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NISSAN

NISSAN NORTH AMERICA, INC.
One Nissan Way
Franklin, TN 37067

December 11th, 2023

Mr. Linc Wehrly
Light Duty Vehicle Center
Compliance Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency
2000 Traverwood Drive
Ann Arbor, MI 48105

Subject: Updated Application for Alternative Methodology Off-Cycle GHG Credits Related to Use of Low-Power-Consumption Compressor Clutch Technology for 2017 and Subsequent Model Years

Dear Mr. Wehrly,

In accordance with the provisions of 40 CFR 86.1869-12(d) Nissan requests Agency approval of an off-cycle greenhouse gas ("GHG") credit of 0.4 grams CO_2/mile for certain Nissan and Infiniti models equipped with a Denso compressor incorporating Low-Power-Consumption LE40 Clutch technology. The basis for this application and the technology is described in detail in Attachments 1 and 2. This credit value would be applied to Nissan Rogue and Nissan Maxima vehicles with auto A/C that use a Denso compressor incorporating Low-Power-Consumption LE40 Clutch technology for 2017 and subsequent model years. These models are detailed in Attachments 3 and 4.

The comparative baseline technology used to establish the 0.4 grams CO_2/mile credit value is the difference between the power consumption of the industry standard clutch with similar performance characteristics (circa 2012) and the Denso Low-Power-Consumption Compressor LE40 Clutch. The conversion formula between the power savings and equivalent GHG reduction is modeled after the description in the Joint Technical Support Document (EPA-420-R-12-901) for High Efficiency Lighting and is also detailed in Attachment 1.

This application meets the requirements of 40 CFR 86.1869-12 in that neither the 2-cycle test procedure (used to determine manufacturer compliance with fleet-average GHG standards) nor the 5-cycle test procedure outlined in 40 CFR 86.1869-12(c) adequately measure the real-world

emission reduction attributable to the use of Denso compressor incorporating Low-Power-Consumption LE40 Clutch technology.

Nissan stipulates that Denso Low-Power-Consumption Compressor LE40 Clutch is not subject to the credit exclusion provisions of 40 CFR 86.1869-12(a) as it relates to safety-critical systems, crash avoidance systems or safety standard compliance.

Nissan respectfully requests that the Agency accept that its recent discussions concerning this request satisfies 40 CFR 86.1869-12(d)(1). Nissan initially applied for this off-cycle credit in April of 2020. Nissan has since had several discussions with EPA and gathered / presented the requested data. All open items have been closed and therefore Nissan is submitting this updated application for off-cycle credits based on the latest communication received from EPA on October 25, 2023.

Nissan respectfully requests that the Agency notify us when this application has been officially received and accepted.

If you have any questions or comments, please contact Mr. Ryuichi Haya of Nissan Technical Center North America at e-mail: Ryuichi.Haya@nissan-usa.com.

Best Regards,

Davin Beltran
Senior Manager, Regulatory Compliance
Program Management Office
Nissan North America, Inc.

Attachments:
1. Off-Cycle Credit Updated Application for Low-Power-Consumption Compressor Clutch
2. Denso Low Power Consumption Compressor LE40 Clutch - Supplier material
3. Model-specific and fleet-wide GHG credit calculations.
4. Planned Future Models that Incorporate Denso Compressor LE40 Clutch (Confidential Business Information)
5. EPA LE40 Clutch Usage Updated Final for EPA – material shared in August 2022

Redacted cc:
Mr. Maurice Hicks, NHTSA
Mr. Otto Matheke, NHTSA

Attachment 1

Request for Off-Cycle GHG Credit for Low-Power-Consumption Compressor Clutch

Executive Summary

Nissan requests Agency approval of an off-cycle greenhouse gas (GHG) credit of 0.4 grams CO_2/mile for certain 2017 and later models with Auto A/C equipped with a Denso Compressor incorporating Low-Power-Consumption LE40 Clutch technology. This technology is described in detail in Attachment 2.

This request uses a methodology that calculates credits based on power consumption reduction against the industry standard power consumption of compressor clutches (circa 2012). Nissan references the equation used on High Efficiency Exterior Lighting Credit in the Joint Technical Support Document: Final Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy ("JTSD") with modification of the usage factor from the Rogue and Maxima actual in-use data.
This approach uses the electrical load factors developed by EPA's full vehicle simulation analysis and published in JTSD, Table 5-18.

