6.0 ± 0.1 m to the left of the intended travel path. The PTM's leg articulation is to start on apparatus movement and stops when the apparatus stops. As this simulates a running adult pedestrian, the PTM speed is 8 km/h.

Test Parameters - Obstructed from the Right

The obstructed crossing path from the right scenario consists of the subject vehicle traveling straight at a constant speed towards a child PTM, which enters its travel path (perpendicular to the travel path) from the right side of the vehicle. The child PTM crosses the subject vehicle's travel path from in front of two stopped VTDs. The VTDs are parked to the right of the subject vehicle's travel path, in the adjacent lane, at 1.0 m (3 ft) from the side of the subject vehicle (tangent with the right outermost point of the subject vehicle when the subject vehicle is in the intended travel path). The VTDs are parked one after the other and are facing in the same direction as the subject vehicle. One VTD is directly behind the other, separated by 1.0 ± 0.1 m. The subject vehicle must be able to avoid contact with the child PTM crossing its path. NHTSA specifies testing this scenario with a 50% overlap during daylight. The subject vehicle testing speed is any speed between 10 km/h and 50 km/h, while the child PTM speed is 5 km/h.

Pedestrian Test Mannequin - Obstructed from the Right

A child PTM is used for the obstructed scenario. NHTSA specifies that the child PTM is secured to a moving apparatus so that it faces the direction of motion at 4.0 ± 0.1 m to the right of the intended travel path. The PTM's leg articulation is to start on apparatus movement and stops when the apparatus stops. This scenario simulates a running child pedestrian and the child PTM speed is 5 km/h.

Test Conduct Prior to FCW or Vehicle Braking Onset

NHTSA specifies that, as the subject vehicle approaches the crossing path of the PTM, beginning when the headway corresponds to L_0, the subject vehicle speed be maintained within 1.6 km/h of the test speed with minimal and smooth accelerator pedal inputs. Furthermore, beginning when the headway corresponds to L_0, the subject vehicle heading is to be maintained with minimal steering input such that the subject vehicle travel path does not deviate more than 0.3 m laterally from the intended travel path and the subject vehicle's yaw rate does not exceed ±1.0 deg/s. Prior to the start of a test trial, as long as the specified initialization procedure is executed, a subject vehicle may be driven under any conditions including any speed and direction, and on any road surface, for any elapsed time prior to reaching the point where a test trial begins. For all tests, there is no specific limitations on how a subject vehicle is driven prior to the start of a test trail, in the same manner as for the lead vehicle trials.

The PTM apparatus is to be triggered at a time such that the pedestrian test mannequin meets the intended overlap. The agency specifies that the PTM achieve its intended speed within 1.5 m after the apparatus begins to move and maintains its intended speed within 0.4 km/h until the test completion criteria is satisfied.

Test Conduct after Either FCW or Vehicle Braking Onset

NHTSA specifies that after FCW or vehicle braking onset, the subject vehicle's accelerator pedal is released at any rate such that it is fully released within 500 ms. This action is omitted for vehicles with cruise control active.

During testing, no manual brake application is permitted and the PTM continues to move until one of the test completion criteria is satisfied.

Test Completion Criteria

NHTSA specifies that any test run is complete when the subject vehicle comes to a complete stop without making contact with the PTM, when the PTM is no longer in the forward path of the subject vehicle, or when the subject vehicle makes contact with the PTM.

Stationary Pedestrian

Test Parameters

The stationary pedestrian scenario consists of the subject vehicle traveling straight at a constant speed towards the adult PTM, which is stationary at an overlap of 25%, facing away from the approaching subject vehicle. The subject vehicle must be able to avoid contact with the stationary PTM during daylight and darkness with lower beam and upper beam. The subject vehicle testing speed is any speed between 10 km/h and 55 km/h.

Pedestrian Test Mannequin

An adult PTM is used for this scenario and NHTSA specifies that the PTM be stationary and face away from the subject vehicle. The pedestrian test mannequin legs remain still.

Test Conduct Prior to FCW or Vehicle Braking Onset

NHTSA specifies that as the subject vehicle approaches the stationary PTM, beginning when the headway corresponds to L_0, the subject vehicle speed be maintained within 1.6 km/h of the test speed with minimal and smooth accelerator pedal inputs. Furthermore, beginning when the headway corresponds to L_0, the subject vehicle heading is to be maintained with minimal steering input such that the subject vehicle travel path does not deviate more than 0.3 m laterally from the intended travel path and the subject vehicle's yaw rate does not exceed ±1.0 deg/s. Similarly to the other tests, the subject vehicle may be driven under any conditions including any speed and direction, and on any road surface, for any elapsed time prior to reaching the point where a test trial begins.

Test Conduct after Either FCW or Vehicle Braking Onset

NHTSA specifies that after FCW or vehicle braking onset, the subject vehicle's accelerator pedal is released at any rate such that it is fully released within 500 ms. This action is omitted for vehicles with cruise control active. No manual braking is permitted during testing until one of the test completion criteria is satisfied.

Test Completion Criteria

NHTSA specifies that any test run is complete when the subject vehicle comes to a complete stop without making contact with the PTM or when the subject vehicle makes contact with the PTM.

Pedestrian Moving Along the Path

Test Parameters

The pedestrian moving along path scenario consists of the subject vehicle traveling straight at a constant speed towards an adult PTM moving away from the vehicle. The PTM is moving at 5 km/h at an overlap of 25%, facing away on the same travel path as the vehicle. The

PTM's movement is parallel to and in the same direction as the subject vehicle. The subject vehicle must be able to avoid contact with the moving PTM during daylight and darkness with lower beam and upper beam. The subject vehicle testing speed is any speed between 10 km/h and 65 km/h.

Test Conduct Prior to FCW or Vehicle Braking Onset

NHTSA specifies that as the subject vehicle approaches the moving PTM, beginning when the headway corresponds to L_0, the subject vehicle speed is maintained within 1.6 km/h of the test speed with minimal and smooth accelerator pedal inputs. Furthermore, beginning when the headway corresponds to L_0, the subject vehicle heading is to be maintained with minimal steering input such that the subject vehicle travel path does not deviate more than 0.3 m laterally from the intended travel path and the subject vehicle's yaw rate does not exceed ±1.0 deg/s. Similarly to the other tests the subject vehicle may be driven under any conditions including any speed and direction, and on any road surface, for any elapsed time prior to reaching the point where a test trial begins.

The PTM is to be secured to a moving apparatus triggered any time after the distance between the front plane of the subject vehicle and a parallel contact plane on the pedestrian test mannequin corresponds to L_0. The specifications state that the PTM achieve its intended speed within 1.5 m after the apparatus begins to move and maintain its intended speed within 0.4 km/h until one of the test completion criteria is satisfied.

Test Conduct after Either FCW or Vehicle Braking Onset

NHTSA specifies that after FCW or vehicle braking onset, the subject vehicle's accelerator pedal is released at any rate such that it is fully released within 500 ms. This action is omitted for vehicles with cruise control active. No manual braking is permitted during testing until one of the test completion criteria is satisfied.

Test Completion Criteria

NHTSA specifies that any test run is complete when the subject vehicle slows to a speed below that of the PTM without making contact with the PTM, or when the subject vehicle makes contact with the PTM.

C. Appendix C: Description of the False Activation Test Procedures

Test Parameters

Headway calculation

NHTSA specifies that for each test run conducted, the headway (L_0, $L_{2.1}$, $L_{1.1}$), in meters, between the front plane of the subject vehicle and either the steel trench plate's leading edge or the rearmost plane normal to the centerline of the vehicle test devices providing a 5.0 second, 2.1 second, and 1.1 second time to collision (TTC) is calculated. L_0, $L_{2.1}$, and $L_{1.1}$ are determined with the following equation where V_{SV} is the speed of the subject vehicle in m/s:

$L_x = \mathrm{TTC}_x \times (V_{SV})\ m$

$TTC_0 = 5.0\ s$

$TTC_{2.1} = 2.1\ s$

$TTC_{1.1} = 1.1\ s$

Steel Trench Plate

Test Parameters

The steel trench plate false activation scenario involves the subject vehicle approaching at 80 km/h a steel plate, commonly used in road construction, placed on the surface of a test track in its intended travel path. The steel trench plate is positioned flat on the test surface so that its longest side is parallel to the vehicle's intended travel path and horizontally centered on the vehicle's intended travel path. The steel plate presents no imminent danger, and the subject vehicle can safely travel over the plate without harm. NHTSA specifies testing with and without manual brake application.

Test Conduct

The procedure states that as the subject vehicle approaches the steel trench plate, the subject vehicle speed shall be maintained within 1.6 km/h of the test speed with minimal and smooth accelerator pedal inputs beginning when the headway corresponds to L_0. Furthermore, beginning when the headway corresponds to L_0, the subject vehicle heading is to be maintained with minimal steering input such that the subject vehicle travel path does not deviate more than 0.3 m laterally from the intended travel path and the subject vehicle's yaw rate does not exceed ±1.0 deg/s. If an FCW occurs, the subject vehicle's accelerator pedal is released at any rate such that it is fully released within 500 ms. This action is omitted for tests performed with the subject vehicle's cruise control active.

For testing without manual brake application, no manual brake application is made until one of the test completion criteria is satisfied. For testing with manual brake application, the subject vehicle's accelerator pedal, if not already released, is released when the headway corresponds to $L_{2.1}$ at any rate such that it is fully released within 500 ms. The service brake application occurs at headway $L_{1.1}$.

Test Completion Criteria

The test run is complete when the subject vehicle comes to a stop prior to crossing over the leading edge of the steel trench plate or when the subject vehicle crosses over the leading edge of the steel trench plate.

Pass-through Test

Test Parameters

The pass-through test simulates the subject vehicle approaching at 80 km/h vehicle test devices secured in a stationary position parallel to one another with a lateral distance of 4.5 m ±0.1 m between the vehicles' closest front wheels. The centerline between the two vehicles is parallel to the intended travel path and the travel path is free of obstacles. NHTSA tests with and without manual brake application.

Test Conduct

The procedure states that as the subject vehicle approaches the gap between the two vehicle test devices, beginning when the headway corresponds to L_0, the subject vehicle speed be maintained within 1.6 km/h of the test speed with minimal and smooth accelerator pedal inputs. Furthermore, beginning when the headway corresponds to L_0, the subject vehicle heading is to be maintained with minimal steering input such that the subject vehicle travel path does not deviate more than 0.3 m laterally from the intended travel path and the subject vehicle's yaw rate does not exceed ±1.0 deg/s. If an FCW occurs, the subject vehicle's accelerator pedal is released at any rate such that it is fully released within 500 ms. This action is omitted for vehicles with cruise control active.

