May 3, 2017

**Attn: Linc Wehrly**

**U.S. Environmental Protection Agency**
**Office of Transportation & Air Quality**
**Assessment and Standards Division**
**2000 Traverwood Drive**
**Ann Arbor, MI 48105**

**Re: Application for Alternative Methodology for Off-Cycle Technology Credits**

Dear Mr. Wehrly,

Pursuant to the provisions of 40 CFR 86.1869-12(d), 49 CFR 531.6(b), and 49 CFR 533.6(b) FCA US LLC ("FCA US") hereby requests approval for off-cycle $CO_2$ credits for the following technologies used on 2009 and subsequent model year vehicles. In addition, off-cycle fuel consumption credits will be calculated using the procedure in 40 CFR 600.510-12(c)(3) for 2017 and subsequent model year vehicles.

- High efficiency alternators

High efficiency alternators were considered for the pre-approved technology menu, but not included due to the limited amount of vehicle data available at that time. To support the acceptance of high efficiency alternators as an off-cycle credit generating technology, FCA conducted extensive laboratory testing to determine the real-world power consumption to help calculate the benefit of high efficiency alternators. Attached is a description of the technology and details of the methodology used to determine the credit levels. The methodologies are supported by numerous analyses in U.S. Environmental Protection Agency's (EPA) rulemaking documents, the EU Technical Guidelines for Eco-Innovations, and internal FCA analyses.

This request for off-cycle credits is submitted in accordance with subsection 40 CFR 86.1869-12(d) which enables manufacturers to earn credits by demonstrating that the technology at issue results in a carbon-related exhaust emissions benefit when tested using an alternative EPA-approved methodology.

FCA is a full line automotive manufacturer engaged in the design and production of light-duty vehicles ranging from compact passenger cars to full size pickup trucks. FCA is committed to implementing technologies that reduce greenhouse gases and fuel consumption.

Sincerely,

Paul Mendrick

Manager – Vehicle Environmental Certification
Vehicle Safety and Regulatory Compliance – FCA US LLC

Cc: Gary R Oshnock
Fuel Economy/GHG Programs, Vehicle Safety and Regulatory Compliance, FCA US LLC

# High Efficiency Alternator Technology

## Definition

A high efficiency alternator increases a vehicle's mechanical-to-electrical energy conversion efficiency thereby reducing $CO_2$ emissions, and increasing fuel economy. The industry recognized standard for measuring alternator efficiency is the Verband de Automobilinudstrie standard (VDA). FCA recommends the use of 67% VDA as a baseline for high efficiency alternators.

## Credits

Using FCA mean electrical loads determined through laboratory testing and the methodology described below, FCA proposes the use of a single scalable credit value as calculated by the following formula for all vehicle categories.

$$Credit\ \left(\frac{g}{mi}\right) = 0.14\frac{g}{mi}\ (\eta_{alt} - \eta_{baseline})$$

Where:

$\eta_{alt}$ – VDA efficiency of alternator

$\eta_{baseline}$ – baseline alternator efficiency of 67% VDA

## Description of Technology

Automotive alternators convert mechanical energy from an internal combustion engine to electrical energy for a vehicle's electrical systems. The additional mechanical load on the engine from the alternator results in the increased consumption of fuel and resultant $CO_2$ emissions. A variety of mechanical and electrical losses are inevitable in this energy conversion process, and high efficiency alternators use new technologies to reduce these losses, thereby reducing the alternator load on the engine and resulting in better fuel economy and lower $CO_2$ emissions. The alternator is designed to function for the full useful life of the vehicle; no degradation in performance is expected.

The efficiency of the alternator is the ratio of the alternator output power to the power supplied to the alternator by the engine. The threshold of 67% VDA for high efficiency is supported by the EU Eco-Innovation methodology, EPA statements, and Robert Bosch sales data. The EU approved methodology for calculating eco-innovation credit[1] uses a baseline VDA of 67% for determining credits for high efficiency alternators on new vehicle types. This methodology is a scalable based on alternator percent VDA values similar to what is derived in the following sections. The EPA used a baseline alternator efficiency of 65% in the Joint TSD for the 2017-2025[2] GHG regulation, based on a 2008 Delco-Remy Alternator. In the discussion of high efficiency alternator off-cycle credits in the Federal Register Final

[1] COMMISION IMPLEMENTING DECISION (EU) 2016/588 of 14 April 2016 [2016] OJ L 101/25

[2] EPA-420-R-12-901 (August 2012) Joint Technical Support Document: Final Rulemaking for 2017-2025 Light Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; page 5-65

Rule for 2017-2025EPA 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…* [3]

Additionally, Robert Bosch has provided 2005 North American sales data[4] showing an average baseline efficiency of 66.6% VDA. Based on the above sources, FCA 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.

