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OFFICE OF  
AIR AND RADIATION

February 23, 2015

CD-15-04 (LDV/LDT/ICI/LIMO)

**SUBJECT: Determination and Use of Vehicle Road-Load Force and Dynamometer Settings**

Dear Manufacturer:

The purpose of this letter is to refine and clarify the procedures to be used by vehicle manufacturers in establishing vehicle road-load force and dynamometer settings.

I. Purpose

This guidance replaces the previous guidance contained in Advisory Circular 55c, issued on December 12, 1988, VPCD98-16, issued on December 21, 1998 and guidance letter CCD-02-01, issued on January 7, 2002. This guidance letter supplements the EPA previously issued single roll dynamometer guidance letters VPCD-98-09, and CD-00-04. EPA finds it appropriate to update the recommended procedures and the allowed flexibility in determining road-load. This guidance letter also clarifies the manufacturer's responsibilities when using the allowed flexibilities in determining the road-load force settings, sets the acceptable road-load force tolerance for production vehicle audits, and highlights consequences for testing compliance vehicles with inaccurate road-load force specifications.

II. Background

A. When a vehicle is tested for emissions and fuel economy on a chassis dynamometer, the load from aerodynamic drag, friction, and tire losses associated with road operation must be simulated. Since the introduction of the SFTP requirements, EPA has required manufacturers to supply representative road-load forces for vehicles at speeds between 15 km/hr (9.3 mph) and 115 km/hr (71.5 mph) for emissions and fuel economy testing (reference 40 CFR §86.129-00 and § 600.111-08).

B. Dynamometer settings are determined in two stages. First, actual on-road operation must be characterized, which is referred to as the road-load force specification. Second, a road-load derivation is performed to determine how much load the dynamometer will need to apply to simulate the road-load measured during the on-road test. EPA has previously established test procedures for both steps. Since that time, EPA, industry, and SAE have worked together to

publish updated procedures which have become widely used and accepted: SAE J1263, J2263, and J2264. EPA also allows the use of other methods such as analytical modeling, when the manufacturer uses good engineering judgment.

C. The method a manufacturer elects to use to characterize the road-load force is optional; however, the manufacturer is responsible for the accuracy of the road-load force specification and dynamometer settings. It is also the manufacturer's responsibility to insure that the vehicles it produces conform to the road-load specification reported in the application for certification and used for certification and fuel economy testing.

D. EPA may test, or require the manufacturer to test, production vehicles to verify the accuracy of the manufacturer's reported road-load specification and dynamometer settings (reference 40 CFR Part 86 subpart G, §86.1835, §86.1836, Part 600 §600.008, and CAA sections 206 and 208). In cases where these specifications or settings are found to be inaccurate, EPA may require the manufacturer to retest the affected emission certification vehicles, retest fuel economy data vehicles and recalculate fuel economy label values, recalculate the GHG emissions and CAFE fleet averages, and correct the ABT credit reports (refer to section VII "Revising the road-load specification - Corrective Action" of this guidance for more details).

E. The road-load force specification for all vehicles covered by a certificate of conformity and dynamometer settings used during emissions testing are required to be reported in the application for certification. Certificates of conformity issued by EPA are conditioned on production vehicles being in all material respects as described in the application for certification (reference 40 CFR §86.1848-01). EPA may deny, suspend, or revoke certificates of conformity where it finds that production vehicles have road-load forces that differ substantially from the road-load specification in the application for certification (reference 40 CFR §86.1850-01). Manufacturers failing to provide accurate vehicle road-load specification information in their applications for certification may also be subject to enforcement action, including civil penalties.

### III. Applicability

This guidance is effective beginning with the 2017 model year. Prior to MY 2017 the road-load confirmation procedures specified in AC55 will continue to be used.

### IV. Road-Load Specification and Dynamometer Settings

#### A. Road-Load Definition

1. Road-load is the force imparted on a vehicle while driving at constant speed over a smooth level surface from sources such as tire rolling resistance, driveline losses, and aerodynamic drag.

i. The road-load force specification used to conduct official emissions or fuel economy testing for certification, FE labeling, CAFE, or GHG reporting must represent the road-load force of the actual vehicles produced when loaded to the ETW specification for the sub-configuration being represented by the testing (reference 40 CFR §86.129-00, §600.005, §600.006, §600.007.)

ii. Since official GHG emissions and fuel economy test results must be representative of vehicles tested at 4,000 miles (reference 40 CFR §600.006), the road-load force specification used to conduct official GHG emissions or fuel economy testing must represent the road-load force of actual vehicles produced when they have accumulated 4,000 miles.