For testing without manual brake application, no manual brake application is made until one of the test completion criteria is satisfied. For testing with manual brake application, the subject vehicle's accelerator pedal, if not already released, is released when the headway corresponds to $L_{2.1}$ at any rate such that it is fully released within 500 ms. The service brake application occurs at headway $L_{1.1}$.

Test Completion Criteria

The test run is complete when the subject vehicle comes to a stop prior to its rearmost point passing the vertical plane connecting the forwardmost point of the vehicle test devices or when the rearmost point of the subject vehicle passes the vertical plane connecting the forwardmost point of the vehicle test devices.

List of Subjects

49 CFR Part 571

Imports, Incorporation by reference, Motor vehicle safety, Motor vehicles, Rubber and rubber products.

49 CFR Part 595

Motor vehicle safety, Motor vehicles.

49 CFR Part 596

Automatic emergency braking, Incorporation by reference, Motor vehicles, Motor vehicle safety, Test devices.

In consideration of the foregoing, NHTSA amends 49 CFR chapter V as follows:

PART 571—FEDERAL MOTOR VEHICLE SAFETY STANDARDS

1. The authority citation for part 571 continues to read as follows:

Authority: 49 U.S.C. 322, 30111, 30115, 30117 and 30166; delegation of authority at 49 CFR 1.95.

2. Amend § 571.5 by:

a. Revising paragraph (d)(35);

b. Redesignating paragraphs (l)(49) and (50) as paragraphs (l)(50) and (51), respectively; and

c. Adding new paragraph (l)(49).

The revision and addition read as follows:

§ 571.5 Matter incorporated by reference.

* * * * *

(d) * * *

(35) ASTM E1337-19, "Standard Test Method for Determining Longitudinal Peak Braking Coefficient (PBC) of Paved Surfaces Using Standard Reference Test Tire," approved December 1, 2019, into §§571.105; 571.121; 571.122; 571.126; 571.127; 571.135; 571.136; 571.500.

* * * * *

(l) * * *

(49) SAE J2400, "Human Factors in Forward Collision Warning Systems: Operating Characteristics and User Interface Requirements," August 2003 into § 571.127.

* * * * *

3. Add § 571.127 to read as follows:

§ 571.127 Standard No. 127; Automatic emergency braking systems for light vehicles.

S1. *Scope*. This standard establishes performance requirements for automatic emergency braking (AEB) systems for light vehicles.

S2. *Purpose*. The purpose of this standard is to reduce the number of deaths and injuries that result from crashes in which drivers do not apply the brakes or fail to apply sufficient braking power to avoid or mitigate a crash.

S3. *Application*. This standard applies to passenger cars and to multipurpose passenger vehicles, trucks, and buses with a gross vehicle weight rating (GVWR) of 4,536 kilograms (10,000 pounds) or less.

S4. *Definitions*.

Adaptive cruise control system is an automatic speed control system that allows the equipped vehicle to follow a lead vehicle at a pre-selected gap by controlling the engine, power train, and service brakes.

Ambient illumination is the illumination as measured at the test surface, not including any illumination provided by the subject vehicle.

Automatic emergency braking (*AEB) system* is a system that detects an imminent collision with vehicles, objects, and road users in or near the path of a vehicle and automatically controls the vehicle's service brakes to avoid or mitigate the collision.

Brake pedal application onset is when 11 N of force has been applied to the brake pedal.

Forward collision warning is an auditory and visual warning provided to the vehicle operator by the AEB system that is designed to induce immediate forward crash avoidance response by the vehicle operator.

Forward collision warning onset is the first moment in time when a forward collision warning is provided.

Headway is the distance between the subject vehicle's frontmost plane normal to its centerline and as applicable: the vehicle test device's rearmost plane normal to its centerline; a parallel contact plane (to the subject vehicle's frontmost plane) on the pedestrian test mannequin; and the leading edge of the steel trench plate.

Lead vehicle is a vehicle test device facing the same direction and preceding a subject vehicle within the same travel lane.

Lead vehicle braking onset is the point at which the lead vehicle achieves a deceleration of 0.05 g due to brake application.

Masked threshold is the quietest level of a signal that can be perceived in the presence of noise.

Pedestrian test mannequin is a device used during AEB testing, when approaching pedestrians, meeting the specifications of subpart B of 49 CFR part 596.

Small-volume manufacturer means an original vehicle manufacturer that produces or assembles fewer than 5,000 vehicles annually for sale in the United States.

Steel trench plate is a rectangular steel plate often used in road construction to temporarily cover sections of pavement unsafe to drive over directly.

Subject vehicle is the vehicle under examination for compliance with this standard.

Travel path is the path projected onto the road surface of a point located at the intersection of the subject vehicle's frontmost vertical plane and longitudinal vertical center plane, as the subject vehicle travels forward.

Subject vehicle braking onset is the point at which the subject vehicle achieves a deceleration of 0.15 g due to the automatic control of the service brakes.

Vehicle test device is a device meeting the specifications set forth in subpart C of 49 CFR part 596.

S5. *Requirements.*

(a) Except as provided in S5(b), vehicles manufactured on or after September 1, 2029 must meet the requirements of this standard.

(b) The requirements of S5(a) do not apply to small-volume manufacturers, final-stage manufacturers, and alterers until one year after the dates specified in S5(a).

S5.1. *Requirements when approaching a lead vehicle*.

S5.1.1. *Forward collision warning.* A vehicle is required to have a forward collision warning system, as defined in S4 that provides an auditory and visual signal to the driver of an impending collision with a lead vehicle. The system must operate under the conditions specified in S6 when traveling at any forward speed that is greater than 10 km/h (6.2 mph) and less than 145 km/h (90.1 mph).

(a) *Auditory signal.*

(1) The auditory signal must have a high fundamental frequency of at least 800 Hz.

(2) The auditory signal must have a tempo in the range of 6-12 pulses per second and a duty cycle in the range of 0.25 - 0.95.

(3) The auditory signal must have a minimum intensity of 15–30 dB above the masked threshold.

(4) In-vehicle audio that is not related to a safety purpose or safety system (i.e., entertainment and other audio content not related to or essential for safe performance of the driving task) must be muted, or reduced in volume to within 5 dB of the masked threshold during presentation of the FCW auditory signal.

(b) *Visual signal.*

(1) The visual signal must be located within an ellipse that extends 18 degrees vertically and 10 degrees horizontally of the driver forward line of sight based on the forward-looking eye midpoint (M_f) as described in S14.1.5. of § 571.111.

(2) The visual signal must include the crash pictorial symbol in SAE J2400, 4.1.16, incorporated by reference (see § 571.5).

(3) The visual signal symbol must be red in color and steady burning.

S5.1.2. *Automatic emergency braking*. A vehicle is required to have an automatic emergency braking system, as defined in S4, that applies the service brakes automatically when a collision with a lead vehicle is imminent. The system must operate under the conditions specified in S6 when the vehicle is traveling at any forward speed that is greater than 10 km/h (6.2 mph) and less than 145 km/h (90.1 mph).

S5.1.3. *Performance test requirements.* The vehicle must provide a forward collision warning and subsequently apply the service brakes automatically when a collision with a lead vehicle is imminent such that the subject vehicle does not collide with the lead vehicle when tested using the procedures in S7 under the conditions specified in S6. The forward collision warning is not required if adaptive cruise control is engaged.

S5.2. *Requirements when approaching pedestrians*.

S5.2.1. *Forward collision warning*. A vehicle is required to have a forward collision warning system, as defined in S4, that provides an auditory and visual signal to the driver of an impending collision with a pedestrian. The system must operate under the conditions specified in S6 when the vehicle is traveling at any forward speed that is greater than 10 km/h (6.2 mph) and less than 73 km/h (45.3 mph). The forward collision warning system must meet the auditory signal and visual signal requirements specified in S5.1.1.

S5.2.2. *Automatic emergency braking*. A vehicle is required to have an automatic emergency braking system, as defined in S4, that applies the service brakes automatically when a collision with a pedestrian is imminent when the vehicle is under the conditions specified in S6 and is traveling at any forward speed that is greater than 10 km/h (6.2 mph) and less than 73 km/h (45.3 mph).

S5.2.3. *Performance test requirements.* The vehicle must provide a forward collision warning and apply the brakes automatically such that the subject vehicle does not collide with the pedestrian test mannequin when tested using the procedures in S8 under the conditions specified in S6.

S5.3. *False activation.* The vehicle must not automatically apply braking that results in peak additional deceleration that exceeds what manual braking would produce by 0.25 g or greater, when tested using the procedures in S9 under the conditions specified in S6.

S5.4. *Malfunction detection and controls*.

S5.4.1 The system must continuously detect system malfunctions, including performance degradation caused solely by sensor obstructions. If the system detects a malfunction, or if the system adjusts its performance such that it will not meet the requirements specified in S5.1, S5.2, or S5.3, the system must provide the vehicle operator with a telltale notification.

S5.4.2 Except as provided in S5.4.2.1 and S5.4.2.2, the manufacturer must not provide a control that will place the AEB system in a mode or modes in which it will no longer satisfy the performance requirements of S5.1, S5.2, and S5.3.

S5.4.2.1 The manufacturer may provide a control to allow AEB deactivation that is securely activated, provided the manufacturer enables such activation exclusively in a vehicle owned by a law enforcement agency.

S5.4.2.2 The manufacturer may allow AEB deactivation to occur during low-range four-wheel drive configurations, when the driver selects "tow mode," or when another vehicle system is activated that will have a negative ancillary impact on AEB operation.

S5.4.3 The vehicle's AEB system must always return to the manufacturer's original default AEB mode that satisfies the requirements of S5.1, S5.2, and S5.3 at the initiation of each new ignition cycle, unless the vehicle is in a low-range four-wheel drive configuration selected by the driver on the previous ignition cycle designed for low-speed, off-road driving.

S6. *Test conditions*.

S6.1. *Environmental conditions.*

S6.1.1. *Temperature*. The ambient temperature is any temperature between 0 °C and 40 °C.

S6.1.2. *Wind*. The maximum wind speed is no greater than 10 m/s (22 mph) during lead vehicle avoidance tests and 6.7 m/s (15 mph) during pedestrian avoidance tests.

S6.1.3. *Ambient lighting*.

(a) *Daylight testing*.

(1) The ambient illumination on the test surface is any level at or above 2,000 lux.

(2) Testing is not performed while driving toward or away from the sun such that the horizontal angle between the sun and a vertical plane containing the centerline of the subject vehicle is less than 25 degrees and the solar elevation angle is less than 15 degrees.

(b) *Dark testing*.

(1) The ambient illumination on the test surface is any level at or below 0.2 lux.

(2) Testing is performed under any lunar phase.