## FCA Methodology

FCA considered both 5-cycle and alternative methodologies. Although the 5-cycle methodology would capture a variety of driving conditions (e.g. vehicle speed, ambient temperature, etc.), the key factor in determining the greenhouse gas benefit of high efficiency alternators is the fact that customers use many accessories on a regular basis. These loads are not fully captured in the 2-cycle test or 5-cycle alternative methodology due to the limited accessory use on test. Examples of some such accessory loads include:

- Climate control
- Entertainment accessories (radio, phone chargers, etc.)
- Lighting (interior and exterior)

For this reason, FCA is pursuing off-cycle credits under the alternative demonstration methodology pursuant to 40 CFR 86.1869-12(d).

The proposed alternative methodology compares the GHG impact of high efficiency alternators of varying VDAs to the baseline alternator using the EPA's ALPHA 2.0 model. All vehicle configurations were modeled with various combinations of alternator efficiencies and electrical loads. Alternator efficiencies used in the modeling were 67, 73, and 80 percent VDA; the two electrical loads used were the base electrical load included in the ALPHA 2.0 model and the average real-world electrical load which is 262.85 watts greater than the base load[5]. FCA determined the real-world electrical load by testing the accessory loads of a representative cross section FCA's current product offering. The results of the ALPHA 2.0 modeling are summarized in the chart below[6].

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[3] Federal register Vol. 77, No. 199, pg 62731
[4] Appendix A – 2005 Robert Bosch Alternator Efficiency
[5] Appendix B – Vehicle Testing
[6] Appendix C – ALPHA 2.0 Simulations

