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

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January 29, 2016

Mr. Linc Wehrly
Compliance Division
Light-Duty Vehicle Center
Office of Transportation and Air Quality
U.S. Environmental Protection Agency
2565 Plymouth Road
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Subject: Request for 2009 - 2011 MY and 2014 MY and Beyond Greenhouse Gas (GHG) Off-Cycle Credits

Per 40 CFR 86.1869-12(b), Ford requests GHG off-cycle credits for the following technologies used in 2009 MY and beyond vehicles (technology and methodology outlined in Attachments A through K):

- High efficiency exterior lights (Attachment A)
- Thermal control technology – active seat ventilation (Attachment B)
- Active aerodynamic improvements – active grill shutters (Attachment C)
- Active transmission warm-up (Attachment D)
- Active engine warm-up – cooled exhaust manifold (Attachment E)
- Active engine warm-up – integrated exhaust manifold (Attachment F)
- Engine Idle Start/Stop (Attachment G)

This petition largely replicates Ford's March 20, 2015 petition requesting credits for the subject technologies on 2012 and 2013 model year vehicles. That petition was approved by EPA in September 2015. With this petition, we now seek approval for off-cycle credits for model year 2009-2011vehicles, based on the same technologies covered in the prior petition. This petition uses EPA's values and methodology set forth in 40 CFR 86.1869-12(b), and the Joint Technical Support Document from August 2012.

Ford kindly requests written/e-mail acknowledgment upon EPA receipt and acceptance of this off-cycle credit request. If EPA has any questions about this letter and the related attachments, please contact Ms. Nancy Homeister at nhomeist@ford.com or (313) 594-1035.

Sincerely,

Cynthia Williams

Cynthia Williams, Associate Director
Vehicle Environmental Regulatory Strategy & Planning

Attachment A: High Efficiency Exterior Lights

Definition:

High efficiency exterior lighting means a lighting technology that, when installed on the vehicle, is expected to reduce the total electrical demand of the exterior lighting system when compared to conventional lighting systems.

Credits:

Credits are determined by comparing wattage of new high efficiency exterior lights to the wattage of the baseline lights that are replaced.

Description of Ford System:

Ford uses bidirectional Xenon high intensity discharge (HID) lamps, Xenon HID for short. These lamps are approximately 30 percent more efficient than standard halogen bulbs.

Ford also uses light-emitting diode (LED) lamps, which is one of the most energy-efficient lighting sources. LEDs are increasingly being purchased to replace other types of lamps. LEDs are relatively more expensive than other types of bulbs, but are very cost-effective because they use only a fraction of the electricity of traditional lighting methods and can last far longer.

Ford Methodology:

Ford currently uses high efficiency exterior lights on the following lighting components:

- Low Beam
- High Beam
- Parking/Position
- Turn Signal, Front
- Side Marker, Front
- Tail
- Turn Signal, Rear
- Side Marker, Rear
- License Plate

The credits Ford is requesting are calculated by using EPA's formula from the Joint TSD based on our measured baseline and new light wattage.

The fleet credit will be calculated based on credit for each type of vehicle, vehicle lifetime miles and U.S. sales volume for applicable 2009 and beyond model year products.

Attachment B: Thermal Control Technology - Active Seat Ventilation

Definition:

Active Seat Ventilation, a device which draws air, forces air or transfers heat from the seating surface which is in contact with the occupant and exhausts it to a location away from the seat. At a minimum, the front driver and passenger seat must utilize this technology for a vehicle to be eligible for credit. If the vehicle only has two seats, then these seats must have active seat ventilation for a vehicle to be eligible for credit.

Credits: (40 CFR §86.1869-12 (b) (viii) (B))

Active Ventilation:

(A) The passenger automobile credit is 1.0 grams/mile
(B) The light truck credit is 1.3 grams/mile

Description of Ford System:

Active occupant cooling is achieved by incorporating two thermoelectric modules, one in the cushion and the other in the lumbar region of the seat. Each module is comprised of a thermal electric chiller and the air distribution system matched to the seat foam & trim. The blower draws cabin air and forces the air across the thermal electric chiller exchanger. The air travels through the distribution layer across the lower side of the seat and then uses passages in the foam to bring the cooled air to the surface of the seat. The seat trim is also perforated to allow the air to reach the seat occupant, providing supplemental thermal comfort, thus reducing HVAC load.