Background

The U.S. Environmental Protection Agency (EPA) and the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) have issued rules to reduce greenhouse gas (GHG) emissions and improve fleet average fuel economy. Under the Clean Air Act, EPA established national GHG standards. Separately under the Energy Policy and Conservation Act and the Energy Independence and Security Act NHTSA established Corporate Average Fuel Economy (CAFE) standards.

EPA provides Off-Cycle Credits for vehicle technologies that reduce electrical load, consequently reducing the consumption of fuel and carbon-related exhaust emissions. The Denso LE40 Compressor Clutch reduces vehicle electrical system load during conditions when the air conditioning compressor is running including cabin cooling and window defogging. The Denso LE40 Clutch technology allows for a significant reduction in vehicle electrical load compared to clutches that were in common use when the rule was developed.

Rationale for Alternative Method

The GHG benefit of some technologies can be demonstrated using conventional 2-cycle or 5-cycle chassis dynamometer testing. In this case, the manufacturer can conduct such testing and apply to the Agency for GHG credits. However the real-world GHG benefits of some technologies are not accurately quantified using 2-cycle or 5-cycle chassis dynamometer testing.

Because EPA's 2-cycle testing does not utilize A/C operation, and the 5-cycle test program would not adequately measure the real-world greenhouse gas reduction benefits of the Denso Compressor LE40 Clutch (as only one of the five tests is conducted with the air conditioner compressor switched on), alternative engineering analysis is needed. Considering the nature of this clutch technology, we determined that a bench test to determine the difference in electrical demand between a baseline clutch and the LE40 clutch technology is most appropriate.

The industry standard for understanding impacts of changes to efficiency improvements to Mobile Air-Conditioning systems (MACs) is detailed in SAE J2766: Life Cycle Analysis to Estimate the CO2-Equivalent Emissions from MAC Operation. This model is widely accepted and referenced in many air conditioner off-cycle applications, which have been approved by the EPA. The inputs to this Life Cycle Climate Performance, (LCCP) model gather both historical atmospheric temperature data, along with vehicle registrations and A/C usage based on need for cooling or dehumidifying the cabin to prevent fogging. With this information, a percentage of A/C clutch operation can be calculated for the US overall. After further discussions with EPA, it was proposed by Nissan and agreed to by the EPA to use composite Rogue and Maxima actual in-use data across all temperature ranges instead of the LCCP model referenced above.

The Agency allows manufacturers a further pathway for additional GHG credits for technology that cannot be adequately characterized using either the 2-cycle or 5-cycle chassis dynamometer-based test procedures. This alternative pathway requires a demonstration program that should:

1. Use modeling, on-road testing, on-road data collection or other approved analytical or engineering methods;
2. Be robust, verifiable, and capable of demonstrating the real-world emission benefit with strong statistical significance;
3. Result in a demonstration of baseline and controlled emissions over a wide range of driving conditions and number of vehicles such that issues of data uncertainty are minimized.
4. Result in data on a model type basis unless that manufacturer demonstrates that another basis is appropriate and adequate.
5. Validate in-use durability of the technology for the full useful life of the vehicle.

Nissan requests approval of an "alternative demonstration program" under 40 CFR 86.1869-12(d) for the Denso Low-Power-Consumption Compressor LE40 Clutch.

Description of Technology

The compressor clutch is an electro-mechanical device powered by the vehicle's electrical system that activates by applying current through a coil. When the air conditioning system commands cooling, the clutch is activated by energizing the coil. When energized, the coil

causes a friction plate to connect the compressor drive belt pulley to the compressor shaft allowing torque to be transmitted from the serpentine belt of the engine to operate the compressor. The compressor then compresses gas-phase refrigerant and pumps it through the air conditioning system.

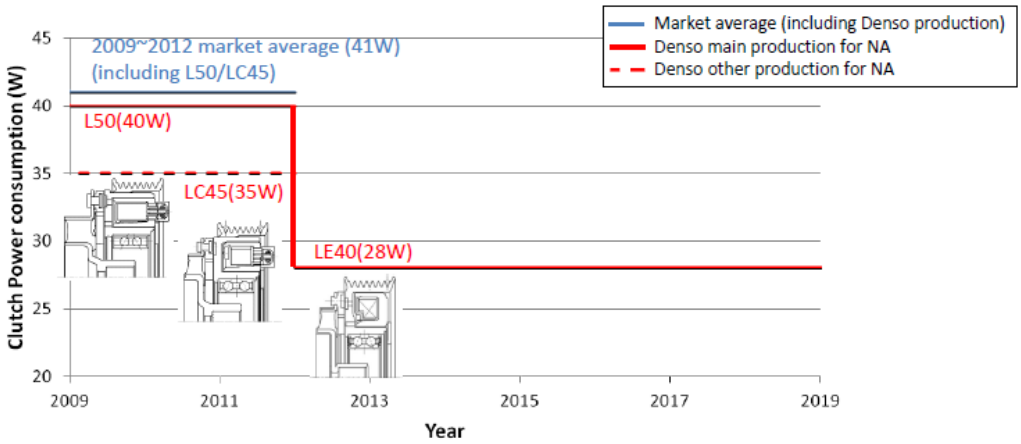
The LE40 Clutch technology reduces the load of the vehicle's electric system during compressor operation. The GHG reduction is accomplished by reducing engine load through reduced alternator demand.