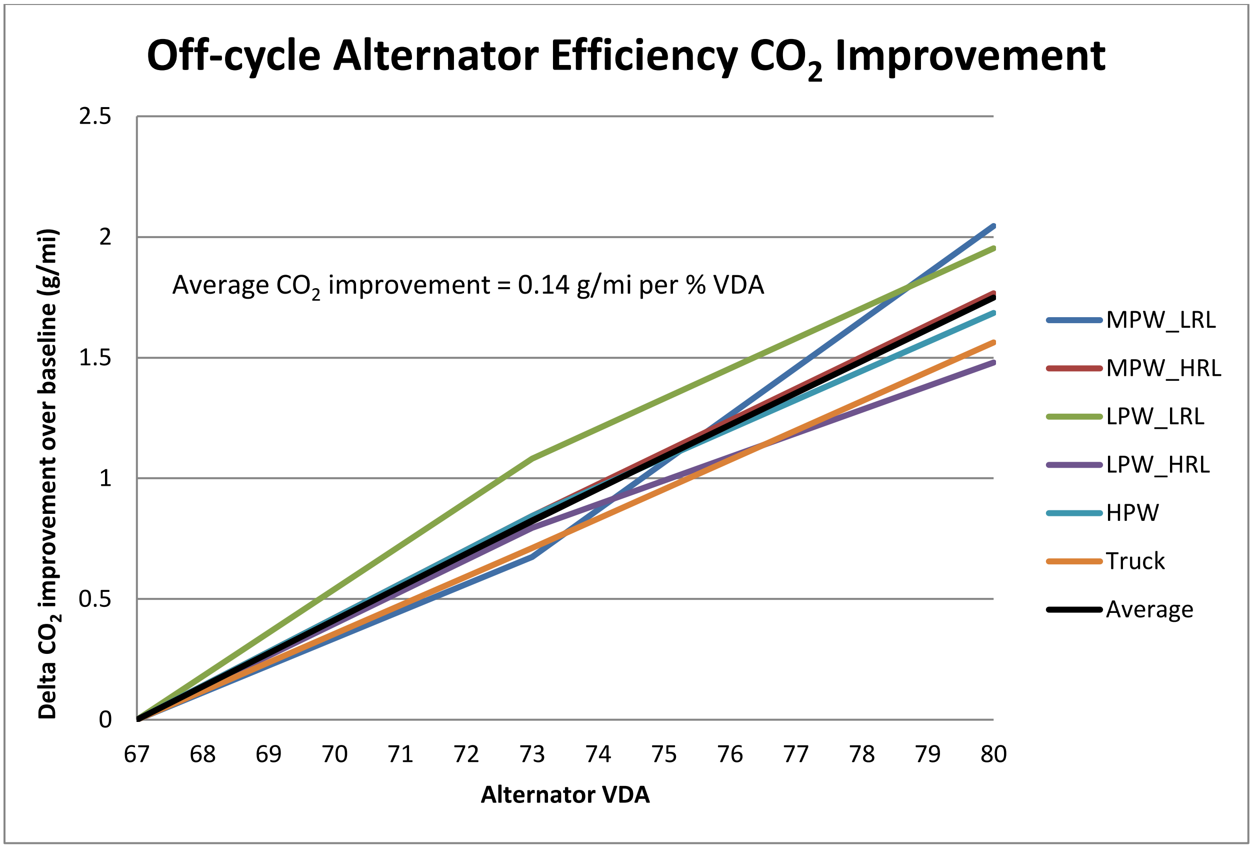


**Figure 1 - ALPHA 2.0 Simulation Results**

The simulation results indicate that the real-world electrical load increase corresponds to an average GHG improvement of 0.14 g/mi per percent VDA improvement in alternator efficiency above what can be measured on-cycle. FCA proposes the use of this formula with VDA improvement measured from a base alternator efficiency of 67% VDA as the appropriate credit value for high efficiency alternator technologies.

At the end of each model year, FCA will determine the credits for each high efficiency alternator using the above formula. The fleet credit will be calculated based on the credit for each type of vehicle, vehicle lifetime miles and U.S. sales volume for applicable 2009 and beyond model year products.

## Appendix A – Robert Bosch Alternator Efficiency

### Alternator efficiency in North America

# Efficiency development 2005-2015

| | 2005 | | | 2010 | | | 2015 | | |
|---|---|---|---|---|---|---|---|---|---|
| Power classes | Share % NA | Ø-efficiency [% VDA] | Ø-efficiency [% VDA] | Share % NA | Ø-efficiency [% VDA] | Ø-efficiency [% VDA] | Share % NA | Ø-efficiency [% VDA] | Ø-efficiency [% VDA] |
| LK1 (≤ 85A) | 2% | 61 | 66.6 | 1% | 62 | 68.2 | 0.2% | 63 | 69.3 |
| LK2 (≤ 110A) | 15% | 65 | | 9% | 66 | | 8.8% | 67 | |
| LK3 (≤ 135A) | 35% | 65 | | 29% | 66 | | 27.4% | 67 | |
| LK4 (≤ 150A) | 31% | 68 | | 33% | 69 | | 31.5% | 70 | |
| LK5 (≤ 185A) | 12% | 69 | | 20% | 70 | | 22.0% | 71 | |
| LK6 (> 185A) | 5% | 70 | | 8% | 71 | | 10.2% | 72 | |

125 Bosch 1886–2011 Starter Motors and Generators

1

## Appendix B – Real World Electrical Load Testing

A series of tests were conducted in FCA's test facilities to measure both the 2-cycle and real-world electrical loads of various FCA products. The real-world electrical load is the load the vehicle can expect under normal driving conditions with typical accessory use. Typical accessory use is defined for this study as radio on, the use of HVAC set appropriately for ambient conditions, exterior lighting use in night time driving conditions, and cold weather accessories used below 40 degrees ambient.

Other accessories could be included in the measurement of the on road electrical load. However the purpose is to measure a nominal electrical load on the vehicle, not a max electrical load. FCA considers the accessories selected and the settings used on the tests as conservative and representative of only those accessories whose usage can be quantified. The loads also do not represent any additional customer activated safety features that have been specifically disqualified from the off-cycle credit program by the agency.

The environmental and base vehicle electrical load was determined by testing a fleet of fourteen vehicles which represent a cross section FCA's current products. These vehicles included 2014 - 2016 model year small, medium and large cars as well as light duty trucks and SUVs in varying trim levels and accessory configurations. All were equipped with production high efficiency alternators and shunts installed to measure the electrical load on the alternator.

| Vehicles Tested |
|---|
| 2014 1.4L Turbo Sport FF |
| 2016 2.4L KL |
| 2015 3.6L JK |
| 2015 3.0L Diesel DS |
| 2015 5.7L DS |
| 2014 3.6L DS |
| 2014 2.4L PF |
| 2015 2.4L UF |
| 2014 3.6L WK |
| 2016 3.6L WK |
| 2016 3.6L UF |
| 2016 2.4L UF |
| 2015 3.6L DS |
| 2016 5.7L DS |

The tests consisted of an FTP and Highway test cycle where the 2-cycle electrical load was measured following the standard test procedure first, and then a series of 2-cycle tests were run at five ambient temperatures: 95F, 75F, 58F, 40F and 20F, with appropriate environmental accessories turned on. The climate control was set to 72F auto in vehicles equipped with automatic climate control or adjusted to maintain driver comfort in manually controlled vehicles.