Ford Methodology:

Per the methodology described in the Joint TSD regarding credit determination, we intend to apply the pre-defined credit listed above for each active ventilation application per vehicle type (car/truck). The fleet credit will be calculated based on credit for each type of vehicle, vehicle lifetime miles and U.S. sales volume for applicable 2009 and beyond model year products.

Attachment C: Active Aerodynamic Improvements (Active Grill Shutters)

Definition:

Active aerodynamic improvements means technologies that are automatically activated under certain conditions to improve aerodynamic efficiency (e.g., lowering of the coefficient of drag, or C_d), while preserving other vehicle attributes or functions.

Credits:

(A) The credit for active aerodynamic improvements for passenger automobiles shall be calculated using the following equation, and rounded to the nearest 0.1 grams/mile:

$$Credit\ \left(\frac{g}{mi}\right) = 19.36\ x\ CD_{reduced}$$

Where:

$CD_{reduced}$ is the percent reduction in the coefficient of drag (Cd), shown as a value from 0 to 1. The coefficient of drag shall be determined using good engineering judgment consistent with standard industry test methods and practices.

(B) The credit for active aerodynamic improvements for light trucks shall be calculated using the following equation, and rounded to the nearest 0.1 grams/mile:

$$Credit\ \left(\frac{g}{mi}\right) = 33.16\ x\ CD_{reduced}$$

Where:

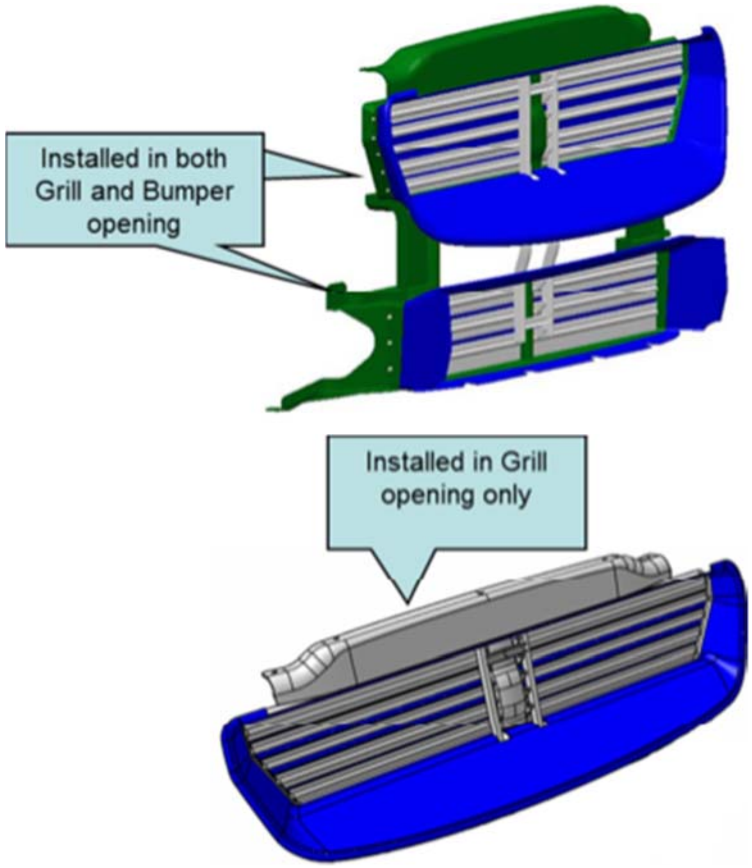
$CD_{reduced}$ is the percent reduction in the coefficient of drag (C_d), shown as a value from 0 to 1. The coefficient of drag shall be determined using good engineering judgment consistent with standard industry test methods and practices.

Description of Ford System:

Aerodynamic drag is reduced by closing electrically-actuated louvers placed in the vehicles' grill openings. The improvement in aerodynamic drag due to closing the shutter system varies approximately with the speed of the vehicle squared. The shutters also assist with engine warm-up -- reducing parasitic losses from cold fluid viscosity effects and assisting windshield defrost performance.