Discussion

For the MY2017-2025 GHG rule, the Agency determined that technologies that reduce electrical load improve GHG emissions at a rate of 3.2 grams/mile per 100W of electrical load reduction. *See* JTSD section 5.2.2, table 5-18. Reducing the electrical demand of the compressor clutch will reduce vehicle electrical system demand and reduce GHG emissions.

At the time of the rule making, the industry standard for clutch power consumption was 41W. (See benchmarking data in Figure 1.) Since that time, Denso has developed a technology to reduce the power consumption while maintaining the key characteristics such as transmission torque, axial length and mass. Denso was able to do this with a patented design on a winding process on a stepped coil. (See Appendix 2 material for detail.) This improvement was able to reduce the power consumption to from 41W to 28W—a power consumption savings of 13W.

Market Trend of Clutch Power Consumption



	Supplier A	Supplier B	Supplier C	DENSO		
Clutch type	-	-	-	LC45	L50	LE40
Power Consumption (W)	40(avg.)	42(avg.)	42 (avg.)	35	40	28
Transmission Torque Capability (Nm)	55~59	35~50	52~56	41	53	41
Axial length(mm)	52~	47~	52~	47	52.5	45
Mass (kg)	2.2~	2.0~	2.1~	1.9	2.1	1.7

Figure 1

Because this power consumption reduction is only applied when the compressor is operating, real-world usage of the air conditioning compressor must be considered. Nissan will use actual in-use data collected from Nissan Rogue and Nissan Maxima Auto A/C vehicles to calculate average compressor usage.

Credit amount calculation method

To calculate the GHG credit for this electrical load reduction the following equation, as similarly described for high efficiency lighting in the 2017-2025 JTSD section 5.2.3, is adapted for the A/C compressor usage rate normalized across the US from LCCP Model Version 3b. Based on EPA analysis, outlined on table 5-18, 3.2g CO_2/mi is reduced for every 100 watts that are reduced across the 5-cycle test, the below formula is derived to scale the credit amount appropriately.

$$\textbf{Credit} = \frac{\textbf{(Baseline Clutch power-Improved Clutch power) x Usage rate x 3.2 g } CO_2\textbf{/mi}}{\textbf{100 watts}}$$

Substituting values based on this engineering analysis:

$$\textbf{LE40 Clutch Credit} = \frac{\textbf{(41W-28W) x 90.3\% x 3.2 g } CO_2\textbf{/mi}}{\textbf{100W}} = \textbf{0.376g } CO_2\textbf{/mi}$$

This application covers certain 2017 and subsequent model year vehicles with auto A/C equipped with a Denso Compressor including Low-Power-Consumption LE40 Clutch technology. (See Appendix 3.) In the future, Nissan may use this LE40 Clutch in additional models. (See Appendix 4 for upcoming planned models.)

Durability Statement

Denso A/C Compressors with Low-Power-Consumption LE40 Clutch technology installed in Nissan and Infiniti models meet all of Nissan's and Denso's internal durability test requirements. Based upon those tests, the Denso A/C Compressors with Low-Power-Consumption LE40 Clutch described herein are validated to perform over the full useful life of the vehicle on which they are installed without deterioration of the GHG benefits attributable to the reduced power consumption technology described above.

Conclusion

Nissan will calculate the model-specific and fleet-wide credit values in accordance with 40 CFR 600.510-12(c) considering vehicle lifetime miles for the applicable category of vehicles and total

production volume. A list of the applicable 2017-2022 models, their related sales, and model-specific and fleet-wide GHG credit calculations are shown in Attachment 3.

Thank you for your consideration of Nissan's request for off-cycle greenhouse gas credits for Denso A/C Compressors with Low-Power-Consumption LE40 Clutch.

