TOYOTA

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Mr. Linc Wehrly
Compliance Division
Light-Duty Vehicle Center
Office of Transportation and Air Quality
U.S. Environmental Protection Agency
2565 Plymouth Road
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Subject: Application for High Efficiency Alternator Off-Cycle GHG Credit

This correspondence represents Toyota's application for High Efficiency Alternator Off-Cycle CO2 credits using the alternative methodology outlined in 40 CFR § 86.1869-12(d). Per 40 CFR § 86.1869-12, vehicle manufacturers may obtain off-cycle credits for the use of a CO2-reducing technology whose benefits are not adequately captured on the Federal Test Procedure and/or the Highway Fuel Economy Test. Therefore, this application for Off-Cycle credits is submitted in accordance with subsection (d) of the regulation, which enables manufacturers to earn credits by demonstrating that the applicable technology provides GHG reduction benefits via an alternative EPA-approved methodology.

Toyota also provides that the High Efficiency Alternator technology subject to this application is not a safety-related technology and would not be subject to any of the exclusions that are set forth in 40 CFR § 86.1869-12(a). 40 CFR § 86.1869-12(a) states that Off-Cycle credits may not be earned for crash avoidance technologies, safety critical systems, technologies designed to reduce frequency of vehicle crashes, or technologies installed to attain compliance with vehicle safety standard or regulation set forth in CFR title 49.

Upon receipt of this application, Toyota would be very appreciative if EPA were to provide written/e-mail acknowledgment of this Off-Cycle credit request. Should EPA have any questions about this correspondence, please contact Matthew Kevnick (734-995-3755; matthew.kevnick@toyota.com) at your earliest convenience.

Thank you very much for your consideration of Toyota's application and we are looking forward to continued dialog regarding this credit request.

Sincerely,

Takashi Nishikiori

Executive/Group Manager
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Unit Function and Powertrain | Powertrain Certification and Test Engineering

Request for High Efficiency Alternator Credits

Introduction and overview

Pursuant to 40 CFR 86.1869-12(d), 49 CFR 531.6(b), and 49 CFR 533.6(c); Toyota hereby requests approval for the following methodology to determine off-cycle CO2 credits from high efficiency alternators for 2017 MY and subsequent model year vehicles.

Toyota proposes the use of a scalable off-cycle credit value as calculated by the following formula determined by the European Commission[1], for all vehicle categories.

$$\text{Credit } \left[{}^{g}/_{\text{mile}}\right] = \left[\left(\frac{P_{RW}}{\eta_{Base}} - \frac{P_{RW}}{\eta_{New}}\right) - \left(\frac{P_{2Cycle}}{\eta_{Base}} - \frac{P_{2Cycle}}{\eta_{New}}\right)\right] \times \frac{V_{Pe}}{1000} \times CF/v$$

where,

- P_{RW}: Power consumption under real world driving [Watt], 588
- P_{2Cycle}: Power consumption under FTP and Highway test modes [Watt], 297
- η_{Base}: Baseline alternator efficiency, 0.67
- η_{New}: Efficiency with new alternator
- V_{Pe}: Engine efficiency relating consumed fuel to output mechanical energy [L/kWh], 0.264 for normal gasoline engine, 0.280 for gasoline turbo engine and 0.220 for diesel engine. Each value is determined in accordance with 'Willans' approach'.
- CF: Conversion factor of CO2 per consumed fuel [g/L], 2330 for gasoline and 2640 for diesel.
- v: Average driving speed [mph], 32

Description of System

In converting mechanical energy from the internal combustion engine to electrical energy for a vehicle's electrical systems, the additional mechanical load from the alternator results in the increased consumption of fuel and subsequent CO2 emissions. As the energy conversion process encounters a variety of mechanical and electrical losses, high efficiency alternators can reduce these loses thereby reducing the alternator load on the engine and offering better fuel economy and lower CO2 emissions.

The Verband der Automobilindustrie (VDA) efficiency is the accepted industry standard for measuring alternator efficiency and this efficiency is the ratio of the alternator output power to the power supplied to the alternator. With regards to the baseline VDA efficiency considerations:
(i) The EU released methodology recommends a baseline VDA of 67% for calculating the eco-innovation credit for high efficiency alternators on new vehicles types that is a scalable credit.

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[1] COMMISSION IMPLEMENTING DECISION (EU) 2016/588

(ii) . The EPA uses a baseline alternator efficiency of 65% in its Joint TSD for the 2017-2025 GHG regulation, based on a 2008 Delco-Remy Alternator.
(iii) Additionally, the Federal Register Final Rule for 2017-2025 EPA indicated that 68% VDA would be an appropriate threshold to begin awarding high efficiency alternator off-cycle credits: "*The 68% VDA number stated by the Alliance of Automobile Manufacturers seems to be appropriate starting point given current technology…*"[1]

Based on the Joint TSD comments and EU methodology Toyota recommends that 67% VDA be used as the baseline alternator efficiency in the high efficiency alternator off-cycle credit calculation to harmonize with the European Commission's decision.