The active shutter system has a variable position control system integrated into the PCM. The strategy determines the shutter opening based on engine cooling requests. This strategy is integrated with and analogous

Active Grill Shutters (Figure 1.1)



to Ford's fan control system, determining the powertrain cooling needs based on key inputs such as engine coolant temperature, intake air temperature, ambient temperature, vehicle speed, throttle position, and A/C head pressure. For example, during closed pedal conditions the cooling request is reduced to help close the shutters, anticipating the reduction in heat load for the low load condition. The shutters are also likely opened under braking events to take advantage of these "no cost" powertrain cooling opportunities. Under potential snow and ice conditions the shutters are kept partially open (~30%) to avoid freezing the shutters closed.

Ford has developed a process for ensuring that the AGS system remains sufficiently closed to provide at least 75% effectiveness over an FTP, Highway, and US06 test run using a Road Speed Modulated Fan (RSF), where fan speed is proportional to the vehicle speed. The 75% effectiveness determination utilizes the position of the AGS over this drive cycle, weighted by the aerodynamic effectiveness and vehicle speed and excluding any braking events.

When grill shutters are installed on an application, different configurations are available and can include shutters in all or only part of the front openings (grill and / or bumper). Some turbo charged vehicle applications utilize a secondary set of independently controlled grill shutters, which modulate the air flow to the charge air cooler heat exchanger. The primary function of these shutters is to maintain an optimum temperature of the boosted intake air to maximize performance and to mitigate condensate formation.

Ford Methodology/Data:

- Wind tunnel data collected on prototype vehicle with shutters disabled, then repeated with shutters enabled.
- Determined the aero benefits (counts of aero).
- Utilized the TSD performance metric to determine the corresponding benefit in CO_2 reduction associated with the % improvement for both cars and trucks.
- Actual calculations based on testing prototypes that provide data representative of production values. Development data consists of estimates based on clay model testing.

The fleet credit will be calculated based on credit for each type of vehicle, vehicle lifetime miles and U.S. sales volume for applicable 2009 and beyond model year products.

Attachment D: Active Transmission Warm-Up

Definition:

Active transmission warmup means a system that uses waste heat from the vehicle to quickly warm the transmission fluid to an operating temperature range using a heat exchanger, increasing the overall transmission efficiency by reducing parasitic losses associated with the transmission fluid, such as losses related to friction and fluid viscosity.

Credits:

(A) The passenger automobile credit is 1.5 grams/mile.

(B) The light truck credit is 3.2 grams/mile.

Description of Ford System:

To assist automatic transmission fluid warm-up (as well as cooling), a heat exchanger is incorporated into the engine coolant loop. With this the transmission warm-up will provide improved fuel economy performance through faster transmission fluid warm-up rates by minimizing viscous/parasitic losses during initial warm-up where heater performance is not affected. During colder ambient operation the transmission warm-up loop is bypassed until the engine coolant temperature starts to stabilize, i.e., entering thermostat control.

ATWU Schematic (Figure 1.2)