References:

1) Joint Technical Support Document: Final Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards Pages 5-64~5-72, EPA-420-R-12-901, August 2012.
2) SAE J2766: Life Cycle Analysis to Estimate the CO2-Equivalent Emissions from MAC Operation https://saemobilus.sae.org/content/J2766_201908/#references

Denso low power consumption clutch LE40

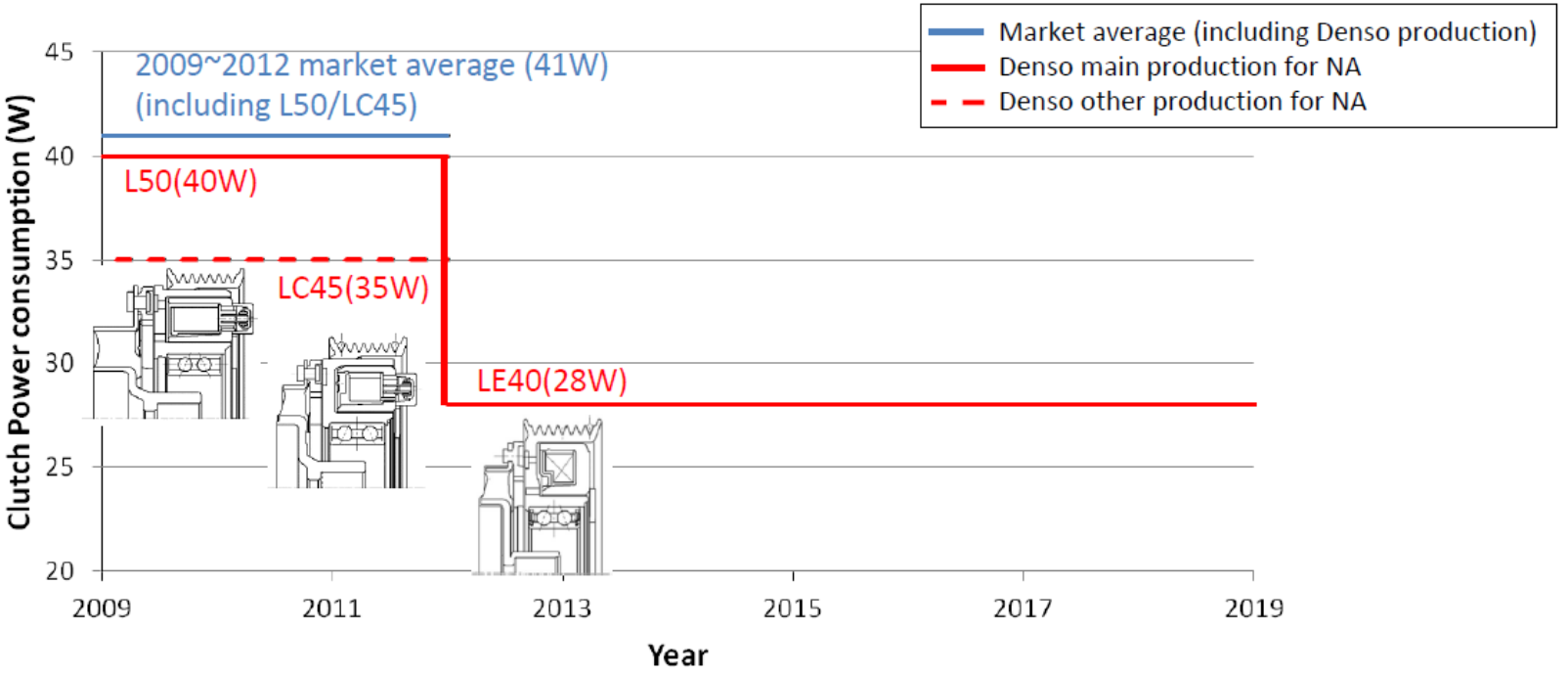
Agenda

-Overview of market trend about clutch power consumption

-The difficulty of low power consumption clutch

-How to achieve low power consumption clutch

Market Trend of Clutch Power Consumption



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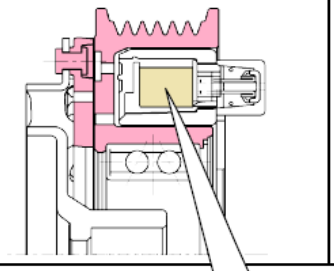
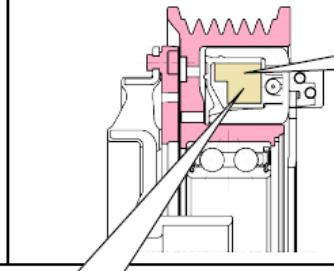
Mass (kg)	2.2~	2.0~	2.1~	1.9	2.1	1.7

