Vehicle Environmental Regulatory Strategy & Planning
Sustainability, Environment & Safety Engineering
Ford Motor Company

World Headquarters
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April 16, 2021

To: Mr. Linc Wehrly
Compliance Division
Light-Duty Vehicle Center
Office of Transportation and Air Quality
U.S. Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, Michigan 48105

To: Mr. James Tamm
Fuel Economy Division Chief
Office of Rulemaking
National Highway Traffic Safety Administration
1200 New Jersey Avenue SE
Washington, DC 20590

Subject: Request for 2020 MY and Beyond Greenhouse Gas (GHG) and Fuel Economy Off-Cycle Credits

Per 40 CFR 86.1869-12, 49 CFR 531.6(b), and 49 CFR 533.6(b), Ford requests GHG off-cycle credits for the following technologies:

- DENSO LE40 A/C Compressor Clutch
- [redacted]

Pursuant to 40 CFR § 86.1869-12 and per 49 CFR 531.6, vehicle manufacturers may obtain off-cycle credits for the use of a technology whose benefits are not adequately captured on the Federal Test Procedure and/or the Highway Fuel Economy Test. This request for off-cycle credits is submitted in accordance with subsection (d) of that rule, 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 methodology approved by EPA in consultation with NHTSA. 40 CFR § 86.1869-12(a) provides that off-cycle credits may not be earned for crash avoidance technologies, safety critical systems, technologies designed to reduce the frequency of vehicle crashes, or technologies installed to attain compliance with any vehicle safety standard or regulation set forth in CFR title 49. Ford hereby states that the above listed technology that is the subject of this request are not safety-related technologies and are therefore not subject to any of the exclusions set forth in subsection (a).

Ford kindly requests written/e-mail acknowledgment upon receipt and acceptance of this off-cycle credit proposal. If you have any questions about this letter and the related attachments, please contact Mr. Matthew Duffy at mduffy6@ford.com or (313) 323-2398.

Sincerely,

Steve Henderson, Manager
Vehicle Environmental Regulatory Strategy & Planning

1. DENSO LE40 A/C Compressor Clutch

Pursuant to 40 CFR 86.1869-12(d), 49 CFR 531.6(b), and 49 CFR 533.6(b) Ford hereby requests approval for the following methodology to determine off-cycle CO2 credits for the DENSO LE40 A/C compressor clutch technology.

Ford proposes the use of a 0.3 g/mi credit for both cars and trucks. The LE40 clutch improves compressor electrical efficiency with improved winding and magnetic flux design, leading to reduced alternator load and thus lower emissions. This value is determined by bench testing of the LE40 clutch power draw and A/C usage information from the GREEN-MAC Life Cycle Climate Performance (LCCP) model. With this application Ford seeks approval for off-cycle credits based on the technology, credit level, and methodology detailed below.

a. Description of Technology

The LE40 clutch makes three improvements over industry standard A/C compressor clutches. First, it uses a reduced coil wire diameter. The reduced diameter reduces coil size and mass while increasing electrical resistance, which decreases power consumption and has the negative effect of decreasing Ampere turns for an equivalent turn coil. Second, the LE40 clutch uses an improved winding technique to create a stepped coil, reducing dead space around the clutch's thermal fuse as well as the clutch's size and mass (Figure 1).

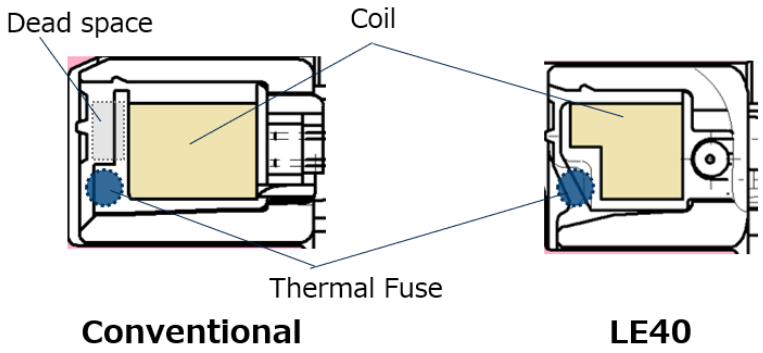

Figure 1: Conventional and LE40 clutches, showing LE40's stepped coil design and reduction of dead space around the thermal fuse.