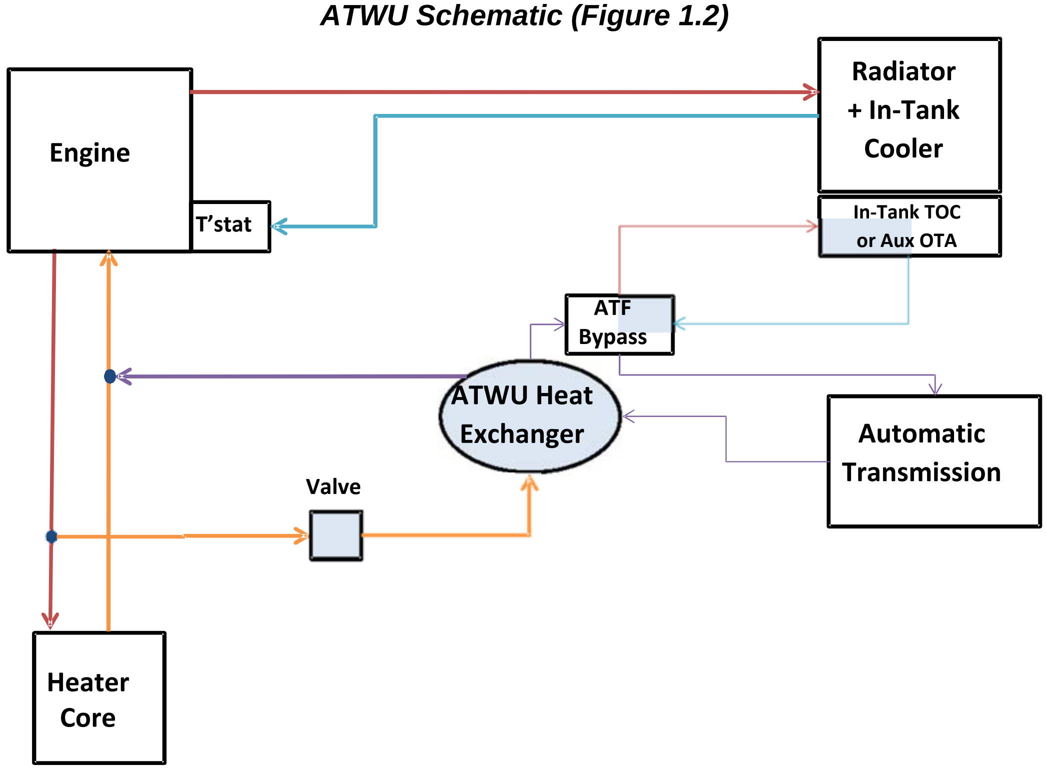


Figure 1.2 shows the 5.0L F-150. The schematic for other programs have minor differences in valve locations for packaging and other constraints, but the active heating of the transmission fluid among the different vehicle lines is functionally the same.

Ford Methodology:

Per the methodology described in the Joint TSD regarding credit determination, we intend to apply the pre-defined credit listed above for each active transmission warm-up application per vehicle type (car/truck). The fleet credit will be calculated based on credit for each type of vehicle, vehicle lifetime miles and U.S. sales volume for 2009 and beyond model year products.

Attachment E: Active Engine Warm-Up - Cooled Exhaust Manifold

Definition:

Active engine warm-up means a system using waste heat from the vehicle to warm up targeted parts of the engine. This reduces engine friction losses and enables the closed-loop fuel control more quickly allowing for a faster transition from cold operation to warm operation, thereby decreasing CO_2 emissions, and increasing fuel economy

Credits: (40 CFR §86.1869-12 (b) (vii).)

Active Engine Warm Up

(A) The passenger automobile credit is 1.5 grams/mile.

(B) The light truck credit is 3.2 grams/mile.

Description of Ford System:

A Cooled Exhaust Manifold (CEM) is a secondary component that is downstream of the conventional exhaust manifold that features a heat exchanger that utilizes engine coolant to extract waste heat from the exhaust gas. The heat from the exhaust is transferred to the engine coolant and pumped back to the engine. This serves to accelerate warm-up time when the engine is not up to nominal operating temperature such as during cold start conditions. The benefits are:

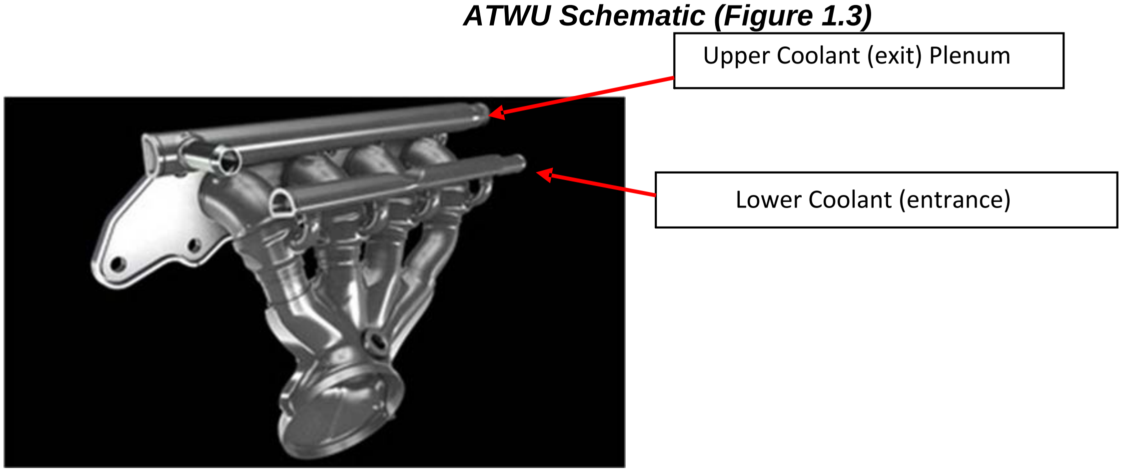
1) By warming the engine up more quickly, total friction losses are reduced.