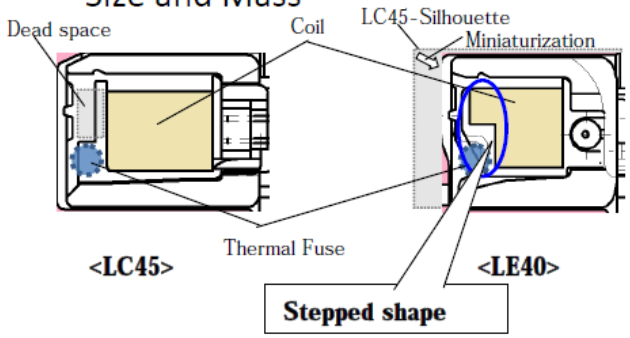
Power consumption of Denso's LE40 (28W) is much lower than market average (41W), while minimizing size & mass, and maintaining the necessary torque for all sizes of variable compressors.

Design Parameter	Target	Purpose
Power consumption	Reduce	Improve Fuel Economy
Size	Reduce	Improve packaging of compressor w/ clutch assembly in smaller E/G compartments.
Mass	Reduce	Improve Fuel Economy
Transmission Torque	Maintain	Maintain enough torque capability to be used on large displacement compressors (>160cc)

L50/LC45 (conventional design)	LE40 (optimized design)
	

1) Reduce coil wire diameter
- + Increase Ω → Reduce Power Consumption
- + Reduce Coil Size
- + Reduce Coil Mass
- - Reduce Ampere Turn (AT) → Reduce Transmission Torque Capability

2) Improve Coil Shape by Improved Winding
- + Reduce dead space → Reduce Coil Size and Mass

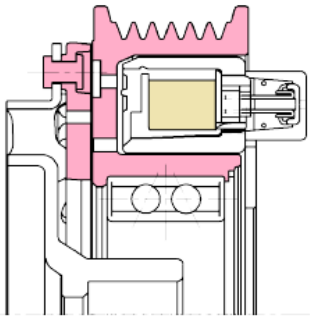
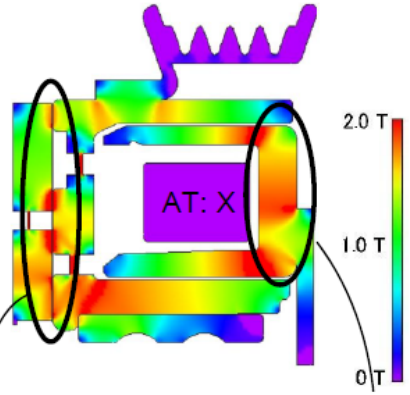
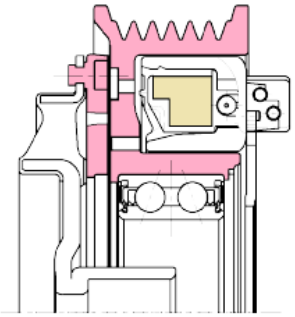
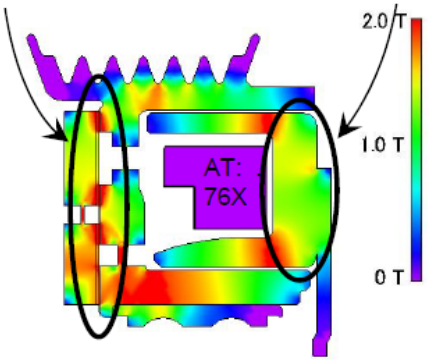


DENSO developed patented winding process to achieve a stepped coil design to reduce dead space and optimize coil size and mass.
※ Patent No. 3837786