2. A dynamometer is used to simulate conditions of actual on-road operation. The dynamometer power absorber is adjusted so that the total "force" experienced by the vehicle is equivalent to the force measured on the road. EPA currently uses electric dynamometers with a three term force versus speed relationship characteristic of tire rolling resistance, driveline losses, and aerodynamic drag. This three-term equation is expressed as  $F = A + Bv + Cv^2$  where F is the road force, v is the vehicle speed.

3. Because it is difficult to measure road-load directly, EPA has adopted the coastdown method to characterize road-load force. During a coastdown test the vehicle is allowed to decelerate with the transmission in neutral while its speed is periodically measured. Using Newton's Law ( $F = MA$ ), force, mass and deceleration can all be related.

## B. Application for Certification Requirements

1. A manufacturer must include in the application for certification, the road-load specification for every vehicle which is covered by the certificate of conformity (a range of values may be given in the Part 1 Application and updated in the Part 2 Application submission) (reference 40 CFR §86.1844-01.) The application must include the road-load force specifications (three term coefficients and RLHP at 50mph) for each vehicle subconfiguration along with a description of the test procedures or analytical methods used and other appropriate information as determined by either the manufacturer or by EPA. For example, a manufacturer may have information to support the use of a temperature correction factor different from what is specified in the recommended procedures. The manufacturer must include the three term target road-load coefficients and RLHP @ 50 mph even if the coastdown method is not used to characterize on-road operation.

2. The dynamometer power absorber settings (three term dynamometer set coefficients) must be included for all test vehicles.

3. A sample submission is included as Enclosure 1; the manufacturer may use any logical format to present the required information as long as EPA can easily select the correct road-load force specifications for confirmatory coastdown testing and in-use surveillance testing.

## C. Test Procedures

1. EPA recommends the procedures found in SAE J2263 as revised 12-2008, and J1263 as revised 03-2010 (the test procedures in J1263 are applicable however the data must be analyzed in such a way to determine a 3 term equation of force) and J2264 as revised 01-2014. EPA may approve future revisions to the above procedures. The following stipulations apply to coastdown testing used for certification, fuel economy, or GHG emissions testing:

### i. Vehicle Preparation

a. The coastdown test vehicle weight must be adjusted to the ETW specification for the subconfiguration it is representing including the driver and test equipment. An allowance for the fuel consumed during the test can be added to the pre-test weight. The post test vehicle weight including the driver and all test equipment must be within 25 lbs of the ETW specification for the sub-configuration it is representing. If the post test vehicle weight differs by more than 25 lbs from the ETW, the road-load coefficients must be analytically corrected to represent the vehicle at ETW.

b. The test vehicle should be in the condition and adjustment recommended by the manufacturer for normal operation. As the purpose of this procedure is to characterize the performance of actual production vehicles, the test vehicle shall not receive any preparation or adjustment which would make it unrepresentative of the production vehicles. For example, removing or retracting the brake pads without accounting for normal brake drag analytically would be considered unrepresentative. Normal brake applications are allowed as necessary during the coastdown test procedure to ensure that no unrepresentative brake drag conditions exist.

c. The test vehicle should be warmed up by driving for a minimum of 30 minutes at 50 miles /hr (80 kph). Testing for GHG emissions, CAFE, and derived 5 cycle fuel economy labeling is based on the FTP and Highway drive cycles which have average speeds of 21.2 and 48.3 miles/hr respectively. The purpose of the warm-up period is to allow the vehicle tires and driveline to reach a stabilized temperature which will be representative of these test conditions. Operating at higher speeds during the warm-up period is not permitted because this could allow the vehicle tires and driveline to reach temperatures higher than those seen on the FTP and Highway drive cycles. If a manufacturer has data to show that 30 minutes is not a sufficient period of time to achieve the stabilized temperature at 50 miles/hr then more time is allowed. It is also acceptable to develop a second set of road-load coefficients to represent the higher speeds seen on the US06 cycle where higher stabilized temperatures may be appropriate. In this case higher speeds which reflect the US06 cycle may be used for the vehicle warm-up drive.

d. The test vehicle and tires should be aged with sufficient mileage to represent the road-load force at the 4,000 mile test point. If the vehicle has accumulated over 6,200 miles, the data should be adjusted to represent the road-load at the 4,000 mile test point. The test vehicle must not exceed 10,000 miles. The tires may be aged separately from the test vehicle.