(3) Testing is not performed while driving toward the moon such that the horizontal angle between the moon and a vertical plane containing the centerline of the subject vehicle is less than 25 degrees and the lunar elevation angle is less than 15 degrees.

S6.1.4. *Precipitation*. Testing is not conducted during periods of precipitation or when visibility is affected by fog, smoke, ash, or other particulate.

S6.2. *Road conditions*.

S6.2.1. *Test Track surface and construction.* The tests are conducted on a dry, uniform, solid-paved surface. Surfaces with debris, irregularities, or undulations, such as loose pavement, large cracks, or dips may not be used.

S6.2.2. *Surface friction.* The road test surface produces a peak friction coefficient (PFC) of 1.02 when measured using an ASTM F2493 standard reference test tire, in accordance with ASTM E1337-19 (incorporated by reference, see § 571.5), at a speed of 64 km/h (40 mph), without water delivery.

S6.2.3. *Slope.* The test surface has any consistent slope between 0 percent and 1 percent.

S6.2.4. *Markings.* The road surface within 2 m of the intended travel path is marked with zero, one, or two lines of any configuration or color. If one line is used, it is straight. If two lines are used, they are straight, parallel to each other, and at any distance from 2.7 m to 4.5 m apart.

S6.2.5. *Obstructions.* Testing is conducted such that the vehicle does not travel beneath any overhead structures, including but not limited to overhead signs, bridges, or gantries. No vehicles, obstructions, or stationary objects are within 7.4 m of either side of the intended travel path except as specified.

S6.3. *Subject vehicle conditions*.

S6.3.1. *Malfunction notification.* Testing is not conducted while the AEB malfunction telltale specified in S5.4 is illuminated.

S6.3.2. *Sensor obstruction*. All sensors used by the system and any part of the vehicle immediately ahead of the sensors, such as plastic trim, the windshield, etc., are free of debris or obstructions.

S6.3.3. *Tires*. The vehicle is equipped with the original tires present at the time of initial sale. The tires are inflated to the vehicle manufacturer's recommended cold tire inflation pressure(s) specified on the vehicle's placard or the tire inflation pressure label.

S6.3.4. *Brake burnish*.

(a) Vehicles subject to § 571.105 are burnished in accordance with S7.4 of § 571.105.

(b) Vehicles subject to § 571.135 are burnished in accordance with S7.1 of § 571.135.

S6.3.5. *Brake temperature*. The average temperature of the service brakes on the hottest axle of the vehicle during testing, measured according to S6.4.1 of § 571.135, is between 65°C and 100°C prior to braking.

S6.3.6. *Fluids*. All non-consumable fluids for the vehicle are at 100 percent capacity. All consumable fluids are at any level from 5 to 100 percent capacity.

S6.3.7. *Propulsion battery charge.* The propulsion batteries are charged at any level from 5 to 100 percent capacity.

S6.3.8. *Cruise control.* Cruise control, including adaptive cruise control, is configured under any available setting.

S6.3.9. *Adjustable forward collision warning*. Forward collision warning is configured in any operator-configurable setting.

S6.3.10. *Engine braking.* A vehicle equipped with an engine braking system that is engaged and disengaged by the operator is tested with the system in any selectable configuration.

S6.3.11. *Regenerative braking*. Regenerative braking is configured under any available setting.

S6.3.12. *Headlamps*.

(a) Daylight testing is conducted with the headlamp control in any selectable position.

(b) Darkness testing is conducted with the vehicle's lower beams active and separately with the vehicle's upper beams active.

(c) Prior to performing darkness testing, headlamps are aimed according to the vehicle manufacturer's instructions. The weight of the loaded vehicle at the time of headlamp aiming is within 10 kg of the weight of the loaded vehicle during testing.

S6.3.13. *Subject vehicle loading*. The vehicle load, which is the sum of any vehicle occupants and any test equipment and instrumentation, does not exceed 277 kg. The load does not cause the vehicle to exceed its GVWR or any axle to exceed its GAWR.

S6.3.14. *AEB system initialization.* The vehicle is driven at a speed of 10 km/h or higher for at least one minute prior to testing, and subsequently the starting system is not cycled off prior to testing.

S6.4. *Equipment and test devices.*

S6.4.1. The vehicle test device is specified in 49 CFR part 596, subpart C. Local fluttering of the lead vehicle's external surfaces does not exceed 10 mm perpendicularly from the reference surface, and distortion of the lead vehicle's overall shape does not exceed 25 mm in any direction.

S6.4.2. Adult pedestrian test mannequin is specified in 49 CFR part 596, subpart B.

S6.4.3. Child pedestrian test mannequin is specified in 49 CFR part 596, subpart B.

S6.4.4. The steel trench plate used for the false activation test has the dimensions 2.4 m x 3.7 m x 25 mm and is made of ASTM A36 steel. Any metallic fasteners used to secure the steel trench plate are flush with the top surface of the steel trench plate.

S7. *Testing when approaching a lead vehicle*.

S7.1. *Setup*.

(a) The testing area is set up in accordance with figure 2 to this section.

(b) Testing is conducted during daylight.

(c) For reference, table 1 to S7.1 specifies the subject vehicle speed (V_{SV}), lead vehicle speed (V_{LV}), headway, and lead vehicle deceleration for each test that may be conducted.

(d) The intended travel path of the vehicle is a straight line toward the lead vehicle from the location corresponding to a headway of L_0.

(e) If the road surface is marked with a single or double lane line, the intended travel path is parallel to and 1.8 m from the inside of the closest line. If the road surface is marked with two lane lines bordering the lane, the intended travel path is centered between the two lines.

(f) For each test run conducted, the subject vehicle speed (V_{SV}), lead vehicle speed (V_{LV}), headway, and lead vehicle deceleration will be selected from the ranges specified in table 1 to S7.1.

Table 1 to S7.1 –Test Parameters when Approaching a Lead Vehicle

	Speed (km/h)		Headway (m)	Lead Vehicle Decel (g)	Manual Brake Application
	V_{SV}	V_{LV}			
Stopped Lead Vehicle	Any 10-80	0	--	--	No
	Any 70-100	0	--	--	Yes
Slower-Moving Lead Vehicle	Any 40-80	20	--	--	No
	Any 70-100	20	--	--	Yes
Decelerating Lead Vehicle	50	50	Any 12-40	Any 0.3-0.5	No
	50	50	Any 12-40	Any 0.3-0.5	Yes
	80	80	Any 12-40	Any 0.3-0.5	No
	80	80	Any 12-40	Any 0.3-0.5	Yes

S7.2. *Headway calculation*. For each test run conducted under S7.3 and S7.4, the headway (L_0), in meters, providing 5.0 seconds time to collision (*TTC*) is calculated. L_0 is determined with the following equation where V_{SV} is the speed of the subject vehicle in m/s and V_{LV} is the speed of the lead vehicle in m/s:

Equation 1 to S7.2

$$L_0 = \mathrm{TTC}_0 \times (V_{SV} - V_{LV})$$

$$\mathrm{TTC}_0 = 5.0$$

S7.3. *Stopped lead vehicle*.

S7.3.1. *Test parameters*.

(a) For testing with no subject vehicle manual brake application, the subject vehicle test speed is any speed between 10 km/h and 80 km/h, and the lead vehicle speed is 0 km/h.

(b) For testing with manual brake application of the subject vehicle, the subject vehicle test speed is any speed between 70 km/h and 100 km/h, and the lead vehicle speed is 0 km/h.

S7.3.2. *Test conduct prior to forward collision warning onset.*

(a) The lead vehicle is placed stationary with its longitudinal centerline coincident to the intended travel path.

(b) Before the headway corresponds to L_0, the subject vehicle is driven at any speed, in any direction, on any road surface, for any amount of time.

(c) The subject vehicle approaches the rear of the lead vehicle.

(d) Beginning when the headway corresponds to L_0, the subject vehicle speed is maintained within 1.6 km/h of the test speed with minimal and smooth accelerator pedal inputs.

(e) Beginning when the headway corresponds to L_0, the subject vehicle heading is maintained with minimal steering input such that the travel path does not deviate more than 0.3 m laterally from the intended travel path and the subject vehicle's yaw rate does not exceed ±1.0 deg/s.

S7.3.3. *Test conduct after forward collision warning onset.*

(a) The accelerator pedal is released at any rate such that it is fully released within 500 ms. This action is omitted for vehicles tested with cruise control active.

(b) For testing conducted with manual brake application, the service brakes are applied as specified in S10. The onset of brake pedal application occurs 1.0 ± 0.1 second after forward collision warning onset.

(c) For testing conducted without manual brake application, no manual brake application is made until the test completion criteria of S7.3.4 are satisfied.

S7.3.4. *Test completion criteria.* The test run is complete when the subject vehicle comes to a complete stop without making contact with the lead vehicle or when the subject vehicle makes contact with the lead vehicle.

S7.4. *Slower-moving lead vehicle.*

S7.4.1. *Test parameters*.

(a) For testing with no subject vehicle manual brake application, the subject vehicle test speed is any speed between 40 km/h and 80 km/h, and the lead vehicle speed is 20 km/h.

(b) For testing with manual brake application of the subject vehicle, the subject vehicle test speed is any speed between 70 km/h and 100 km/h, and the lead vehicle speed is 20 km/h.

S7.4.2. *Test conduct prior to forward collision warning onset.*

(a) The lead vehicle is propelled forward in a manner such that the longitudinal center plane of the lead vehicle does not deviate laterally more than 0.3m from the intended travel path.

(b) The subject vehicle approaches the lead vehicle.

(c) Before the headway corresponds to L_0, the subject vehicle is driven at any speed, in any direction, on any road surface, for any amount of time.

(d) Beginning when the headway corresponds to L_0, the subject vehicle and lead vehicle speed is maintained within 1.6 km/h of the test speed with minimal and smooth accelerator pedal inputs.

(e) Beginning when the headway corresponds to L_0, the subject vehicle and lead vehicle headings are be maintained with minimal steering input such that the subject vehicle's travel path does not deviate more than 0.3 m laterally from the centerline of the lead vehicle, and the yaw rate of the subject vehicle does not exceed ±1.0 deg/s prior to the forward collision warning onset.

S7.4.3. *Test conduct after forward collision warning onset.*

(a) The subject vehicle's accelerator pedal is released at any rate such that it is fully released within 500 ms. This action is omitted for vehicles tested with cruise control active.

(b) For testing conducted with manual braking application, the service brakes are applied as specified in S10. The onset of brake pedal application is 1.0 ±0.1 second after the forward collision warning onset.

(c) For testing conducted without manual braking application, no manual brake application is made until the test completion criteria of S7.4.4 are satisfied.

S7.4.4. *Test completion criteria.* The test run is complete when the subject vehicle speed is less than or equal to the lead vehicle speed without making contact with the lead vehicle or when the subject vehicle makes contact with the lead vehicle.

