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

Subject: Request for GHG credit for Climate Control Seats (CCS)

Dear Mr. Wehrly:

Pursuant to the provisions of 40 CFR § 86.1869-12(d), Hyundai Motor Company (HMC), represented by the Hyundai America Technical Center, Inc. (HATCI), requests off-cycle greenhouse gas (GHG) credit for the use of Climate Control Seat (CCS) technology. Based on the test results and analysis provided in Attachment B, HMC requests credits equal to 2.3 grams CO_2 per mile (for passenger car applications) and 2.9 grams CO_2 per mile (for light truck applications) for 2012+ model year HMC vehicles with CCS technology. HMC also plans to request off-cycle CAFE credits for CCS technology applied for 2017 model year and later.

Background
Greenhouse gas emission standards through 2025 represent a major initiative in US energy and climate policy. EPA and DOT have issued a joint rulemaking that set greenhouse gas emissions and fuel economy standards for the largest sources of greenhouse gases from transportation, including cars, light trucks, and heavy-duty trucks. Over the course of the program, light-duty GHG regulations are projected to: cut 6 billion metric tons of GHG emissions, nearly double vehicle fuel efficiency while protecting consumer choice, reduce America's dependence on oil and provide significant savings for consumers at the fuel pump. To achieve these worthy goals, a key regulatory element is the ability for manufacturers to have a variety of options and flexibilities in meeting the standards.

A key flexibility is the off-cycle credits provision; off-cycle credits are an opportunity for manufacturers to generate credits for technologies that provide CO_2 reductions not captured by the traditional 2-cycle (FTP, HWFET) emissions tests conducted on a chassis dynamometer. There are three pathways by which a manufacturer may accrue off-cycle credits. The first is a pre-determined menu of credit values for specific off-cycle technologies. In cases where additional lab testing can demonstrate emission benefits of a technology, a second pathway allows manufacturers to use a broader array of emission tests known as 5-cycle testing, which captures more elements of real-world driving, including high speeds and hard acceleration (US06), solar loads, high temperature, and A/C use (SC03), and cold temperatures (cold FTP). The third pathway allows manufacturers to seek EPA approval to use an alternative methodology for determining the off-cycle credits.

Climate control seats influence occupant thermal comfort, and therefore impact how much the vehicle's air conditioning system is used. For example, when an occupant is cooled by CCS technology, they will not require as much A/C load to reach thermal comfort. However, as the SC03 drive trace is the only standard EPA cycle to utilize air conditioning (and does not utilize auxiliary thermal technologies), the benefit of CCS

will not be apparent when assessing 2-cycle or 5-cycle fuel economy test data. While the off-cycle credit menu detailed in 40 CFR 86.1869-12 includes active seat ventilation, its technology benefit value was based on a 2005 NREL study; the more recent NREL study detailed in this application shows significantly more benefit. Therefore, HMC is pursuing additional off-cycle credits for climate control seat technology through the alternative methodology.

Technology Description

Climate Control Seats are a seat technology that utilizes motorized blowers, thermoelectric devices, and seating surfaces designed for high airflow to move chilled air through the seat and onto the occupant. In HMC vehicle applications, the Climate Control Seat contains two thermoelectric chillers: one in the seat back, one in the seat cushion. The seat cushion contains one blower motor with air ducts to direct blower air flow through both the seat cushion and seat back. CCS technology provides active cooling, which occurs when the blower motor passes ambient cabin air across the integrated thermoelectric chillers; the chilled air then moves through the seating surfaces and onto the passenger.

The technology in Gentherm Climate Control Seats is more advanced than the technology evaluated in the 2005 NREL study to determine the emission benefit of ventilated seats; CCS technology is differentiated from the seat technology from the 2005 NREL study primarily due to the embedded thermoelectric device(s) in CCS. As described in the following section, CCS technology allows vehicle occupants to reach equivalent thermal comfort at a higher cabin ambient temperature compared to a baseline seat; CCS therefore has the potential to reduce A/C system fuel use more than ventilated seats.

Technology Evaluation

In 2017, NREL evaluated the performance of Gentherm climate control seats, and investigated their impact on vehicle emissions. Additionally, NREL investigated whether the emissions benefit of active cooled seats was larger than the benefit of active seat ventilation.