### ii. Road or Track Test Facility

a. The test road or test track should be straight, smooth, and level for a sufficient distance to obtain the necessary data.

b. The road or test track surface should be hard and smooth. The surface texture and composition should be similar to road surfaces commonly in use. Unless corrections for grade

are applied per the SAEJ2263 procedure, the grade shall not exceed 0.5 percent and road crown should be minimal. The grade must be constant,  $\pm 0.1$  percent, throughout the test section.

c. Tests must be conducted on the road or track in opposite directions with minimal interference from other vehicles during the data collection periods. During the data collection period, the track surface and vehicle should be dry and the track should be free of obstacles or significant irregularities. The absence of intermittent wind barriers near the road or track surface is preferred to reduce positional wind variations.

2. The manufacturer may, within the constraints of good engineering practice, use any test procedure to characterize road-load force. EPA recognizes that wind tunnels, precision electric dynamometers, tire testing, component bench testing, etc. are tools and techniques that can be used to characterize changes in a vehicle's road-load. EPA believes that the ability to use such techniques will allow the manufacturer to reduce costs and/or increase accuracy. Therefore, EPA will allow the manufacturer to select its own test procedures and calculation methods. However, any procedures and/or methods that differ from the recommended procedure must be described in the application for certification.

3. As an overall check, EPA will continue to test vehicles using the recommended procedures described above.

4. If EPA conducts confirmatory road-load force coastdown testing and discovers after evaluating the results that a manufacturer's procedures and methods are producing inaccurate or unrepresentative road-load force specifications, EPA will refuse to accept additional test results until the deficiencies are corrected.

#### D. Road-load Force Specification

1. Vehicles are grouped into subconfigurations for fuel economy calculations.

i. The fuel economy regulations define a subconfiguration based on "road-load horsepower" and ETW (ref. 40 CFR §600.002-95 (a) (51)). (For the single-roll dynamometer the equivalent parameter is the "Total Road-Load Horsepower" at 50 mph (TRLHP 50), rounded to a tenth of a horsepower.)

ii. Vehicles are grouped into subconfigurations within vehicle configurations as defined in 40 CFR §600.002.

2. For each vehicle subconfiguration, a representative road-load force specification (three-term coefficients) must be established.

i. Optional equipment that increases aerodynamic drag and which has a projected installation rate of over 33 percent on a carline in a test group must be installed on the test vehicle or accounted for if analytical methods are employed to determine the road-load force specification. This applies only to optional equipment or features which affect aerodynamic drag (e.g. roof rack). Such optional equipment that has a projected installation rate of less than 33

percent on a carline in a test group may be removed from the test vehicle or not accounted for. This does not apply to any feature which delineates a vehicle configuration or subconfiguration or any component or feature which is necessary for the operation of the vehicle.

ii. Optional equipment that decreases aerodynamic drag and which has a projected installation rate of less than 67 percent on a carline in a test group must not be installed on the test vehicle or accounted for if analytical methods are employed to determine the road-load force specification unless a manufacturer elects to further subdivide vehicles into a subconfiguration including only vehicles with these options installed.

iii. In predicting installation rates, the manufacturer must consider the actual installation rates in past model years and other relevant factors to make an accurate forecast for the next model year.

3. Some vehicles have driver controlled equipment which may significantly affect road-load force. The road-load force should be specified for conditions of normal or average operation. EPA has determined that convertibles, sun roofs, and removable tops on vehicles are normally operated in a closed configuration; vehicles with manually engaged four-wheel drive are normally driven in two-wheel drive mode; and windshield wipers are normally turned off in default position. The manufacturer should make similar determinations, using good engineering judgment, for other such equipment.

4. For active devices (which are not driver controlled) which may behave differently during the coastdown test than during the emission test cycles or normal drive conditions, manufacturers shall seek EPA approval under CFR 86.1840 for determining the settings for coastdown testing and road-load force specification. Examples of these active devices are active grill shutters, active suspension height, and active aerodynamic features.