S7.5. *Decelerating lead vehicle*.

S7.5.1. *Test parameters.*

(a) The subject vehicle test speed is 50 km/h or 80 km/h, and the lead vehicle speed is identical to the subject vehicle test speed.

(b) [Reserved]

S7.5.2. *Test conduct prior to lead vehicle braking onset.*

(a) Before the 3 seconds prior to lead vehicle braking onset, the subject vehicle is be driven at any speed, in any direction, on any road surface, for any amount of time.

(b) Between 3 seconds prior to lead vehicle braking onset and lead vehicle braking onset:

(1) The lead vehicle is propelled forward in a manner such that the longitudinal center plane of the vehicle does not deviate laterally more than 0.3 m from the intended travel path.

(2) The subject vehicle follows the lead vehicle at a headway of any distance between 12 m and 40 m.

(3) The subject vehicle's speed is maintained within 1.6 km/h of the test speed with minimal and smooth accelerator pedal inputs prior to forward collision warning onset.

(4) The lead vehicle's speed is maintained within 1.6 km/h.

(5) The subject vehicle and lead vehicle headings are maintained with minimal steering input such that their travel paths do not deviate more than 0.3 m laterally from the centerline of the lead vehicle, and the yaw rate of the subject vehicle does not exceed ±1.0 deg/s until onset of forward collision warning.

S7.5.3. *Test conduct following lead vehicle braking onset.*

(a) The lead vehicle is decelerated to a stop with a targeted average deceleration of any value between 0.3g and 0.5g. The targeted deceleration magnitude is achieved within 1.5 seconds of lead vehicle braking onset and is maintained until 250 ms prior to coming to a stop.

(b) After forward collision warning onset, the subject vehicle's accelerator pedal is released at any rate such that it is fully released within 500 ms. This action is omitted for vehicles with cruise control active.

(c) For testing conducted with manual braking application, the service brakes are applied as specified in S10. The brake pedal application onset occurs 1.0 ± 0.1 second after the forward collision warning onset.

(d) For testing conducted without manual braking application, no manual brake application is made until the test completion criteria of S7.5.4 are satisfied.

S7.5.4. *Test completion criteria.* The test run is complete when the subject vehicle comes to a complete stop without making contact with the lead vehicle or when the subject vehicle makes contact with the lead vehicle.

S8. *Testing when approaching a pedestrian.*

S8.1. *Setup*.

S8.1.1. *General*.

(a) For reference, table 2 to S8.1.1 specifies the pedestrian test mannequin direction of travel, overlap, obstruction condition and speed (V_P), the subject vehicle speed (V_{SV}), and the lighting condition for each test that may be conducted.

(b) The intended travel path of the vehicle is a straight line originating at the location corresponding to a headway of L_0.

(c) If the road surface is marked with a single or double lane line, the intended travel path is parallel to and 1.8 m from the inside of the closest line. If the road surface is marked with two lane lines bordering the lane, the intended travel path is centered between the two lines.

(d) For each test run conducted, the subject vehicle speed (V_{SV}) will be selected from the range specified in table 2 to S8.1.1.

Table 2 to S8.1.1 –Test Parameters when Approaching a Pedestrian

	Direction	Overlap	Obstructed	Speed (km/h)		Lighting Condition
				V_{SV}	V_P	
Pedestrian Crossing Road	Right	25%	No	Any 10 - 60	5	Daylight
	Right	50%	No	Any 10 - 60	5	Daylight
						Lower Beams
						Upper Beams
	Left	50%	No	Any 10 - 60	8	Daylight
	Right	50%	Yes	Any 10 - 50	5	Daylight
Stationary Pedestrian	Right	25%	No	Any 10 - 55	0	Daylight
						Lower Beams
						Upper Beams
Pedestrian Moving Along the Path	Right	25%	No	Any 10 - 65	5	Daylight
						Lower Beams
						Upper Beams

S8.1.2. *Overlap*. As depicted in figure 1 to this section, overlap describes the location of the point on the front of the subject vehicle that would make contact with a pedestrian if no braking occurred. Overlap is the percentage of the subject vehicle's overall width that the pedestrian test mannequin traverses. It is measured from the right or the left, depending on the side of the subject vehicle where the pedestrian test mannequin originates. For each test run, the actual overlap will be within 0.15 m of the specified overlap.

S8.1.3. *Pedestrian test mannequin*.

(a) For testing where the pedestrian test mannequin is secured to a moving apparatus, the pedestrian test mannequin is secured so that it faces the direction of motion. The pedestrian test mannequin leg articulation starts on apparatus movement and stops when the apparatus stops.

(b) For testing where the pedestrian test mannequin is stationary, the pedestrian test mannequin faces away from the subject vehicle, and the pedestrian test mannequin legs remain still.

S8.2. *Headway calculation*. For each test run conducted under S8.3, S8.4, and S8.5, the headway (L_0), in meters, providing 4.0 seconds time to collision (*TTC*) is calculated. L_0 is determined with the following equation where V_{SV} is the speed of the subject vehicle in m/s and $V_{P\text{-}y}$ is the component of speed of the pedestrian test mannequin in m/s in the direction of the intended travel path:

Equation 2 to S8.2

$$L_0 = \mathrm{TTC}_0 \times (V_{SV} - V_{P\text{-}y})$$

$$\mathrm{TTC}_0 = 4.0$$

S8.3. *Pedestrian crossing road*.

S8.3.1. *Test parameters and setup (unobstructed from right).*

(a) The testing area is set up in accordance with figure 3 to this section.

(b) Testing is conducted in the daylight or darkness conditions, except that testing with the pedestrian at the 25 percent overlap is only conducted in daylight conditions.

(c) Testing is conducted using the adult pedestrian test mannequin.

(d) The movement of the pedestrian test mannequin is perpendicular to the subject vehicle's intended travel path.

(e) The pedestrian test mannequin is set up 4.0 ± 0.1 m to the right of the intended travel path.

(f) The intended overlap is 25 percent from the right or 50 percent.

(g) The subject vehicle test speed is any speed between 10 km/h and 60 km/h.

(h) The pedestrian test mannequin speed is 5 km/h.

S8.3.2 *Test parameters and setup (unobstructed from left).*

(a) The testing area is set up in accordance with figure 4 to this section.

(b) Testing is conducted in the daylight condition.

(c) Testing is conducted using the adult pedestrian mannequin.

(d) The movement of the pedestrian test mannequin is perpendicular to the intended travel path.

(e) The pedestrian test mannequin is set up 6.0 ± 0.1 m to the left of the intended travel path.

(f) The intended overlap is 50 percent.

(g) The subject vehicle test speed is any speed between 10 km/h and 60 km/h.

(h) The pedestrian test mannequin speed is 8 km/h.

S8.3.3. *Test parameters and setup (obstructed).*

(a) The testing area is set up in accordance with figure 5 to this section.

(b) Testing is conducted in the daylight condition.

(c) Testing is conducted using the child pedestrian test mannequin.

(d) The movement of the pedestrian test mannequin is perpendicular to the intended travel path.

(e) The pedestrian test mannequin is set up 4.0 ± 0.1 m to the right of the intended travel path.

(f) The intended overlap is 50 percent.

(g) Two vehicle test devices are secured in stationary positions parallel to the intended travel path. The two vehicle test devices face the same direction as the intended travel path. One vehicle test device is directly behind the other separated by 1.0 ± 0.1 m. The frontmost plane of the vehicle test device furthermost from the subject vehicle is located 1.0 ± 0.1 m from the parallel contact plane (to the subject vehicle's frontmost plane) on the pedestrian test mannequin. The left side of each vehicle test device is 1.0 ± 0.1 m to the right of the vertical plane parallel to the intended travel path and tangent with the right outermost point of the subject vehicle when the subject vehicle is in the intended travel path.

(h) The subject vehicle test speed is any speed between 10 km/h and 50 km/h.

(i) The pedestrian test mannequin speed is 5 km/h.

S8.3.4. *Test conduct prior to forward collision warning or subject vehicle braking onset.*

(a) Before the headway corresponds to L_0, the subject vehicle is driven at any speed, in any direction, on any road surface, for any amount of time.

(b) The subject vehicle approaches the crossing path of the pedestrian test mannequin.

(c) Beginning when the headway corresponds to L_0, the subject vehicle speed is maintained within 1.6 km/h of the test speed with minimal and smooth accelerator pedal inputs.

(d) Beginning when the headway corresponds to L_0, the subject vehicle heading is maintained with minimal steering inputs such that the subject vehicle's travel path does not deviate more than 0.3 m laterally from the intended travel path, and the yaw rate of the subject vehicle does not exceed ±1.0 deg/s prior to any automated braking onset.

(e) The pedestrian test mannequin apparatus is triggered at a time such that the pedestrian test mannequin meets the intended overlap, subject to the criteria in S8.1.2. The pedestrian test mannequin achieves its intended speed within 1.5 m after the apparatus begins to move and maintains its intended speed within 0.4 km/h until the test completion criteria of S8.3.6 are satisfied.

S8.3.5. *Test conduct after either forward collision warning or subject vehicle braking onset.*

(a) After forward collision warning or subject vehicle braking onset, the subject vehicle's accelerator pedal is released at any rate such that it is fully released within 500 ms. This action is omitted for vehicles with cruise control active.

(b) No manual brake application is made until the test completion criteria of S8.3.6 are satisfied.

(c) The pedestrian mannequin continues to move until the completion criteria of S8.3.6 are satisfied.

S8.3.6. *Test completion criteria*. The test run is complete when the subject vehicle comes to a complete stop without making contact with the pedestrian test mannequin, when the pedestrian test mannequin is no longer in the path of the subject vehicle, or when the subject vehicle makes contact with the pedestrian test mannequin.

S8.4. *Stationary pedestrian.*

S8.4.1. *Test parameters and setup*.

(a) The testing area is set up in accordance with figure 6 to this section.

(b) Testing is conducted in the daylight or darkness conditions.

(c) Testing is conducted using the adult pedestrian test mannequin.

(d) The pedestrian mannequin is set up at the 25 percent right overlap position facing away from the approaching vehicle.

(e) The subject vehicle test speed is any speed between 10 km/h and 55 km/h.

(f) The pedestrian mannequin is stationary.

S8.4.2. *Test conduct prior to forward collision warning or subject vehicle braking onset.*

(a) Before the headway corresponds to L_0, the subject vehicle is driven at any speed, in any direction, on any road surface, for any amount of time.

(b) The subject vehicle approaches the pedestrian test mannequin.

(c) Beginning when the headway corresponds to L_0, the subject vehicle speed is maintained within 1.6 km/h of the test speed with minimal and smooth accelerator pedal inputs.