Third, the LE40 clutch has an improved design for magnetic flux density (Figure 2). This decreases the magnetic resistance of the clutch and allows transmission torque capability to match or exceed that of conventional design clutches, even in spite of the decreased Ampere turns. Note in Figure 3 that the LE40 clutch is able to meet a 42 Nm transmission torque requirement with 2 A of current while the LC45 (a conventional design clutch) requires 2.5 A to meet the same requirement.

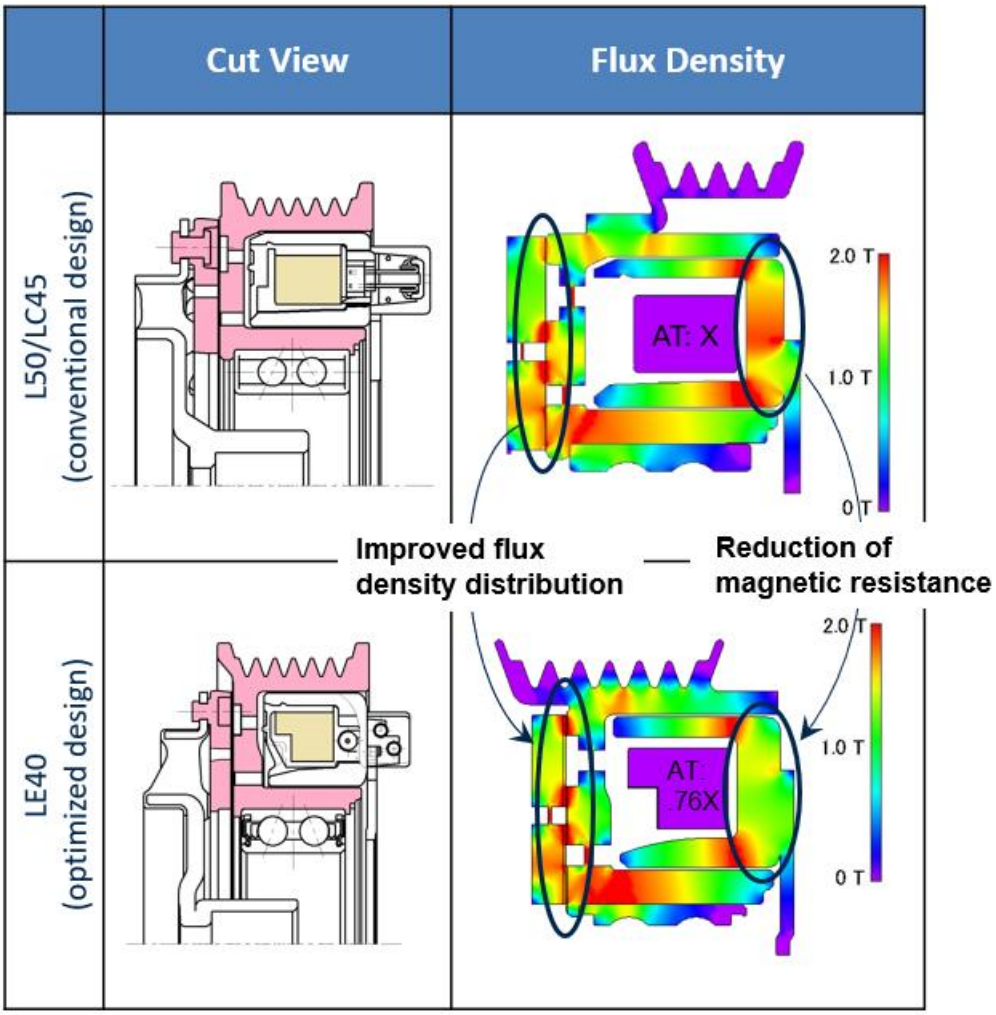

Figure 2: Improved magnetic flux density of LE40 clutch compared to conventional design.