The five ambient temperatures the vehicles were tested at were selected based on EPA MOVES data for low, mid, and high temp zones. A single average temperature was used in the low and high temp zones. Three data points were taken to observe the full electrical load profile in the mid temp zone since cabin comfort typically dictates the use of heat at 40F and the use of air conditioning at 75F. The inclusion of 58F was done because it is the national average ambient temperature. The results of the vehicle testing were weighted by the MOVES data according to the table below.

| Low temp zone | Mid temp zone | High temp zone |
|---|---|---|
| <40°F | 41°F to 80°F | >80°F |
| 21.95% | 68.75% | 9.70% |

Figure 2 - EPA MOVES Ambient Temperature

The accessory loads for radio and exterior lights were not included in the vehicle level testing. In the case of the radios, they were not included in vehicle level testing because radios do not work in the vehicle test cells. The radio loads were measured from a bench test following a standard procedure for determining nominal radio electrical load. It was assumed that the radio is always on under all driving conditions as that is the standard key on mode in FCA products. The exterior light loads were based on the rated wattage of the exterior lights and usage weighted according to TSD Table 5-21[7]. The measured real world loads are as follows.

| Real World Load Type | Measured Load |
|---|---|
| **Environmental**<br>MOVES temperature weighted | 194.25 Watts |
| **Lighting**<br>VMT and usage weighted for night driving | 41.3 Watts |
| **Radio**<br>Nominal load, volume weighted | 27.3 Watts |
| **Total Real World Accessory Load** | **262.85 Watts** |

[7] EPA-420-R-12-901 (August 2012) Joint Technical Support Document: Final Rulemaking for 2017-2025 Light Duty Vehicle Greenhouse Gas Emission standards and Corporate Average Fuel Economy Standards; page 5-71

# Appendix C – ALPHA 2.0 Test Results

| Test Number | Test Vehicle Configuration | VDA | Additional Elec. Load | GHG (g/mi) |
|---|---|---|---|---|
| 1 | MPW_LRL | 67% | 0 | 262.2555 |
| 2 | | 73% | 0 | 261.0448 |
| 3 | | 80% | 0 | 259.817 |
| 4 | | 67% | 262.85 | 272.9682 |
| 5 | | 73% | 262.85 | 271.0831 |
| 6 | | 80% | 262.85 | 268.4844 |
| 7 | MPW_HRL | 67% | 0 | 361.2735 |
| 8 | | 73% | 0 | 360.0124 |
| 9 | | 80% | 0 | 358.8849 |
| 10 | | 67% | 262.85 | 370.7575 |
| 11 | | 73% | 262.85 | 368.6529 |
| 12 | | 80% | 262.85 | 366.6022 |
| 13 | LPW_LRL | 67% | 0 | 232.3893 |
| 14 | | 73% | 0 | 231.1879 |
| 15 | | 80% | 0 | 229.9368 |
| 16 | | 67% | 262.85 | 243.0863 |
| 17 | | 73% | 262.85 | 240.8039 |
| 18 | | 80% | 262.85 | 238.6808 |
| 19 | LPW_HRL | 67% | 0 | 280.5549 |
| 20 | | 73% | 0 | 279.2243 |
| 21 | | 80% | 0 | 277.9467 |
| 22 | | 67% | 262.85 | 291.028 |
| 23 | | 73% | 262.85 | 288.9019 |
| 24 | | 80% | 262.85 | 286.94 |
| 25 | HPW | 67% | 0 | 351.835 |
| 26 | | 73% | 0 | 350.5533 |
| 27 | | 80% | 0 | 349.3246 |
| 28 | | 67% | 262.85 | 362.0689 |
| 29 | | 73% | 262.85 | 359.9433 |
| 30 | | 80% | 262.85 | 357.8733 |
| 31 | Truck | 67% | 0 | 426.659 |
| 32 | | 73% | 0 | 425.3906 |
| 33 | | 80% | 0 | 424.1485 |
| 34 | | 67% | 262.85 | 436.9571 |
| 35 | | 73% | 262.85 | 434.9767 |
| 36 | | 80% | 262.85 | 432.8835 |

FCA Confidential Business Information

## Appendix D – Credit Estimates 2009-2016

[redacted]