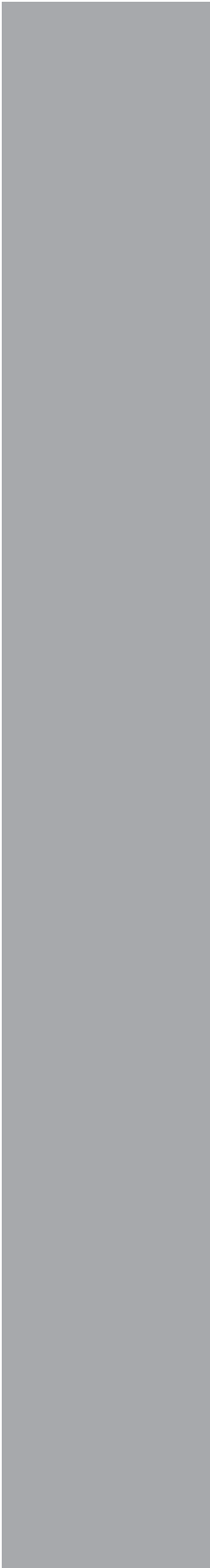

**EPA Decision Document:
Off-Cycle Credits for BMW Group,
Ford Motor Company, and Hyundai
Motor Company**



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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 proposed by the manufacturer that includes opportunity for public comment. These are described in more detail in Section II. Pursuant to those rules, BMW Group (BMW), Ford Motor Company (Ford), and Hyundai Motor Company (Hyundai) submitted applications requesting off-cycle credits for a several technologies and model years.

This decision document evaluates demonstrations for credits made using the public process pathway. All three manufacturers applied for credits for the Denso air conditioning compressor with variable crankcase suction valve technology. EPA requested comment on a similar application from General Motors (GM) for credits from the Denso device in June of 2015,¹ and subsequently approved those credits in September of that year.² Ford additionally applied for credits from high-efficiency alternators and from some thermal control technologies: glass/glazing and solar reflective surface coating (paint).

EPA published a notice in the *Federal Register* on June 19, 2017 announcing a 30-day public comment period for these applications.³ EPA received comments from the Alliance of Automobile Manufacturers (AAM),⁴ Global Automakers,⁵ Fiat Chrysler Automobiles (FCA), the Motor & Equipment Manufacturers Association (MEMA), and joint comments submitted by the Union of Concerned Scientists (UCS) on behalf of themselves and two other non-governmental organizations: the Natural Resources Defense Council (NRDC), and the American Council for an Energy-Efficient Economy (ACEEE). EPA received no adverse comments regarding the Denso compressor applications, and, based on our engineering evaluation, is hereby approving the technologies, methodologies for determining credits, and the credit levels described in the applications from the manufacturers and in the Federal Register. UCS commented extensively on the glass and paint credits requested by Ford, and presented detailed

¹ 80 FR 31598, June 3, 2015.

² "EPA Decision Document: Off-cycle Credits for Fiat Chrysler Automobiles, Ford Motor Company, and General Motors Corporation," EPA-420-R-15-014, September 2015.

³ 82 FR 27819, June 19, 2017.

⁴ The Alliance of Automobile Manufacturers is a trade group representing 12 vehicle manufacturers, including BMW and Ford.

⁵ Global Automakers is a trade group representing 12 vehicle manufacturers, including Hyundai.

analyses and positions that EPA is continuing to review. EPA is continuing to consider the comments it received on the glass and paint credits and is not taking action on Ford's request for those credits at this time.

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 applications 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 2014.⁶ 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 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.⁷ 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 that they propose for determining the off-cycle CO₂ credits.⁸ 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;

⁶ 40 CFR 86.1869-12(b).

⁷ 40 CFR 86.1869-12(c).

⁸ 40 CFR 86.1869-12(d).

- 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.
- 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.⁹ 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. 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.

⁹ 40 CFR 86.1869-12(d)(2).

III. EPA Decisions on Off-cycle Credit Applications

A. BMW of North America

BMW of North America (BMW) applied for off-cycle credits for an air conditioning compressor manufactured by Denso that has been shown to result in efficiency improvements warranting air conditioning efficiency credits beyond those provided in the regulations. This compressor, known as the Denso SAS compressor, 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 General Motors (GM) for the use of the Denso SAS compressor.¹⁰

The credits calculated by BMW for the Denso SAS compressor would be in addition to the credits of 1.7 grams/mile for variable-displacement A/C compressors already allowed under EPA regulations. However, it is important to note that EPA regulations place a limit on the cumulative credits that can be claimed for improving the efficiency of A/C systems. The rationale for this limit is that the additional fuel consumption of A/C systems can never be reduced to zero, and the limits established by regulation reflect the maximum possible reduction in fuel consumption projected by EPA. These limits, or caps, on credits for A/C efficiency, must also be applied to A/C efficiency credits granted under the off-cycle credit approval process. In other words, cumulative A/C efficiency credits for an A/C system – from the A/C efficiency regulations and those granted via the off-cycle regulations – must comply with the stated limits.