(d) Beginning when the headway corresponds to L_0, the subject vehicle heading is maintained with minimal steering inputs such that the subject vehicle's travel path does not deviate more than 0.3 m laterally from the intended travel path, and the yaw rate of the subject vehicle does not exceed ±1.0 deg/s prior to any automated braking onset.

S8.4.3. *Test conduct after either forward collision warning or subject vehicle braking onset.*

(a) After forward collision warning or subject vehicle braking onset, the subject vehicle’s accelerator pedal is released at any rate such that it is fully released within 500 ms. This action is omitted with vehicles with cruise control active.

(b) No manual brake application is made until the test completion criteria of S8.4.4 are satisfied.

S8.4.4. *Test completion criteria.* The test run is complete when the subject vehicle comes to a complete stop without making contact with the pedestrian test mannequin, or when the subject vehicle makes contact with the pedestrian test mannequin.

S8.5. *Pedestrian moving along the path.*

S8.5.1. *Test parameters and setup.*

(a) The testing area is set up in accordance with figure 7 to this section.

(b) Testing is conducted in the daylight or darkness conditions.

(c) Testing is conducted using the adult pedestrian test mannequin.

(d) The movement of the pedestrian test mannequin is parallel to and in the same direction as the subject vehicle.

(e) The pedestrian test mannequin is set up in the 25 percent right offset position.

(f) The subject vehicle test speed is any speed between 10 km/h and 65 km/h.

(g) The pedestrian test mannequin speed is 5 km/h.

S8.5.2. *Test conduct prior to forward collision warning or subject vehicle braking onset.*

(a) Before the headway corresponds to L_0, the subject vehicle is driven at any speed, in any direction, on any road surface, for any amount of time.

(b) The subject vehicle approaches the pedestrian test mannequin.

(c) Beginning when the headway corresponds to L_0, the subject vehicle speed is maintained within 1.6 km/h of the test speed with minimal and smooth accelerator pedal inputs.

(d) Beginning when the headway corresponds to L_0, the subject vehicle heading is maintained with minimal steering inputs such that the travel path does not deviate more than 0.3 m laterally from the intended travel path, and the yaw rate of the subject vehicle does not exceed ±1.0 deg/s prior to any automated braking onset.

(e) The pedestrian test mannequin apparatus is triggered any time after the distance between the front plane of the subject vehicle and a parallel contact plane on the pedestrian test mannequin corresponds to L_0. The pedestrian test mannequin achieves its intended speed within 1.5 m after the apparatus begins to move and maintains its intended speed within 0.4 km/h until the test completion criteria of S8.5.4 are satisfied.

S8.5.3. *Test conduct after either forward collision warning or subject vehicle braking onset.*

(a) After forward collision warning or subject vehicle braking onset, the subject vehicle's accelerator pedal is released at any rate such that it is fully released within 500 ms. This action is omitted for vehicles with cruise control active.

(b) No manual brake application is made until the test completion criteria of S8.5.4 are satisfied.

S8.5.4. *Test completion criteria*. The test run is complete when the subject vehicle slows to speed below the pedestrian test mannequin travel speed without making contact with the pedestrian test mannequin or when the subject vehicle makes contact with the pedestrian test mannequin.

S9. *False AEB activation*.

S9.1. *Headway calculation*. For each test run to be conducted under S9.2 and S9.3, the headway ($L_0, L_{2.1}, L_{1.1}$), in meters, providing 5.0 seconds, 2.1 seconds, and 1.1 seconds time to collision (TTC) is calculated. L_0, $L_{2.1}$, and $L_{1.1}$ are determined with the following equation where V_{SV} is the speed of the subject vehicle in m/s:

Equation 3 to S9.1

$$L_x = \mathrm{TTC}_x \times (V_{SV})$$

$$TTC_0 = 5.0$$

$$TTC_{2.1} = 2.1$$

$$TTC_{1.1} = 1.1$$

S9.2. *Steel trench plate*.

S9.2.1. *Test parameters and setup*.

(a) The testing area is set up in accordance with figure 8 to this section.

(b) The steel trench plate is secured flat on the test surface so that its longest side is parallel to the vehicle's intended travel path and horizontally centered on the vehicle's intended travel path.

(c) The subject vehicle test speed is 80 km/h.

(d) Testing is conducted with manual brake application and without manual brake application.

(e) Testing is conducted during daylight.

S9.2.2. *Test conduct*.

(a) Before the headway corresponds to L_0, the subject vehicle is driven at any speed, in any direction, on any road surface, for any amount of time.

(b) The subject vehicle approaches the steel trench plate.

(c) Beginning when the headway corresponds to L_0, the subject vehicle speed is maintained within 1.6 km/h of the test speed with minimal and smooth accelerator pedal inputs.

(d) Beginning when the headway corresponds to L_0, the subject vehicle heading is maintained with minimal steering input such that the travel path does not deviate more than 0.3 m laterally from the intended travel path, and the yaw rate of the subject vehicle does not exceed ±1.0 deg/s.

(e) If forward collision warning occurs, the subject vehicle’s accelerator pedal is released at any rate such that it is fully released within 500 ms. This action is omitted for vehicles with cruise control active.

(f) For tests where no manual brake application occurs, manual braking is not applied until the test completion criteria of S9.2.3 are satisfied.

(g) For tests where manual brake application occurs, the subject vehicle's accelerator pedal, if not already released, is released when the headway corresponds to $L_{2.1}$ at any rate such that it is fully released within 500 ms.

(h) For tests where manual brake application occurs, the service brakes are applied as specified in S10. The brake application pedal onset occurs at headway $L_{1.1}$.

S9.2.3. *Test completion criteria*. The test run is complete when the subject vehicle comes to a stop prior to crossing over the leading edge of the steel trench plate or when the subject vehicle crosses over the leading edge of the steel trench plate.

S9.3. *Pass-through*.

S9.3.1. *Test parameters and setup*.

(a) The testing area is set up in accordance with figure 9 to this section .

(b) Two vehicle test devices are secured in a stationary position parallel to one another with a lateral distance of 4.5 m ±0.1 m between the vehicles' closest front wheels. The centerline between the two vehicles is parallel to the intended travel path.

(c) The subject vehicle test speed is 80 km/h.

(d) Testing is conducted with manual brake application and without manual brake application.

(e) Testing is conducted during daylight.

S9.3.2. *Test conduct*.

(a) Before the headway corresponds to L_0, the subject vehicle is driven at any speed, in any direction, on any road surface, for any amount of time.

(b) The subject vehicle approaches the gap between the two vehicle test devices.

(c) Beginning when the headway corresponds to L_0, the subject vehicle speed is maintained within 1.6 km/h with minimal and smooth accelerator pedal inputs.

(d) Beginning when the headway corresponds to L_0, the subject vehicle heading is maintained with minimal steering input such that the travel path does not deviate more than 0.3

m laterally from the intended travel path, and the yaw rate of the subject vehicle does not exceed ±1.0 deg/s.

(e) If forward collision warning occurs, the subject vehicle’s accelerator pedal is released at any rate such that it is fully released within 500 ms.

(f) For tests where no manual brake application occurs, manual braking is not applied until the test completion criteria of S9.3.3 are satisfied.

(g) For tests where manual brake application occurs, the subject vehicle's accelerator pedal, if not already released, is released when the headway corresponds to $L_{2.1}$ at any rate such that it is fully released within 500 ms.

(h) For tests where manual brake application occurs, the service brakes are applied as specified in S10. The brake application onset occurs when the headway corresponds to $L_{1.1}$.

S9.3.3. *Test completion criteria*. The test run is complete when the subject vehicle comes to a stop prior to its rearmost point passing the vertical plane connecting the forwardmost point of the vehicle test devices or when the rearmost point of the subject vehicle passes the vertical plane connecting the forwardmost point of the vehicle test devices.

S10. *Subject vehicle brake application procedure*.

S10.1. The procedure begins with the subject vehicle brake pedal in its natural resting position with no preload or position offset.

S10.2. At the option of the manufacturer, either displacement feedback, hybrid feedback, or force feedback control is used.

S10.3. *Displacement feedback procedure*. For displacement feedback, the commanded brake pedal position is the brake pedal position that results in a mean deceleration of 0.4 g in the absence of AEB system activation.

(a) The mean deceleration is the deceleration over the time from the brake pedal achieving the commanded position to 250 ms before the vehicle comes to a stop.

(b) The pedal displacement controller displaces the brake pedal at a rate of 254 mm/s ±25.4 mm/s to the commanded brake pedal position.

(c) The pedal displacement controller may overshoot the commanded position by any amount up to 20 percent. If such an overshoot occurs, it is corrected within 250 ms from when the commanded position is first achieved.

(d) The achieved brake pedal position is any position within 10 percent of the commanded position from 250 ms after the commanded brake pedal position is first achieved to the end of the test.

S10.4. *Hybrid brake pedal feedback procedure*. For hybrid brake pedal feedback, the commanded brake pedal application is the brake pedal position and a subsequent commanded brake pedal force that results in a mean deceleration of 0.4 g in the absence of AEB system activation.

(a) The mean deceleration is the deceleration over the time from the brake pedal achieving the commanded position to 250 ms before the vehicle comes to a stop.

(b) The hybrid controller displaces the brake pedal at a rate of 254 mm/s ±25.4 mm/s to the commanded pedal position.

(c) The hybrid controller may overshoot the commanded position by any amount up to 20 percent. If such an overshoot occurs, it is corrected within 250 ms from then the commanded position is first achieved.

(d) The hybrid controller begins to control the force applied to the brake pedal and stops controlling pedal displacement within 100 ms after the commanded brake pedal displacement occurs.

(e) The hybrid controller applies a pedal force of at least 11.1 N from the onset of the brake application until the end of the test.

(f) The average pedal force is maintained within 10 percent of the commanded brake pedal force from 350 ms after commended pedal displacement occurs until test completion.

S10.5. *Force feedback procedure*. For force feedback, the commanded brake pedal application is the brake pedal force that results in a mean deceleration of 0.4 g in the absence of AEB system activation.

(a) The mean deceleration is the deceleration over the time from when the commanded brake pedal force is first achieved to 250 ms before the vehicle comes to a stop.

(b) The force controller achieves the commanded brake pedal force within 250 ms. The application rate is unrestricted.

(c) The force controller may overshoot the commanded force by any amount up to 20 percent. If such an overshoot occurs, it is corrected within 250 ms from when the commanded force is first achieved.

(d) The force controller applies a pedal force of at least 11.1 N from the onset of the brake application until the end of the test.

(e) The average pedal force is maintained within 10 percent of the commanded brake pedal force from 250 ms after commended pedal force occurs until test completion.

