

**EPA Decision Document:
Off-Cycle Credits for Hyundai Motor
Group - Doowon Air Conditioning
Compressor**

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Compliance Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

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I. Introduction

EPA's light-duty vehicle greenhouse gas (GHG) rules include opportunities for manufacturers to generate CO₂ credits for technologies that provide CO₂ reductions not captured by the 2-cycle emissions test. There are three pathways by which manufacturers can generate off-cycle credits: (1) a pre-determined "menu" of technologies and credits that is available for 2014 and later model years, (2) a testing-based option, and (3) an alternative methodology that includes opportunity for public comment. These are described in more detail in Section II.

Pursuant to those rules, Hyundai Motor Group (Hyundai) submitted an application requesting off-cycle credits for the use of a Doowon air conditioning compressor with crankcase suction valve (CS valve) technology in vehicles equipped with this technology starting in model year 2022 and later.

This technology and methodology for demonstrating the effectiveness of this technology have been previously approved through the public process by the EPA on multiple occasions. Therefore, the EPA is not publishing this request and allowing for public comments as no adverse comments to this type of technology have been received to date. Furthermore, the EPA is hereby approving the technologies, methodologies for determining credits, and credit levels as described in the application from Hyundai.

Section II of this document provides background on EPA's off-cycle credits program. Section III provides EPA's decision. This decision document applies only to the application referenced herein.

II. EPA's Off-cycle Credits Program

EPA's light-duty vehicle greenhouse gas (GHG) program provides three pathways by which a manufacturer may accrue off-cycle carbon dioxide (CO₂) credits for those off-cycle technologies that achieve CO₂ reductions in the real world but where those reductions are not adequately captured on the test procedure used to determine compliance with the CO₂ standards. The first is a predetermined list of credit values for specific off-cycle technologies that may be used beginning in model year 2014.¹ This pathway allows manufacturers to use conservative credit values established by EPA for a wide range of technologies, with minimal data submittal or testing requirements. In cases where additional laboratory testing can demonstrate emission benefits of an off-cycle technology, a second pathway allows

¹ See 40 CFR 86.1869-12(b).

manufacturers to use a broader array of emission tests (known as “5-cycle” testing because the methodology uses five different testing procedures) to demonstrate and justify off-cycle CO₂ credits.² The additional emission tests allow emission benefits to be demonstrated over some elements of real-world driving not captured by the GHG compliance tests, including high speeds, hard accelerations, and cold temperatures. Credits determined according to this methodology do not undergo additional public review. The third and last pathway allows manufacturers to seek EPA approval to use an alternative methodology for determining the off-cycle CO₂ credits.³ This option is only available if the benefit of the off-cycle technology cannot be adequately demonstrated using the 5-cycle methodology. Manufacturers may also use this option for model years prior to 2014 to demonstrate off-cycle CO₂ reductions for technologies that are on the predetermined list, or to demonstrate reductions that exceed those available via use of the predetermined list.

Under the regulations, a manufacturer seeking to demonstrate off-cycle credits with an alternative methodology (i.e., under the third pathway described above) must describe a methodology that meets the following criteria:

- Use modeling, on-road testing, on-road data collection, or other approved analytical or engineering methods;
- Be robust, verifiable, and capable of demonstrating the real-world emissions benefit with strong statistical significance;
- 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;
- Result in data on a model type basis unless the manufacturer demonstrates that another basis is appropriate and adequate.

Further, the regulations specify the following requirements regarding an application for off-cycle CO₂ credits:

- A manufacturer requesting off-cycle credits must develop a methodology for demonstrating and determining the benefit of the off-cycle technology and carry out any necessary testing and analysis required to support that methodology.
- A manufacturer requesting off-cycle credits must conduct testing and/or prepare engineering analyses that demonstrate the in-use durability of the technology for the full useful life of the vehicle.
- The application must contain a detailed description of the off-cycle technology and how it functions to reduce CO₂ emissions under conditions not represented on the compliance tests.
- The application must contain a list of the vehicle model(s) which will be equipped with the technology.