BMW requested an off-cycle GHG credit of 1.1 grams CO₂ per mile for the Denso SAS compressor (the same as was approved for GM in 2015). BMW repeated the bench test modeling analysis using vehicle-specific BMW input data, and, like the original Denso analysis, demonstrated a benefit of 1.1 grams/mile. Like GM, BMW also ran vehicle tests using the AC17 test. Six tests were conducted on a 3-series BMW, resulting in a calculated benefit of 1.2 grams/mile, thus substantiating the bench test results. Based on these results, BMW requested a credit of 1.1 grams/mile for all BMW vehicles equipped with the Denso SAS compressor with variable crankcase suction valve technology, starting with 2016 model year vehicles. Details of the testing and analysis can be found in the manufacturer's application. EPA reviewed the application for completeness and made it available for public review and comment as required by the regulations. The BMW off-cycle credit application (with confidential business information redacted) is available in the public docket and on EPA's web site at

¹⁰ "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.

<https://www.epa.gov/vehicle-and-engine-certification/bmw-compliance-materials-light-duty-greenhouse-gas-ghg-standards-0>.

EPA did not receive any adverse comments on the application from BMW. EPA has evaluated the application and finds that the methodologies described therein are sound and appropriate. Therefore, EPA is approving the credits requested by BMW for the 2016 and later model years for all BMW vehicles using this technology. Caps or limits on credits that are specified in the regulations also apply to the credits being approved in this document. Credits for the 2016 and 2017 model years must be reported to EPA not later than May 1, 2018, the date on which reporting of GHG credits for the 2017 model year is due. BMW must include all information necessary to determine the total Megagrams of credits in the reporting to EPA, and they should also include the total Megagrams for each fleet and model year in a summary of credit averaging, banking, and trading.

B. Ford Motor Company

1. Denso Air-Conditioning Compressor

Ford Motor Company (Ford) applied for off-cycle credits for an air conditioning compressor manufactured by Denso that has been shown to result in efficiency improvements warranting air conditioning efficiency credits beyond those provided in the regulations. This compressor, known as the Denso SAS compressor, 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 General Motors (GM) for the use of the Denso SAS compressor.¹¹

The credits calculated by Ford for the Denso SAS compressor would be in addition to the credits of 1.7 grams/mile for variable-displacement A/C compressors already allowed under EPA regulations. However, it is important to note that EPA regulations place a limit on the cumulative credits that can be claimed for improving the efficiency of A/C systems. The rationale for this limit is that the additional fuel consumption of A/C systems can never be reduced to zero, and the limits established by regulation reflect the maximum possible reduction in fuel consumption projected by EPA. These limits, or caps, on credits for A/C efficiency, must also be applied to A/C efficiency credits granted under the off-cycle credit approval process. In other words, cumulative A/C efficiency credits for an A/C system – from the

¹¹ “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.

A/C efficiency regulations and those granted via the off-cycle regulations – must comply with the stated limits.

Ford requested an off-cycle GHG credit of 1.1 grams CO₂ per mile for the Denso SAS compressor (the same as was approved for GM in 2015). Ford cited the bench test modeling analysis referenced in the original GM application, which demonstrated a benefit of 1.1 grams/mile. Like other manufacturers, Ford also ran vehicle tests using the AC17 test. Six tests were conducted on a 2017 Lincoln MKC, resulting in a calculated benefit of 1.5 grams/mile, thus substantiating the bench test results. Based on these results, Ford requested a credit of 1.1 grams/mile for all Ford vehicles equipped with the Denso SAS compressor with variable crankcase suction valve technology, starting with 2017 model year vehicles. Details of the testing and analysis can be found in the manufacturer's application. EPA reviewed the application for completeness and made it available for public review and comment as required by the regulations. The Ford off-cycle credit application (with confidential business information redacted) is available in the public docket and on EPA's web site.