5. A manufacturer may substitute the road-load force specification from a worse case subconfiguration to a better case subconfiguration using good engineering judgment.

6. When a new vehicle or major updates to an existing vehicle is planned to be introduced, the road-load force specification is generally developed on a vehicle built of prototype parts or derived from data from various sources. Under these circumstances, EPA expects a manufacturer to confirm the actual road-load force by testing actual production vehicles as soon as possible after production begins.

7. A manufacturer has the obligation to update its application to adequately describe the vehicles which are being produced. Any revision to the road-load specifications must be used for all subsequent testing. In addition, if the road-load force specification is revised for any reason, all data previously run for the same model year must be reevaluated for representativeness.

## V. EPA Road-load Force Confirmation Testing

### A. General

It is imperative for emissions and fuel economy testing that the road-load force data specified by the manufacturer be representative of the final production fleet. EPA's road-load confirmatory audit program is designed to identify cases where reported road-load force specifications differ substantially from the road-load force experienced by actual production vehicles.

### B. Road-load Confirmations

1. EPA may test, or require a manufacturer to test, production vehicles to verify road-load force specifications. EPA may also require a manufacturer to supply appropriate vehicles for EPA testing. EPA may specify the testing be conducted at the manufacturer's test facility or at a facility leased by EPA (reference 40 CFR Part 86 subpart G, §86.1835, §86.1836, Part 600 §600.008, and CAA sections 206 and 208).

2. EPA may conduct initial screening tests of vehicles procured from the general U.S. Fleet. These tests will generally be used by EPA to determine which vehicles to select for production audits. If the result of such a test exceeds the confirmation criteria specified in section VI, the manufacturer could optionally revise the road-load specification based on the screening test or provide production vehicles for testing as described in paragraph c. 2. of section VI below.

3. Vehicles and tires used for road-load confirmation testing should have accumulated 4,000 miles of service prior to road-load testing.

4. EPA will conduct testing using the recommended practice procedures in section IV C.

### C. Dynamometer Setting Confirmation

As with road confirmations, EPA may determine, or require the manufacturer to determine, the appropriate dynamometer settings for any test vehicle or category of production vehicles. EPA may require the manufacturer to supply vehicles for this purpose. (ref. 40 CFR §86.1835, §86.1836, and §600.008)

## VI. EPA Road-load Force Confirmation Criteria

A. As described in prior EPA guidance issued on January 7, 2002, CCD 02-01 which is replaced by this guidance letter, EPA will evaluate the road-load based on an "energy loss" model. For a given driving pattern or schedule, the total road-load energy loss may be easily calculated by considering the rate of energy loss for each speed on the schedule and the total amount of time spent at that speed over the entire schedule. The rate of energy loss due to road-load may be expressed as  $P_v = F_v v$ , for a specific speed,  $v$ , and a known road-load force at that speed,  $F_v$ . Then, for a given speed, the total amount of energy lost due to road-load is simply  $E_v$

$= P_v t_v$ , where  $t_v$  is the total time spent at speed  $v$  during a driving schedule. Using the definition above, this may be rewritten as  $E_v = F_v \sum t_v$ . The total amount of energy lost due to road-load over a complete driving schedule is then  $E_v$  summed over all speeds in that schedule. This quantity may then be used to evaluate and compare multiple road-load curves over the same driving schedule, assuming the schedule is broken into some set of finite speed intervals.

B. Road-load force data are used by EPA for fuel economy and emissions testing over the FTP, Highway (HFET), SC03, and US06 driving schedules. Evaluating the energy loss due to road-load over the FTP, HFET, and US06 cycles will emphasize road-load discrepancies at lower and higher speeds, respectively. Since vehicle variation plays a larger role at lower speeds and road-load curves are extrapolated from coastdown data when below 10 mph, only speeds of 10 mph and above will be considered for evaluation.

C. 1. If a production vehicle's city (FTP) energy loss due to road-load, calculated based on a production vehicle coastdown audit, is 10% greater than the city (FTP) energy loss due to road-load, calculated based on the road-load specification, then that road-load specification is substantially unrepresentative. If a production vehicle's highway (HFET) or highway portion (bag 2) of the US06 energy loss due to road-load, calculated based on a production vehicle coastdown audit, is 7% greater than the highway energy loss due to road-load, calculated based on the road-load specification, then that road-load specification is substantially unrepresentative.