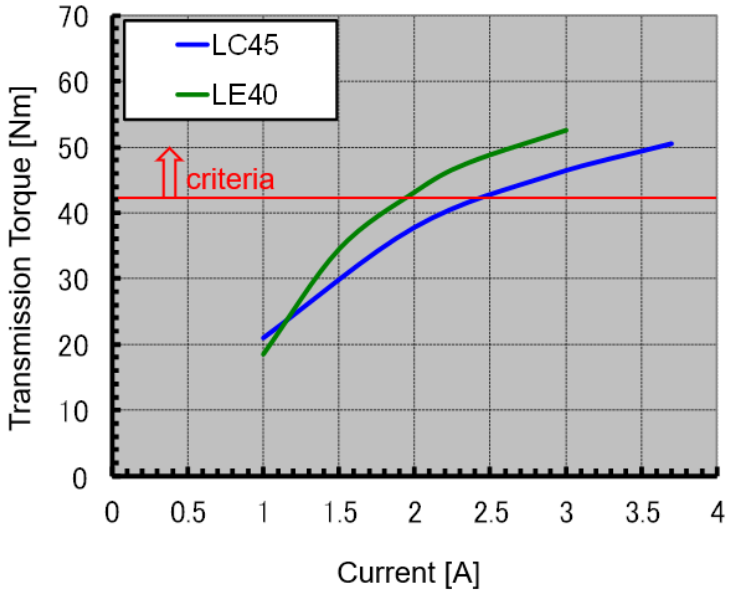

Figure 3: Comparison of LE40 and LC45 (conventional) clutches' transmission torque vs current curves.

b. Rationale for Using Alternative Demonstration Methodology

Ford has considered both the 5-cycle and alternative demonstration methodologies to request credits for the LE40 clutch. Although the 5-cycle test captures a variety of driving conditions, only the SC03 makes use of the A/C compressor. Additionally, the 5-cycle calculation suggests the A/C usage is only ~13% of VMT, while literature, the LCCP model, and field data collected by Ford indicate that it is substantially higher. Due to these factors, the full benefit of the LE40 clutch would not be captured with the 5-cycle methodology, and an alternative methodology approach is appropriate. Because A/C is not used for 2-cycle tests, Ford expects that the efficiency improvement of the LE40 clutch will have no impact on 2-cycle test results.

Ford is pursuing off-cycle credits under an alternative demonstration methodology pursuant to 40 CFR § 86.1869-12(d).

c. Proposed Alternative Demonstration Methodology

i. Bench Testing

The power consumption of the LE40 clutch has been compared by DENSO to that of various other clutches in the baseline 2009-2012 timeframe. The average power consumption of these clutches was 41 W. When tested in the same way, the LE40 compressor clutch was measured to have power consumption of 28 W for savings of 13 W versus the average baseline. Further detail may be seen in Appendix A.

ii. Calculation of Credit

In order to calculate a credit value from the power savings enabled by the LE40 clutch, the reduction in wattage must be converted to a g CO_2 per mile value and the usage rate of the technology over all VMT must be established. In order to convert the power savings to g CO_2 per mile, the Joint Technical Support Document published in 2012 used a value of 3.2 g CO_2 per mile per 100 W saved. This value has subsequently been accepted by EPA when calculating credits for new off-cycle technologies, including Ford's application for High-Efficiency Alternator credits.

To establish A/C usage rate, Ford has collected real-world usage data from 33 2020 MY Escape (19 truck configuration, 14 car configuration) and 37 2020 MY Explorer (truck) vehicles equipped with the LE40 clutch, consisting of approximately 14,500 trips and 210,000 miles traveled over 5,800 hours. When VMT-weighted by the ambient temperature bins from the MOVES dataset, overall A/C usage was found to be evenly split, with 50% of total VMT using A/C and 50% not using A/C. Ford realizes that this 50% A/C usage rate is lower than usage rates suggested by the LCCP model that other manufacturers have cited when applying for credits for this technology. However, Ford uses a unique system ("Enhanced Window Anti-Fogging Strategy", or EWAFS) designed to limit A/C usage in mild ambient conditions where A/C was previously used as a precaution against fogging. EWAFS is not equipped on all Ford vehicles, but it is present on a sufficient number of its current vehicles (including the 2020 MY Escape and Explorer) that Ford believes a 50% A/C usage rate is the best representation of its vehicle portfolio for the purpose of this credit application. The 2020 MY Escape and Explorer A/C usage may be seen in Figure 4.