Figure 1 to § 571.127 —Percentage Overlap Nomenclature

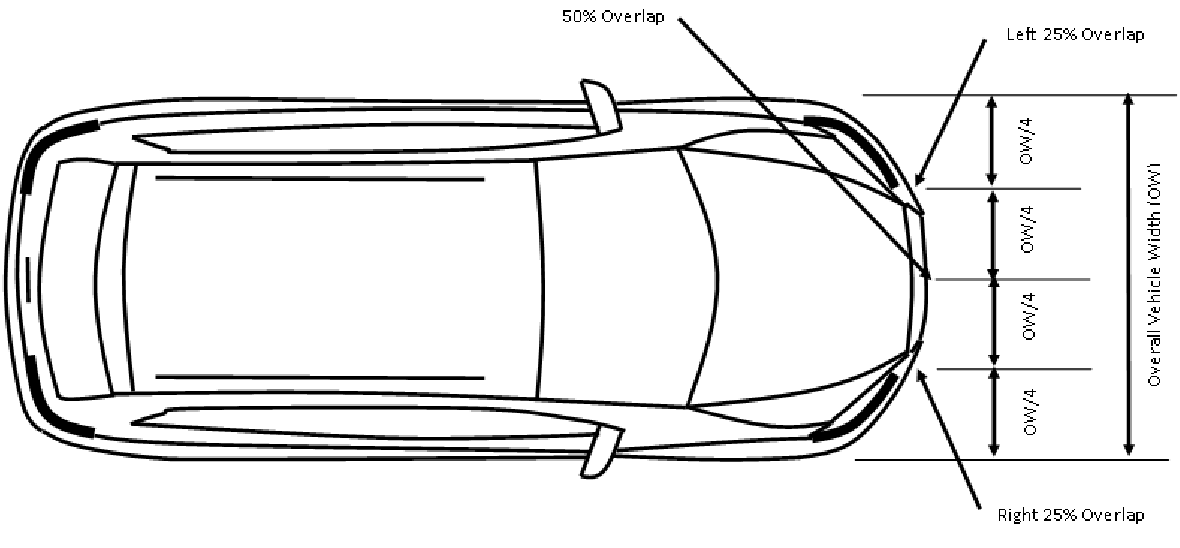


Figure 2 to § 571.127 — Setup for Lead Vehicle Automatic Emergency Braking

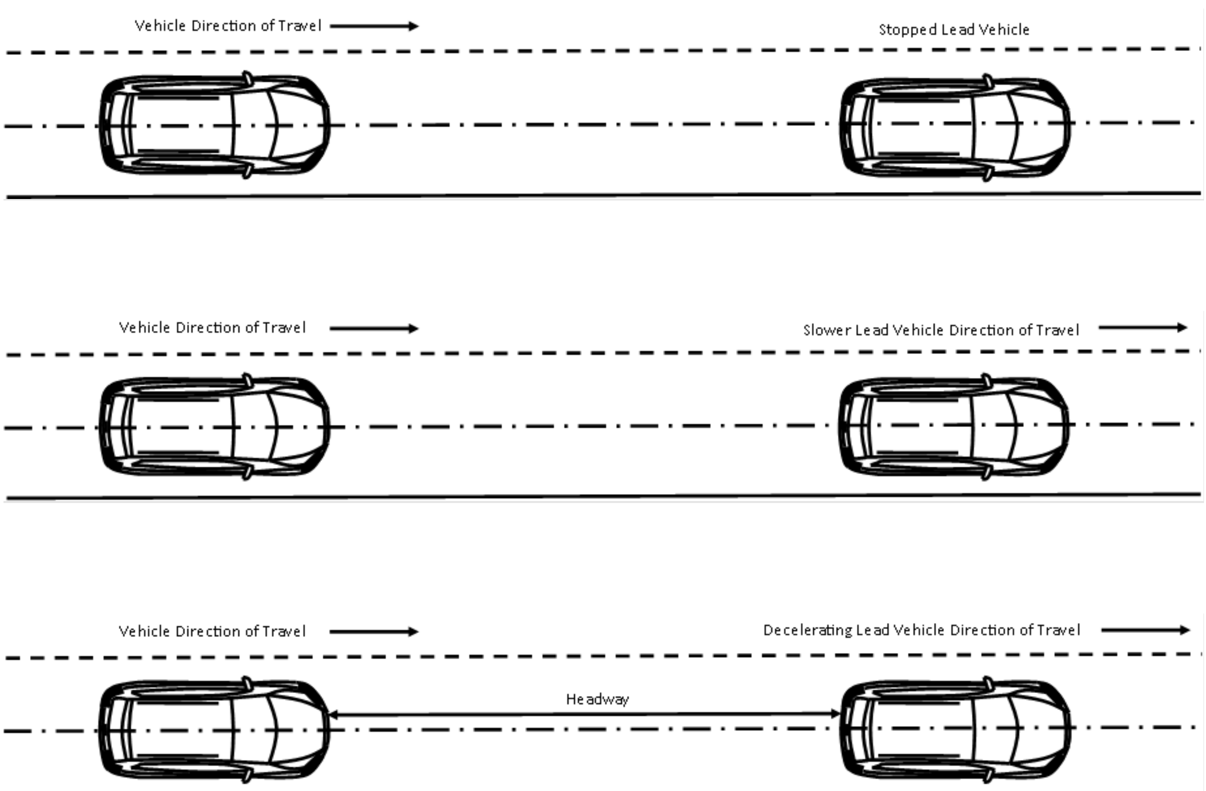


Figure 3 to § 571.127 — Setup for Pedestrian, Crossing Path, Right

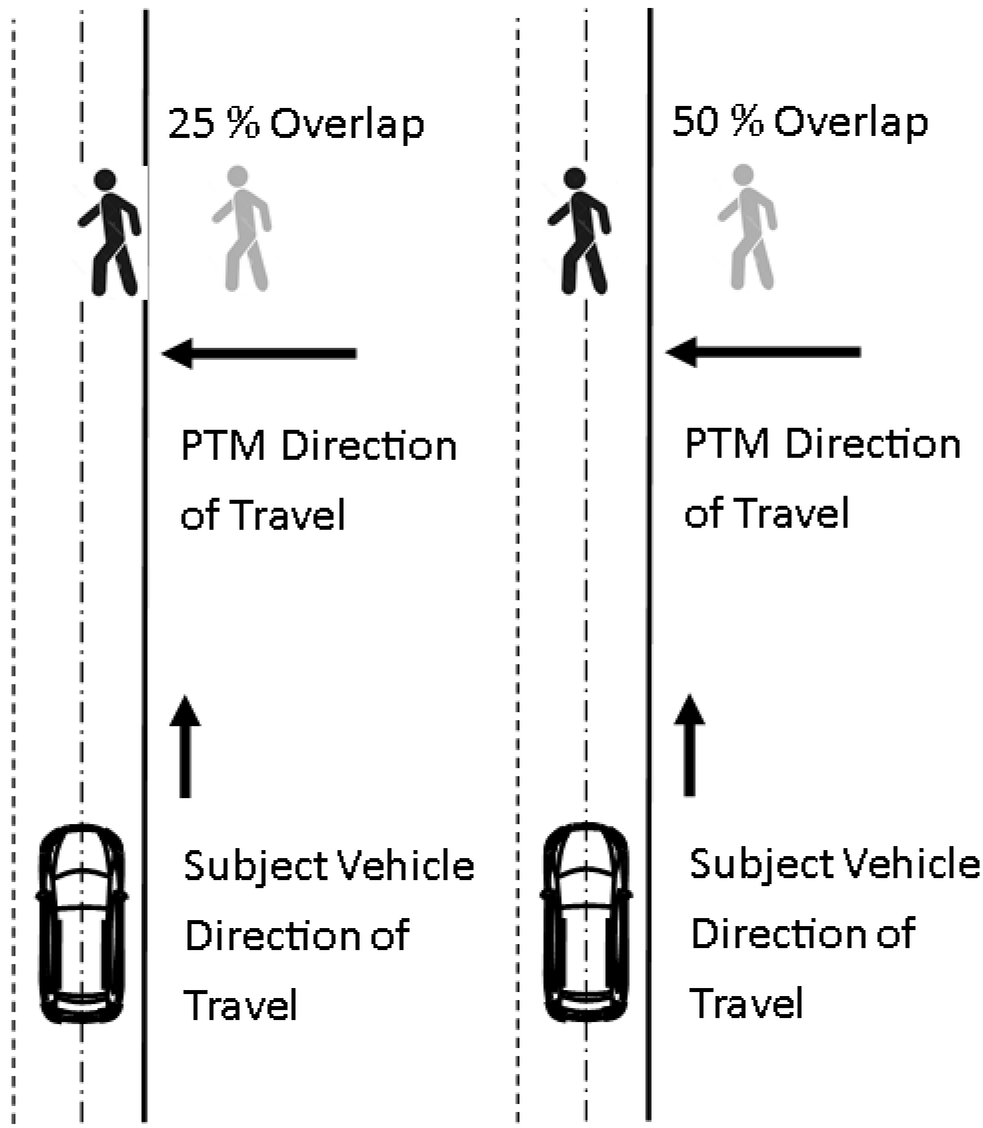

25 % Overlap
PTM Direction of Travel
Subject Vehicle Direction of Travel
50 % Overlap
PTM Direction of Travel
Subject Vehicle Direction of Travel