2. If audit results indicate a substantially unrepresentative road-load force specification, EPA will review the road-load results with the manufacturer. At this point EPA will presume the manufacturer's road-load force specification is substantially unrepresentative for the entire affected production vehicle population. The manufacturer must either revise the specification to the EPA confirmed road-load results or provide additional representative production vehicles to be tested by EPA or the manufacturer subject to EPA oversight, at EPA's discretion. The average of all appropriate production vehicle results would constitute the revised specification.

D. 1. These confirmation tolerances account for test and vehicle variability as well as differences between vehicles within a sub-configuration. They do not constitute an allowance. If a sufficient number of representative vehicles are tested, the averages should be very close to the specifications.

2. A systematic bias indicates that the specifications are unrepresentative and shall be corrected.

## VII. Revising the Road-load Specification - Corrective Action

A. Revisions to the road-load force specification as described above must be used for all subsequent testing. In addition, if the road-load force specification is revised for any reason, all emissions and fuel economy data previously provided for the same model year or carry over model year(s) must be corrected.

B. All previous emissions or fuel economy data that was required to be corrected under paragraph A above must be removed or replaced and cannot be used to demonstrate compliance



to any emission standard (including the GHG fleet average or the in-use GHG standards) or used in CAFE calculations. If any of the replaced data was used in prior GHG or CAFE calculations, EPA will require the manufacturer to replace the previous data with representative data for all required tests, to remove or replace the previous data for all supplemental fuel economy tests, and to recalculate the GHG and CAFE fleet averages and ABT credits/debits. If applicable, the gas guzzler tax must also be recalculated based on the representative test data.

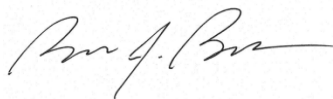
C. If any previous emissions or fuel economy data that was required to be corrected under paragraph A above was used in a fuel economy label calculation, EPA will require that the manufacturer replace the previous data with representative data and recalculate the fuel economy label values under the provisions of 40 CFR Part §600.312-08(a)(5). The original sales forecasts should not be revised for this calculation, the only modifications being those necessary to account for the road-load force specification revision. If any of the recalculated label values are lower, the label must be revised. (See Section 600.312-08(a)(6).)

D. EPA considers the road-load force specification to be a vehicle characteristic similar to curb weight. Certificates of conformity only cover vehicles which do, in fact, conform to the road-load specifications in the application for certification.

E. The manufacturer's application for certification must comply with the regulatory reporting requirements. Failure to comply with the application reporting requirements or rendering inaccurate any data submitted in an application may result in the denial of issuing a certificate or the suspension or the revocation of a previously issued certificate (reference 40 CFR §86.1850). Manufacturers failing to provide accurate vehicle road-load specification information in their applications for certification may also be subject to enforcement action, including civil penalties.

If you have any questions, please contact your certification team representative.

Sincerely,



Byron Bunker, Director  
Compliance Division  
Office of Transportation and Air Quality

Enclosure

## Enclosure to CD-15-05 Sample Submission

Durability Group		EEPAHHGNNABC																								
TestGroup		EEPAV02.4ABC																								
		Test																								
Carline	Model/	Engine	Engine	Trans.		Curb	Weight							Axle		Tire	Tire	Tire	Coastdown	RLHP	Target Coeff 70 F			Target Coeff 20 F		
Name	Code	Code	Disp	Type/Code	GVW	Weight	basis	LVW	ALVW	ETW	Ratio	N/V	Size	Mfr.	Model	Time	at 50 mph	A	B	C	A	B	C			
EPA Car	LX	123	2.4	A6	3900	3195	LVW	3495	Na	3500	2.06	25	225/65R17	Goodyear	AT	18.7	12.3	32.3312	0.1255	0.0209	35.5643	0.1381	0.0230			
EPA Car	LT	123	2.4	M6	3900	3050	LVW	3350	Na	3375	2.06	26	225/65R18	Goodyear	AS	17.3	13.0	34.9500	0.1357	0.0226	38.4450	0.1492	0.0249			
EPA Car	S	123	2.4	SA6	3900	3205	LVW	3505	Na	3500	2.06	26.6	P235/60R16	Goodyear	AS	16.9	13.2	35.754	0.1388	0.0231	39.3293	0.1527	0.0254			