EPA did not receive any adverse comments on the application from Ford. EPA has evaluated the application and finds that the methodologies described therein are sound and appropriate. Therefore, EPA is approving the credits requested by Ford for the 2017 and later model years for all Ford vehicles using this technology. Caps or limits on credits that are specified in the regulations also apply to the credits being approved in this document. Credits for the 2017 model year must be reported to EPA not later than May 1, 2018, the date on which reporting of GHG credits for the 2017 model year is due. Ford must include all information necessary to determine the total Megagrams of credits in the reporting to EPA, and they should also include the total Megagrams for each fleet and model year in a summary of credit averaging, banking, and trading.

2. High-Efficiency Alternator

Ford requested GHG credits for alternators with improved efficiency relative to a baseline alternator, for the 2009 and later model years (in effect, this is for 2010 and later, since 2009 credits have expired and are no longer available). Automotive alternators convert mechanical energy from a combustion engine into electrical energy that can be used to power a vehicle's electrical systems. Alternators inherently place a load on the engine, which results in increased fuel consumption and CO₂ emissions. High efficiency alternators use new technologies to reduce the overall load on the engine yet continue to meet the electrical demands of the vehicle systems, resulting in lower fuel consumption and lower CO₂ emissions. Ford proposed a methodology that would scale credits based on the efficiency of the alternator (as measured using an accepted industry standard procedure). Details of the testing and analysis can be found in the manufacturer's application. EPA reviewed the application for completeness and made it available for public review and comment as required by the regulations. The Ford off-cycle credit application (with confidential business information redacted) is available in the public docket and on EPA's web site.

EPA did not receive any adverse comments on the application from Ford. EPA has evaluated the application and finds that the methodologies described therein are sound and appropriate. Therefore, EPA is approving the credits requested by Ford for the 2010 and later model years for all Ford vehicles using this technology. These credits for model years through 2017 must be reported to EPA not later than May 1, 2018, the date on which reporting of GHG credits for the 2017 model year is due. Ford must include all information necessary to determine the total Megagrams of credits in the reporting to EPA, and they should also include the total Megagrams for each fleet and model year in a summary of credit averaging, banking, and trading.

C. Hyundai Motor Company

Hyundai Motor Company (Hyundai) applied for off-cycle credits for an air conditioning compressor manufactured by Denso that has been shown to result in efficiency improvements warranting air conditioning efficiency credits beyond those provided in the regulations. This compressor, known as the Denso SAS compressor, 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 General Motors (GM) for the use of the Denso SAS compressor.¹²

The credits calculated by Hyundai for the Denso SAS compressor would be in addition to the credits of 1.7 grams/mile for variable-displacement A/C compressors already allowed under EPA regulations. However, it is important to note that EPA regulations place a limit on the cumulative credits that can be claimed for improving the efficiency of A/C systems. The rationale for this limit is that the additional fuel consumption of A/C systems can never be reduced to zero, and the limits established by regulation reflect the maximum possible reduction in fuel consumption projected by EPA. These limits, or caps, on credits for A/C efficiency, must also be applied to A/C efficiency credits granted under the off-cycle credit approval process. In other words, cumulative A/C efficiency credits for an A/C system – from the A/C efficiency regulations and those granted via the off-cycle regulations – must comply with the stated limits.

Hyundai requested an off-cycle GHG credit of 1.4 grams CO₂ per mile for the Denso SAS compressor. Hyundai repeated the bench test modeling analysis using vehicle-specific Hyundai input data, which demonstrated a benefit of 1.4 grams/mile. Like other manufacturers, Hyundai also ran vehicle tests using the AC17 test. Two tests were conducted on a Hyundai Sonata, resulting in a calculated benefit of

¹² “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.

9.3 grams/mile, substantially more than the bench test results. Based on these results, Hyundai requested a credit of 1.4 grams/mile for all 2015-2017 model year Hyundai Sonata vehicles equipped with the Denso SAS compressor with variable crankcase suction valve technology. Details of the testing and analysis can be found in the manufacturer's application. EPA reviewed the application for completeness and made it available for public review and comment as required by the regulations. The Hyundai off-cycle credit application (with confidential business information redacted) is available in the public docket and on EPA's web site.

EPA did not receive any adverse comments on the application from Hyundai. 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 2015-2017 vehicles described in the application. Caps or limits on credits that are specified in the regulations also apply to the credits being approved in this document. These credits must be reported to EPA not later than May 1, 2018, the date on which reporting of GHG credits for the 2017 model year is due. Hyundai must include all information necessary to determine the total Megagrams of credits in the reporting to EPA, and they should also include the total Megagrams for each fleet and model year in a summary of credit averaging, banking, and trading.