Methodology to Determine the Off-Cycle Benefit

The following sections describe the methodology and justifications for the high efficiency alternator off-cycle credit request. Section (A) explains why the high efficiency alternator credit meets the general requirements of the off-cycle credit program, section (B) illustrates why the CO2 benefits are best demonstrated using the alternative EPA approved methodology presented in 40 CFR 86.1869-12(d), and section (C) provides the proposed alternative off-cycle credit methodology in detail.

A. General Requirements for Off-Cycle Credit

Although greenhouse gas emission reduction can be realized during the 2-cycle test, increased electrical loads on the vehicle in on road conditions allow high efficiency alternators to generate a higher greenhouse gas benefit outside the conditions of the Federal Test Procedure and the Highway Fuel Economy Test. Toyota proposes the use of a single scalable credit value that can be applied for all vehicle categories.

B. Rationale for Using The Alternative EPA-approved Methodology

High efficiency alternator technology is not available for credit on the pre-approved technology menu, so Toyota considered both the 5-cycle and alternative methodologies requesting credit. Although the 5-cycle methodology tend to captures a broader range of driving parameters, the potential for greenhouse gas benefits from high efficiency alternators can be fully realized when customers experience high accessory loads on a regular basis, loads which are not fully captured in the 5-cycle methodology. Vehicle systems are continuing to become increasingly complex with increasing accessory loads from Entertainment accessories, Climate Control functions, and Interior/Exterior lighting options.

For this reason, Toyota is pursuing off-cycle credits under the alternative demonstration methodology

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[1] 77 FR 62731

pursuant to 40 CFR § 86.1869-12(d).

C. Proposed Alternative EPA-approved Methodology

As a result of these higher off-cycle accessory loads, a high efficiency alternator will prove to be more beneficial in on-road driving than what would be demonstrable under the regulated test cycles. It is this additional benefit for which Toyota is applying for off-cycle credits under the alternative methodology.

1. Electrical load during 2-cycle and on-road driving conditions

Toyota recommends that electrical load values proposed by Ford[1] (297 Watt for 2 cycle test patterns and 588 Watt for real world driving situations) be used in the credit calculation for the vehicle fleet. As mentioned previously, electrical load depends on usage of select accessories such as climate control and entertainment system. While the power consumption may tend to vary on a vehicle-by-vehicle basis, the data shows there is little difference among the vehicles shown when taken as an average value.

The following example is comparison of electrical load data during 2 cycle testing and shows close result in average:

Mfr.	Model	Electrical load [Watt]	Average [Watt]
Toyota	RAV4 with engine-stop function	252	308
	RAV4 without engine-stop function	364	
Ford	Fusion	275	297
	F-150	318	

If "real" electrical load was required in the GHG reduction estimation, real-time power consumption would need to be tracked, which would prove to be unnecessarily burdensome. For this reason, it seems more reasonable to utilize a unified electrical load value as an industry average based on a number of samples that have been measured in the field. Furthermore, this approach is consistent with the TSD's methodology by which credit values are determined for the pre-approved items and results from these distinct data samples are then expanded for every manufacturer.

2. Calculate a general GHG benefit

Toyota proposes to use the equation which is fundamentally identical to the methodology accepted by

[1] Federal Register Vol. 82, No. 116, EPA–HQ–OAR–2017–0189, FRL–9962–95–OAR

the Europe Commission[1]. By calculating power consumption saving which is not captured in the 2 cycle test mode, GHG benefit is estimated from engine efficiency to create mechanical energy (determined by 'Willans' approach'), conversion factor of fuel to CO2, and vehicle average speed.

$$\text{Credit } \left[{}^{g}/_{\text{mile}}\right] = \left[\left(\frac{P_{RW}}{\eta_{Base}} - \frac{P_{RW}}{\eta_{New}}\right) - \left(\frac{P_{2Cycle}}{\eta_{Base}} - \frac{P_{2Cycle}}{\eta_{New}}\right)\right] \times V_{Pe} \times CF/v$$

Example)
When an alternator has 0.70 efficiency and is used in normal gasoline vehicle (without turbo), the credit is to be:

$$\left[\left(\frac{588}{0.67} - \frac{588}{0.70}\right) - \left(\frac{297}{0.67} - \frac{297}{0.70}\right)\right] \times \frac{0.264}{1000} \times 2330/32 = 0.36$$

Durability

Alternators installed within Toyota vehicles meet all the durability requirements of 40 CFR §86.1869-12(d) and are not subject to any deterioration factors that would reduce the benefits of the high efficiency alternator. Durability testing is conducted by suppliers to meet Toyota specifications.

Conclusion

Based on the rationale provided in this application, Toyota recommends;

- The use of 67% VDA as the industry average baseline alternator efficiency for the credit calculation.
- A single scalable credit formula that can be applied to all vehicle types for 2017 MY and beyond. The attachment shows Toyota's tentative plan for credits to be claimed in 2017MY (confidential and subject to change).
- Regarding the credit determination, apply the scalable methodology for each high efficiency alternator application starting at 68% VDA.
- The fleet credit will be calculated based on credit for each type of vehicle, vehicle lifetime miles and U.S. sales volume for 2017 MY and beyond products.

[1] COMMISSION IMPLEMENTING DECISION (EU) 2013/341

Attachment: Off-cycle credits to be claimed in 17MY (tentative and subject to change, and some more models to be added in the actual application)