Figure 4 to § 571.127 — Setup for Pedestrian, Crossing Path, Left

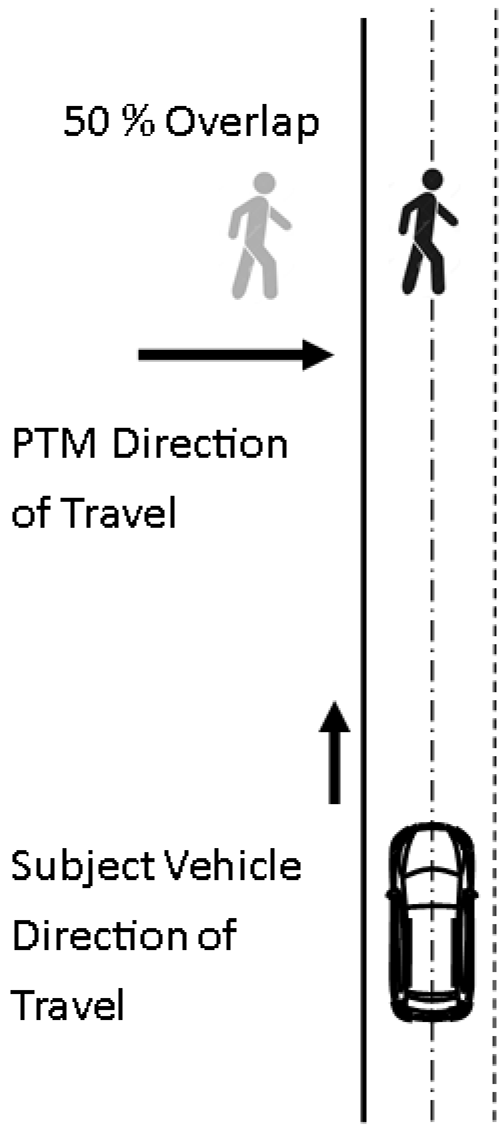


Figure 5 to § 571.127 — Setup for Pedestrian, Obstructed

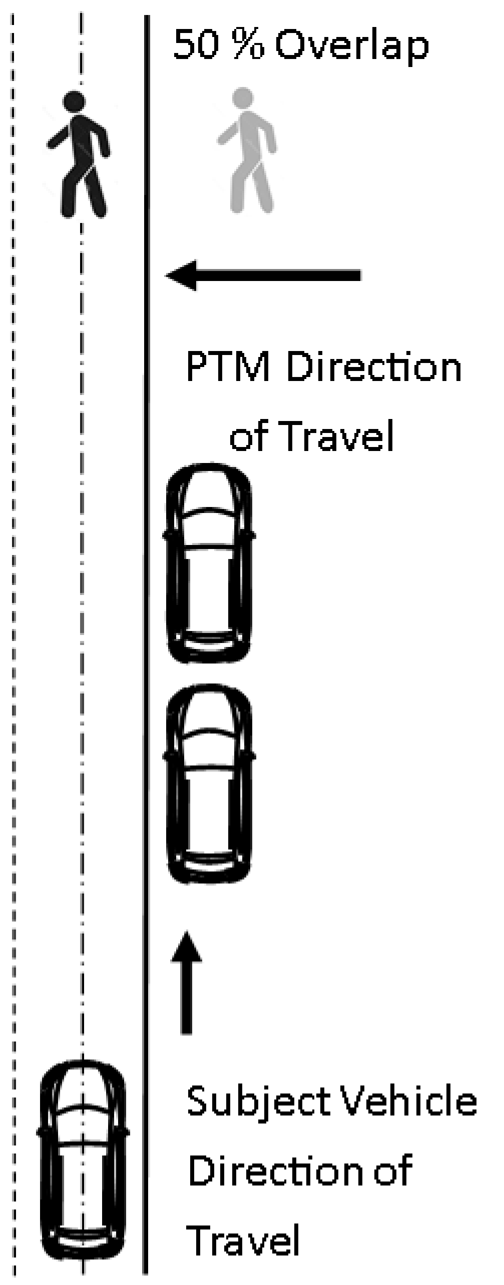


Figure 6 to § 571.127 — Setup for Pedestrian Along-Path Stationary

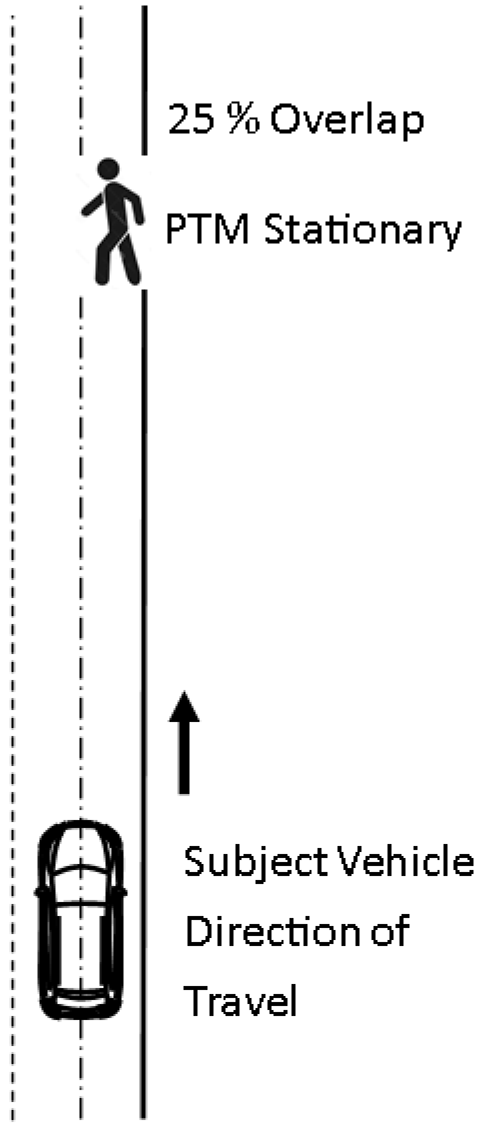


Figure 7 to § 571.127 — Setup for Pedestrian Along-Path Moving

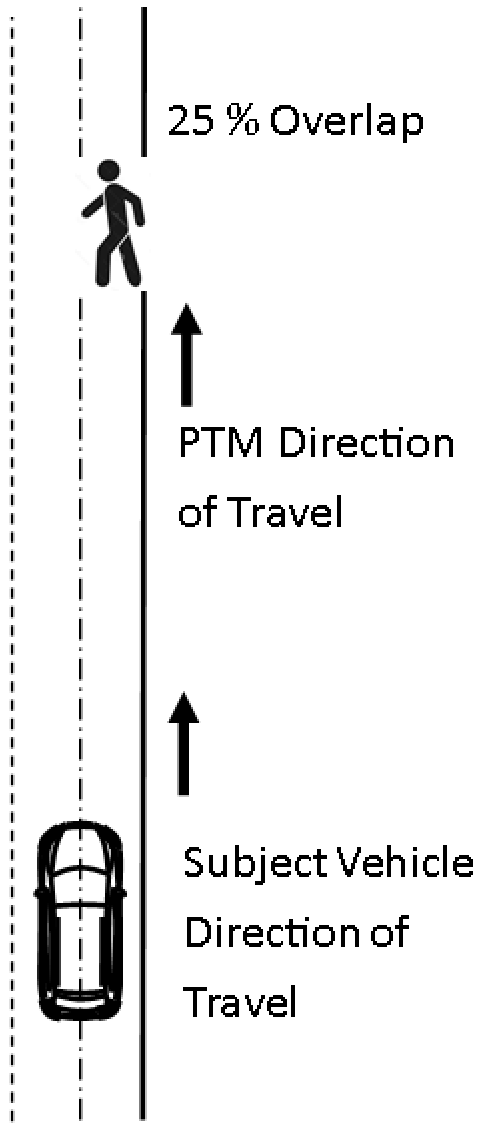


Figure 8 to § 571.127 — Steel Trench Plate

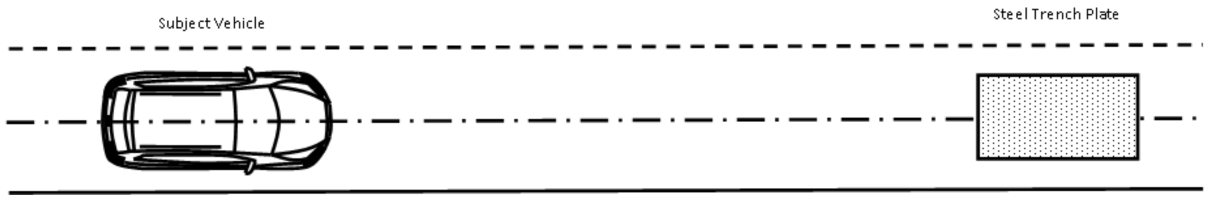
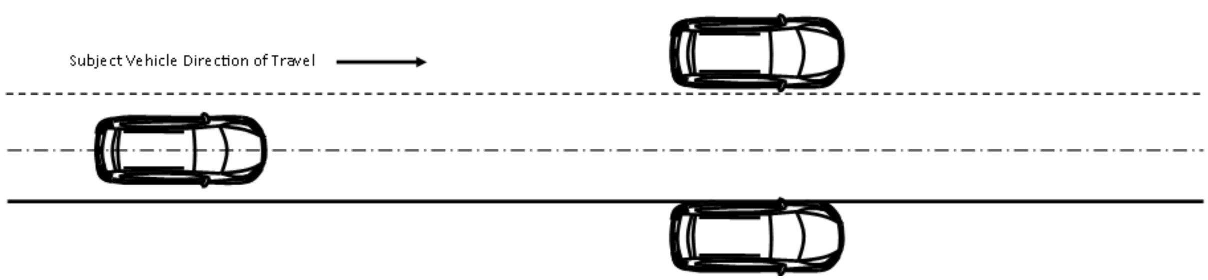


Figure 9 to § 571.127 — Pass-through



PART 595—MAKE INOPERATIVE EXEMPTIONS

4. The authority citation for part 595 continues to read as follows:

Authority: 49 U.S.C. 322, 30111, 30115, 30117, 30122 and 30166; delegation of authority at 49 CFR 1.95.

5. Amend § 595.4 by adding the definition of "Manufacturer" in alphabetical order to read as follows:

§ 595.4 Definitions.

* * * * *

Manufacturer is defined as it is in 49 U.S.C. 30102(a).

* * * * *

6. Add subpart D to read as follows:

Subpart D—Modifications to Law Enforcement Vehicles

§ 595.9 Automatic emergency braking.

A manufacturer, dealer, or motor vehicle repair business that modifies a vehicle owned by a law enforcement agency to provide a means to temporarily deactivate an AEB system is exempted from the "make inoperative" prohibition in 49 U.S.C. 30122 to the extent that such modification affects the motor vehicle's compliance with 49 CFR 571.127, S5.4.2. Modifications that would take a vehicle out of compliance with any other Federal motor vehicle safety standards, or portions thereof, are not covered by this exemption.

7. Add part 596 to read as follows.

PART 596—AUTOMATIC EMERGENCY BRAKING TEST DEVICES

Subpart A—General

Authority: 49 U.S.C. 322, 30111, 30115, 30117 and 30166; delegation of authority at 49 CFR 1.95.

Subpart A--General

§ 596.1 Scope.

This part describes the test devices to be used for compliance testing of motor vehicles with motor vehicle safety standards for automatic emergency braking.

§ 596.2 Purpose.

The design and performance criteria specified in this part are intended to describe devices with sufficient precision such that testing performed with these test devices will produce repetitive and correlative results under similar test conditions to reflect adequately the automatic emergency braking performance of a motor vehicle.

§ 596.3 Application.

This part does not in itself impose duties or liabilities on any person. It is a description of tools that are used in compliance tests to measure the performance of automatic emergency braking systems required by the safety standards that refer to these tools. This part is designed to be referenced by, and become part of, the test procedures specified in motor vehicle safety standards, such as 49 CFR 571.127.

§ 596.4 Definitions.

All terms defined in section 30102 of the National Traffic and Motor Vehicle Safety Act (49 U.S.C. chapter 301, et seq.) are used in their statutory meaning.