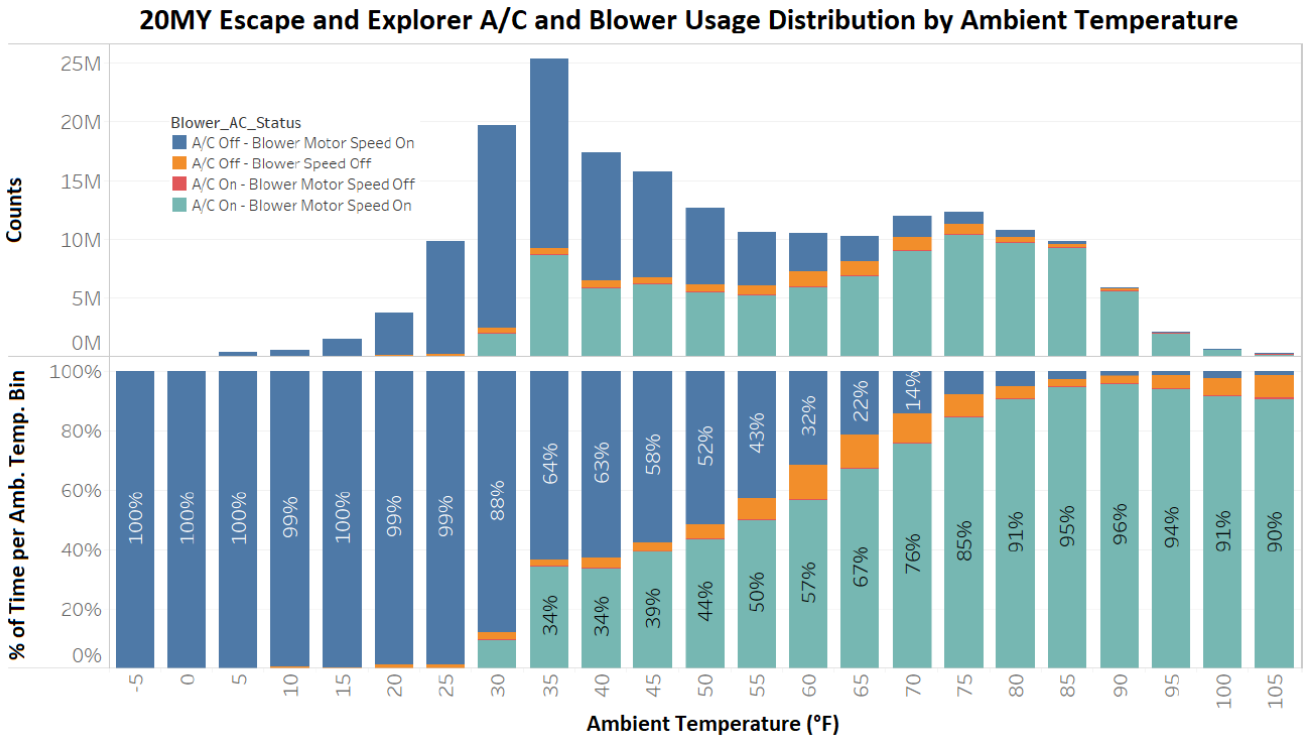

Figure 4: A/C and HVAC blower motor customer usage data for 20MY Escape and 20MY Explorer vehicles equipped with DENSO LE40 A/C compressor clutches.

Combining the 13 W savings, the 3.2 g/mi per 100 W value established by EPA, the 50% A/C usage rate measured for Ford vehicles with EWAFS, and rounding to the nearest tenth of a gram, the calculated credit value is 0.2 g CO_2 per mile:

$$(41\,W - 28\,W) \times \left(\frac{3.2\frac{g}{mi}}{100\,W}\right) \times 50\% = 0.2\,\frac{g}{mi}$$

d. Durability

A/C compressor clutches installed on Ford vehicles are designed to meet all the durability requirements of 40 CFR § 86.1869-12(d) and are not subject to any deterioration factors that would reduce their benefits. Durability testing has been conducted on production equipment to confirm that these systems meet both full useful life requirements and Ford internal durability specifications.

e. Summary

Based on the data and methodology presented, Ford recommends the use of a 0.2 g CO_2 per mile credit for both cars and trucks equipped with the DENSO LE40 A/C compressor clutch. The credit would be applicable for vehicles with the technology installed for 2020 and subsequent model years (Ford has previously described this technology to EPA, with this final application pending 20MY real-world usage data). A list of the vehicle models which are equipped with the technology and projected future vehicles along with an estimate of the off-cycle benefit by vehicle model and the fleet-wide credit benefit based on sales of vehicle models equipped with the technology is provided in Appendix

C. The fleet credit is calculated based on credit for each type of vehicle, vehicle lifetime miles and projected U.S. sales volume for 2020 model year products and beyond.