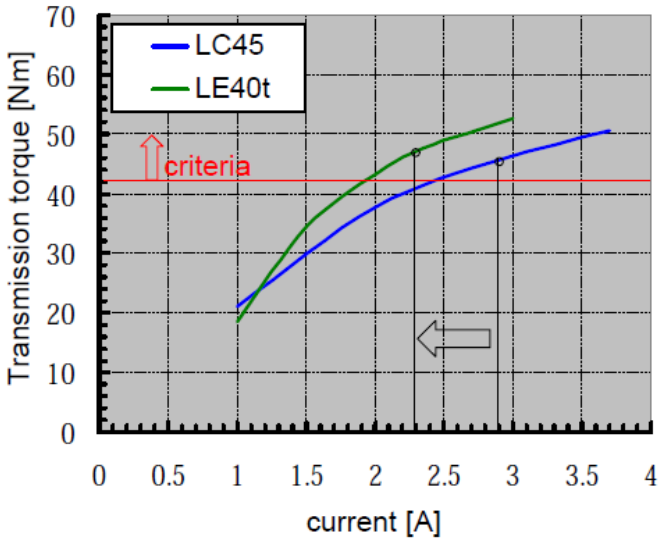
3) Improve Magnetic Circuit Design

- Geometric shape changes
- Coil design allows shift in magnetic field w/more focus on contact points

+ Improve distribution of magnetic flux density → Improve Transmission
+ Reduce Magnetic Resistance → Torque Capability

	Cut View	Flux Density (CAE Result)
L50/LC45 (conventional design)		
LE40 (optimized design)		

Improve flux density distribution — reduction of magnetic resistance



Through design optimization and manufacturing capabilities, DENSO is able to reduce AT, thus reducing power consumption, while maintaining the necessary torque transfer capability.

Calculation/Credit Value

Calculation method is based on The Alliance S.A.F.E. rule comment regarding Efficient Electrical Device Credit

$$Credit_{EED} = (0.032 - OnCycle_{EED}) \cdot VMT\%$$

Source: https://www.regulations.gov/document?D=NHTSA-2018-0067-12073
Attachment 7 – New Technologies

- Credit EED = Off-Cycle Value (g CO2/mi/W) of efficient electrical device
- OnCycle EED = On-cycle benefit (g CO2/mi/W) of efficient electrical device = 0
- VMT% = percentage of vehicle miles travelled with technology active = 69%

Credit EED = (0.032 g/CP2/mi/W-0)*90.3% = 0.0289 g

- Baseline clutch power consumption wattage (2012) = 41W
- LE40 clutch power consumption wattage = 28W

LE40 Credit Value

(41W-28W)*0.0289 gCO2/mi/W = 0.376 g/mi

Compared with the industry standard in 2012 (when LE40 launched), LE40 offers a 13W power consumption reduction, which equates to a 0.4g/mi credit

Supplement

Power Consumption Testing Condition:

- At 20° C ambient temperature, clutch coil resistance is measured.
- A voltage of 12V is applied to the clutch coil, and current is recorded.
- Power consumption is then calculated from current and resistance.

Supporting Equations:

$R = \rho \times (l/A)$
R = resistance
ρ = electrical resistivity
l = length
A = Cross-sectional area

$P = V^2 / R$
P = Power
V = Voltage
R = Resistance

$MMF = N \times I$
MMF = Magnetomotive Force (AT)
N = Number of coil turns
I = Current (A)

Reduction in MMF = Reduction in electromagnetic attraction force

$W = V * I = I^2 * R$
W = work (electricity consumption)
V = Voltage
I = Current
R = Resistance

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Attachment 3

Model-Specific and Fleet GHG Credit Calculations

Model Year	Applicable Model	Sales Volume	Credit Volume (Meg)
2017	Nissan Rogue FWD	99408	7764.3
2018	Nissan Rogue FWD	95576	7465.0
2019	Nissan Rogue FWD	77203	6030.0
2020	Nissan Rogue FWD	64843	5064.6
2021	Nissan Rogue FWD	86221	6734.3
2022	Nissan Rogue FWD	30619	2391.5
2017	Nissan Rogue AWD	140772	12718.2
2018	Nissan Rogue AWD	136005	12287.5
2019	Nissan Rogue AWD	105033	9489.3
2020	Nissan Rogue AWD	85461	7721.1
2021	Nissan Rogue AWD	119683	10812.9
2022	Nissan Rogue AWD	40701	3677.2
2017	Nissan Maxima FWD	89004	6951.7
2018	Nissan Maxima FWD	44405	3468.3
2019	Nissan Maxima FWD	23291	1819.2
2020	Nissan Maxima FWD	24106	1882.8
2021	Nissan Maxima FWD	14845	1159.5
2022	Nissan Maxima FWD	7275	568.2

Attachment 4

Planned 2023MY that incorporate Denso Compressor LE40 Clutch

Nissan Maxima
Nissan Rogue

Planned 2024-26MY that incorporate Denso Compressor LE40 Clutch
REDACTED

Attachment 5

EPA LE40 Clutch Usage Updated Final for EPA – material shared in August 2022

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