Adult pedestrian test mannequin (APTM) means a test device with the appearance and radar cross section that simulates an adult pedestrian for the purpose of testing automatic emergency brake system performance.

Child pedestrian test mannequin (CPTM) means a test device with the appearance and radar cross section that stimulates a child pedestrian for the purpose of testing automatic emergency brake system performance.

Pedestrian test device(s) means an adult pedestrian test mannequin and/or a child pedestrian test mannequin.

Pedestrian test mannequin carrier means a movable platform on which an adult pedestrian test mannequin or child pedestrian test mannequin may be attached during compliance testing.

Vehicle test device means a test device that simulates a passenger vehicle for the purpose of testing automatic emergency brake system performance.

Vehicle test device carrier means a movable platform on which a lead vehicle test device may be attached during compliance testing.

§ 596.5 Matter incorporated by reference.

Certain material is incorporated by reference into this part with the approval of the Director of the Federal Register under 5 U.S.C. 552(a) and 1 CFR part 51. To enforce any edition other than that specified in this section, the National Highway Traffic Safety Administration (NHTSA) must publish notice of change in the *Federal Register* and the material must be available to the public. All approved material is available for inspection at NHTSA and at the National Archives and Records Administration (NARA). Contact NHTSA at: NHTSA Office of Technical Information Services, 1200 New Jersey Avenue SE., Washington, DC 20590; (202) 366-2588. For information on the availability of this material at NARA, visit www.archives.gov/federal-register/cfr/ibr-locations or email fr.inspection@nara.gov. The material may be obtained from the source(s) in the following paragraph of this section.

(a) International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland; phone: + 41 22 749 01 11 fax: + 41 22 733 34 30; website: https://www.iso.org/.

(1) ISO 3668:2017(E), *Paints and varnishes – Visual comparison of colour of paints*, Third edition, 2017-05 (ISO 3668:2017); into § 596.7.

(2) ISO 19206-2:2018(E), *Road vehicles – Test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions – Part 2: Requirements for pedestrian targets*, First edition, 2018-12 (ISO 19206-2:2018); into § 596.7.

(3) ISO 19206-3:2021(E), *Test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions —Part 3: Requirements for passenger vehicle 3D targets*, First edition, 2021-05 (ISO 19206-3:2021); into § 596.10.

(4) ISO 19206-4:2020(E), *Test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions –Part 4: Requirements for bicyclist targets*, First edition, 2020-11 (ISO 19206-4:2020); into § 596.7.

(b) [Reserved]

Subpart B—Pedestrian Test Devices

§ 596.7 Specifications for pedestrian test devices.

(a) *Explanation of usage*. The words "recommended," "should," "can be," or "should be" appearing in sections of ISO 19206-2:2018 (incorporated by reference, see § 596.5), referenced in this section, are read as setting forth specifications that are used.

(b) *Explanation of usage*. The words "may be," or "either" used in connection with a set of items appearing in sections of ISO 19206-2:2018 (incorporated by reference, see § 596.5), referenced in this section, are read as setting forth the totality of items, any one of which may be selected by NHTSA for testing.

(c) *Specifications for the pedestrian test devices*—(1) *General description*. The adult pedestrian test mannequin (APTM) provides a sensor representation of a 50th percentile adult male and consist of a head, torso, two arms and hands, and two legs and feet. The child pedestrian test mannequin (CPTM) provides a sensor representation of a 6– to 7-year-old child and consists of a head, torso, two arms and hands, and two legs and feet. The arms of the APTM and CPTM are posable, but do not move during testing. The legs of the APTM and CPTM articulate and are synchronized to the forward motion of the mannequin.

(2) *Dimensions and posture*. The APTM has basic body dimensions and proportions specified in Annex A, table A.1 in ISO 19206-2:2018 (incorporated by reference, see § 596.5). The CPTM has basic body dimensions and proportions specified in Annex A, table A.1 in ISO 19206-2:2018 (incorporated by reference, see § 596.5).

(3) *Visual properties*—(i) *Head.* The head has a visible hairline silhouette by printed graphic. The hair is black as defined in Annex B table B.2 of ISO 19206-4:2020, as tested in accordance with ISO 3668:2017 (both incorporated by reference, see § 596.5).

(ii) *Face.* The head does not have any facial features (i.e., eyes, nose, mouth, and ears).

(iii) *Skin*. The face, neck and hands have a skin colored as defined Annex B, table B.2 of ISO 19206-4:2020 (incorporated by reference, see § 596.5).

(iv) *Torso and arms.* The torso and arms are black as defined in Annex B table B.2 of ISO 19206-4:2020, as tested in accordance with ISO 3668:2017 (both incorporated by reference, see § 596.5).

(v) *Legs.* The legs are blue as defined in Annex B table B.2 of ISO 19206-4:2020, as tested in accordance with ISO 3668:2017 (both incorporated by reference, see § 596.5).

(vi) *Feet.* The feet are black as defined in Annex B table B.2 of ISO 19206-4:2020, as tested in accordance with ISO 3668:2017 (both incorporated by reference, see § 596.5).

(4) *Infrared properties.* The surface of the entire APTM or CPTM are within the reflectivity ranges specified in Annex B section B.2.2 of ISO 19206-2:2018, as illustrated in Annex B, figure B.2 (incorporated by reference, see § 596.5).

(5) *Radar properties*. The radar reflectivity characteristics of the pedestrian test device approximates that of a pedestrian of the same size when approached from the side or from behind.

(6) *Radar cross section measurements.* The radar cross section measurements of the APTM and the CPTM is within the upper and lower boundaries shown in Annex B, section B.3, figure B.6 of ISO 19206-2:2018 when tested in accordance with the measure procedure in Annex C, section C.3, Scenario 2 Fixed Angle Scans of ISO 19206-3:2021 with a measurement range of 4m to 40m (incorporated by reference, see § 596.5).

(7) *Posture.* The pedestrian test device has arms that are posable and remain posed during testing. The pedestrian test device is equipped with moving legs consistent with standard gait phases specified in Section 5.6 of ISO 19206-2:2018 (incorporated by reference, see § 596.5).

(8) *Articulation properties.* The legs of the pedestrian test device are in accordance with, and as described in, Annex D, section D.2 and illustrated in Figures D.1, D.2, and D.3 of ISO 19206-2:2018 (incorporated by reference, see § 596.6).

§ 596.8 [Reserved]

Subpart C—Vehicle Test Device

§ 596.9 General description.

(a) The vehicle test device provides a sensor representation of a passenger motor vehicle.

(b) The rear view of the vehicle test device contains representations of the vehicle silhouette, a rear window, a high-mounted stop lamp, two taillamps, a rear license plate, two rear reflex reflectors, and two tires.

§ 596.10 Specifications for the vehicle test device.

(a) *Explanation of usage*. The words "recommended," "should," "can be," or "should be" appearing in sections of ISO 19206-3:2021 (incorporated by reference, see § 596.5), referenced in this section, are read as setting forth specifications that are used.

(b) *Explanation of usage*. The words "may be," or "either," used in connection with a set of items appearing in sections of ISO 19206-3:2021 (incorporated by reference, see § 596.5), referenced in this section, are read as setting forth the totality of items, any one of which may be selected by NHTSA for testing.

(c) *Dimensional specifications.* (1) The rear silhouette and the rear window are symmetrical about a shared vertical centerline.

(2) Representations of the taillamps, rear reflex reflectors, and tires are symmetrical about the surrogate's centerline.

(3) The license plate representation has a width of 300 ± 15 mm and a height of 150 ± 15 mm and mounted with a license plate holder angle within the range described in 49 CFR 571.108, S6.6.3.1.

(4) The vehicle test device representations are located within the minimum and maximum measurement values specified in columns 3 and 4 of Tables A.4 of ISO 19206-3:2021 Annex A (incorporated by reference, see § 596.5). The tire representations are located within the minimum and maximum measurement values specified in columns 3 and 4 of Tables A.3 of ISO 19206-3:2021 Annex A (incorporated by reference, see § 596.5). The terms "rear light" means "taillamp," "retroreflector" means "reflex reflector," and "high centre taillight" means "high-mounted stop lamp."

(d) *Visual and near infrared specification.* (1) The vehicle test device rear representation colors are within the ranges specified in Tables B.2 and B.3 of ISO 19206-3:2021 Annex B (incorporated by reference, see § 596.5).

(2) The rear representation infrared properties of the vehicle test device are within the ranges specified in Table B.1 of ISO 19206-3:2021 Annex B (incorporated by reference, see § 596.5) for wavelengths of 850 to 950 nm when measured according to the calibration and measurement setup specified in paragraph B.3 of ISO 19206-3:2021 Annex B (incorporated by reference, see § 596.5).

(3) The vehicle test device rear reflex reflectors, and at least 50 cm^2 of the taillamp representations are grade DOT-C2 reflective sheeting as specified in 49 CFR 571.108, S8.2.

(e) *Radar reflectivity specifications.* (1) The radar cross section of the vehicle test device is measured with it attached to the carrier (robotic platform). The radar reflectivity of the carrier platform is less than 0 dBm^2 for a viewing angle of 180 degrees and over a range of 5 to 100 m when measured according to the radar measurement procedure specified in Section C.3 of ISO 19206-3:2021 Annex C (incorporated by reference, see § 596.5) for fixed-angle scans.

(2) The rear bumper area as shown in Table C.1 of ISO 19206-3:2021 Annex C (incorporated by reference, see § 596.5) contributes to the target radar cross section.

(3) The radar cross section is assessed using radar sensor that operates at 76 to 81 GHz and has a range of at least 5 to 100 m, a range gate length smaller than 0.6m, a horizontal field of view of 10 degrees or more (-3dB amplitude limit), and an elevation field of view of 5 degrees or more (-3dB amplitude).

(4) At least 92 percent of the filtered data points of the surrogate radar cross section for the fixed vehicle angle, variable range measurements are within the radar cross section boundaries defined in Section C.2.2.4 of ISO 19206-3:2021 Annex C (incorporated by reference, see § 596.5) for a viewing angle of 180 degrees when measured according to the radar measurement procedure specified in Section C.3 of ISO 19206-3:2021 Annex C (incorporated by reference, see § 596.5) for fixed-angle scans.

(5) Between 86 to 95 percent of the vehicle test device spatial radar cross section reflective power is with the primary reflection region defined in Section C.2.2.5 of ISO 19206-3:2021 Annex C (incorporated by reference, see § 596.5) when measured according to the radar measurement procedure specified in Section C.3 of ISO 19206-3:2021 Annex C (incorporated by reference, see § 596.5) using the angle-penetration method.

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Sophie Shulman,
Deputy Administrator.