² See 40 CFR 86.1869-12(c).

³ See 40 CFR 86.1869-12(d).

- The application must contain a detailed description of the test vehicles selected and an engineering analysis that supports the selection of those vehicles for testing.
- The application must contain all testing and/or simulation data required under the regulations, plus any other data the manufacturer has considered in the analysis.

Finally, the alternative methodology must be approved by EPA prior to the manufacturer using it to generate credits. As part of the review process defined by regulation, the alternative methodology submitted to EPA for consideration must be made available for public comment.⁴ EPA will consider public comments as part of its final decision to approve or deny the request for off-cycle credits.

Although these credits are requested under regulatory provisions that don't explicitly require limitations, or caps, on credit values, EPA is stipulating here that credits for technologies for which there is a regulatory cap must be held to the applicable regulatory cap, if such credits are approved by EPA. For example, for reasons described in the implementing rulemaking documents and analyses, EPA established caps on thermal technology credits of 3.0 grams/mile for cars and 4.3 grams/mile for trucks. The rationale for these caps is applicable regardless of the off-cycle pathway being used to achieve such credits. EPA also established caps on technologies that improve the efficiency of air conditioning systems (5 grams/mile for cars and 7.2 grams per mile for trucks). Thus, credits approved in this Decision Document are being approved only to the extent that the regulatory caps on credits for certain technologies or categories of technologies are not exceeded.

III. EPA Decisions on Off-cycle Credit Applications

A. Doowon Air Conditioning Compressor with CS Valve Technology

Hyundai applied for off-cycle credits for an air conditioning compressor manufactured by Doowon that has been shown to result in efficiency improvements warranting air conditioning efficiency credits beyond those provided in the regulations. This compressor, called the Doowon compressor with crankcase suction valve (CS valve) technology, improves the internal valve system within the variable-displacement compressor to reduce the internal refrigerant flow necessary throughout the range of displacements that the compressor may use during its operating cycle. The addition of a variable crankcase suction valve allows a larger mass flow under maximum capacity and compressor start-up conditions (when high flow is ideal), and then it can reduce to smaller openings with reduced mass flow in mid-or low-capacity conditions. The refrigerant exiting the crankcase is thus optimized across the range of operating conditions, reducing the overall energy consumption of the air conditioning system. EPA previously approved credits for the use of similar technology, manufactured by Hannon for this manufacturer, and other compressors manufactured by Denso, for other vehicle manufacturers.

The manufacturer has calculated credit values for this compressor model to be 1.3 g/mi. The manufacturer cited bench testing and Life Cycle Climate Performance (LCCP) modeling and analysis to

⁴ See 40 CFR 86.1869-12(d)(2).

back up this value. These values are similar to values already approved for similar technology in other supplier's air conditioning compressors.⁵ ⁶ The application with test data for Hyundai can be found [here](#).

EPA has evaluated the application and finds that the methodologies described therein are sound and appropriate. Therefore, EPA is approving the credits requested by Hyundai for the 2022 model year and later for all vehicles using this technology as described in Hyundai's application. Caps or limits on credits that are specified in the regulations also apply to the credits being approved in this document. All information necessary to determine the total Megagrams of credits must be included in the reporting to EPA, and the total Megagrams for each fleet and model year should be included in a summary of credit averaging, banking, and trading.

⁵ "EPA Decision Document: Off-Cycle Credits for General Motors and Toyota Motor Corporation," EPA-420-R-18-014, June 2018

⁶ "EPA Decision Document: Off-cycle Credits for Fiat Chrysler Automobiles, Ford Motor Company, and General Motors Corporation." Compliance Division, Office of Transportation and Air Quality, U.S. Environmental Protection Agency. EPA-420-R-15-014, September 2015.