NREL evaluated the benefit of climate control seats through experiments involving both human test subjects and sensor-equipped manikins. The experiment results showed Gentherm CCS provided 2.6℃ mean elevation in cabin air temperature for equivalent passenger comfort. Experiment results were used as inputs for a national benefit analysis using vehicle cabin modeling, A/C system modeling, and vehicle propulsion modeling.

From the national analysis, it was determined that mean A/C fuel usage for a CCS equipped vehicle is 24.9 gal/year, compared to 30 gal/year for a baseline vehicle. Using established values and the calculations below, the A/C CO_2 emissions for a CCS-equipped vehicle were determined to be 19.5 g/mile, and 23.5 g/mile for a baseline vehicle.

Established Values:

$8887\ grams\ CO2\ per\ gallon\ of\ gasoline$

$Annual\ VMT: 11346 \frac{mile}{year}$

$$Baseline\ vehicle\ \mathrm{A/C}\ emissions\ = 8887 \frac{g}{gal} * 30 \frac{gal}{year} * \frac{year}{11346\ mi} = 23.498 \frac{g}{mi} = 23.5\ g/mi$$

$$CCS\ vehicle\ average\ \mathrm{A/C}\ emissions\ = 8887 \frac{g}{gal} * 24.9 \frac{gal}{year} * \frac{year}{11346\ mi} = 19.503 \frac{g}{mi} = 19.5\ g/mi$$

Therefore, the A/C emissions reduction due to CCS can be calculated to yield a 17% emission reduction versus a baseline vehicle.

$$\text{A/C } emissions\ reduction\ due\ to\ CCS\ = 1 - \frac{19.5}{23.5} = 0.1702 = 17\%\ emission\ reduction$$

The 17% emission reduction determined from this national analysis was notably higher than the 7.5% emission reduction determined from the 2005 NREL study that was used to calculate the default active seat ventilation menu credit values of 1.0 g/mile (PC) and 1.3 g/mile (LT).

Credit Calculation

The EPA baseline A/C CO_2 emission values for passenger car and light truck are 13.8 g/mile and 17.2 g/mile, respectively. With the 17% emission reduction value from NREL's Gentherm CCS study, the g/mile benefit estimate of Gentherm CCS can be determined through the calculations below, yielding 2.3 g/mile (PC) and 2.9 g/mile (LT).

$$PC\ Credit\ Estimate = 0.17 * 13.8 \frac{g}{mile} = 2.346\ g/mile = 2.3\ \frac{g}{mi}$$

$$LT\ Credit\ Estimate = 0.17 * 17.2 \frac{g}{mile} = 2.924\ g/mile = 2.9\ \frac{g}{mi}$$

Durability

Durability of the Gentherm CCS technology has been proven through several years of production vehicle application. CCS systems applied in HMC vehicles meet 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 technology. CCS durability testing was conducted to meet HMC's specifications, HMC expects the technology will meet EPA in-use durability requirements over the applicable full useful life; ten years for passenger cars, eleven years for light trucks.

Conclusion

Based on the evaluation presented in this application, combined with the final analysis and technology summary, Hyundai Motor Company, represented by HATCI, hereby requests that EPA approve an off-cycle GHG credit of 2.3 grams CO_2 per mile for Climate Control Seat technology equipped in MY12+ Hyundai passenger cars and 2.9 grams CO_2 per mile for Climate Control Seat technology equipped in MY12+ Hyundai light trucks. The requested off-cycle credit has been estimated to be representative of the fuel savings and subsequent GHG emissions reduction that can be expected from this technology in real world usage on U.S. public roads.

There are two conditional restrictions for the CCS off-cycle credits requested in this application; final received credit values will be reduced based on these restrictions. First, HMC vehicles that have already received menu credit for ventilated seats would receive credit equal to the difference between the applicable requested credit value and the applicable menu credit value. Second, HMC vehicles that would exceed the thermal control technology credit cap due to the requested off-cycle credit would instead receive a reduced credit value that will cause them to exactly reach the appropriate cap value (specified in 40 CFR 86.1869-12). Attachment A details the credit received from CCS after applying these restrictions.

HYUNDAI MOTOR GROUP

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Thank you for your consideration of this application for off-cycle GHG credits.

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List of Attachments:

Attachment A: Confidential Listing of MY12+ HMC Vehicles with CCS Technology, Sales Volumes and Credits

Attachment B: National Renewable Energy Laboratory Study - "Impact of Active Climate Control Seats on Energy Use, Fuel Use, and CO2 Emissions: Test and Analysis", by Kreutzer, Rugh, Kekelia and Titov, May 2017