2) Time spent operating in less efficient rich air/fuel ratio modes associated with cold engine operation is reduced due to faster warm-up and less time spent in these cold operation modes.

3) Engine time off during stop/start mode will be optimized due to faster engine/cabin warm-up.

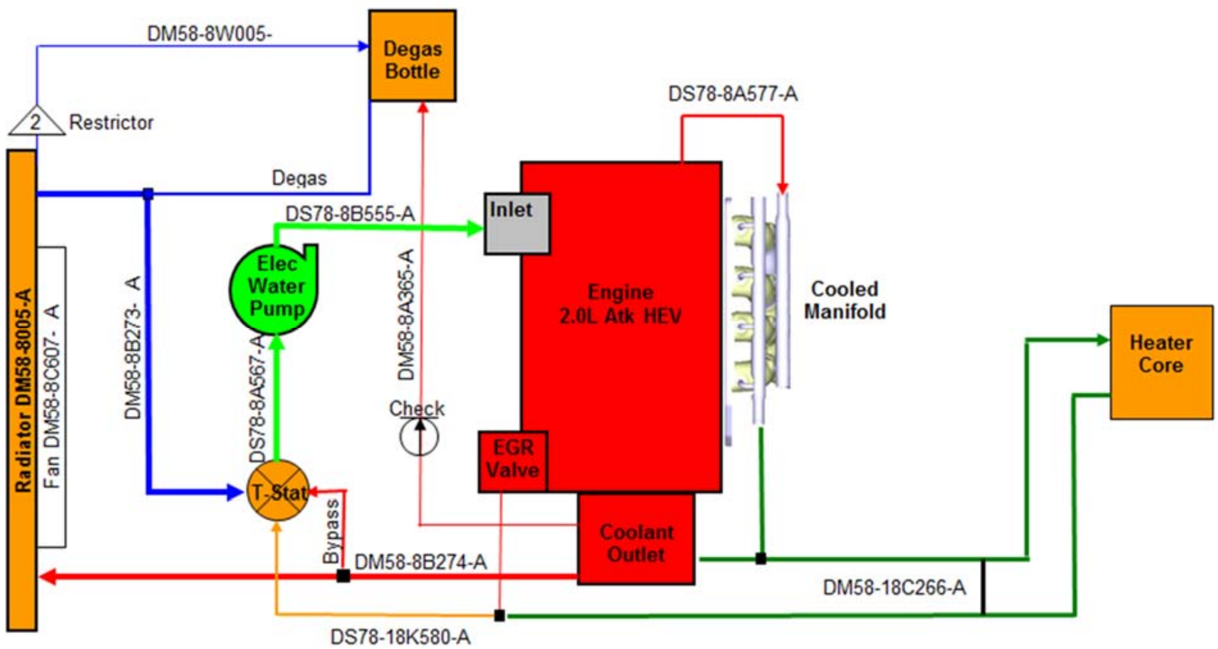
Ford's 2013MY and beyond Hybrid and Plug-in Hybrid Electric Vehicles utilize the cooled exhaust manifold shown below in Figure 1.3:

ATWU Schematic (Figure 1.3)



The coolant flows into the lower plenum where it is distributed to the jackets covering the four exhaust runners. The coolant flows through the jackets over the upper portions of the four runners and then rejoins in the upper plenum before it flows back into the system.

CEM In Coolant Flow System Schematic (Figure 1.4)



The figure above shows the coolant flow circuit for a typical P/HEV. The CEM is located to the right of the red engine and the lines in the diagram represent the coolant flows in the engine cooling system.

Ford Methodology:

Per the methodology described in the Joint TSD regarding credit determination, we intend to apply the pre-defined credit listed above for each active engine warm-up application per vehicle type (car/truck). The fleet credit will be calculated based on credit for each type of vehicle, vehicle lifetime miles and U.S. sales volume for applicable 2009 and beyond model year products.

Attachment F: Active Engine Warm-Up - Integrated Exhaust Manifold

Definition:

Active engine warm-up means a system using waste heat from the vehicle, to warm up targeted parts of the engine. This reduces engine friction losses and enables the closed-loop fuel control more quickly allowing for a faster transition from cold operation to warm operation, thereby decreasing CO_2 emissions, and increasing fuel economy

Credits: (40 CFR §86.1869-12 (b) (vii.))

Active Engine Warm Up:

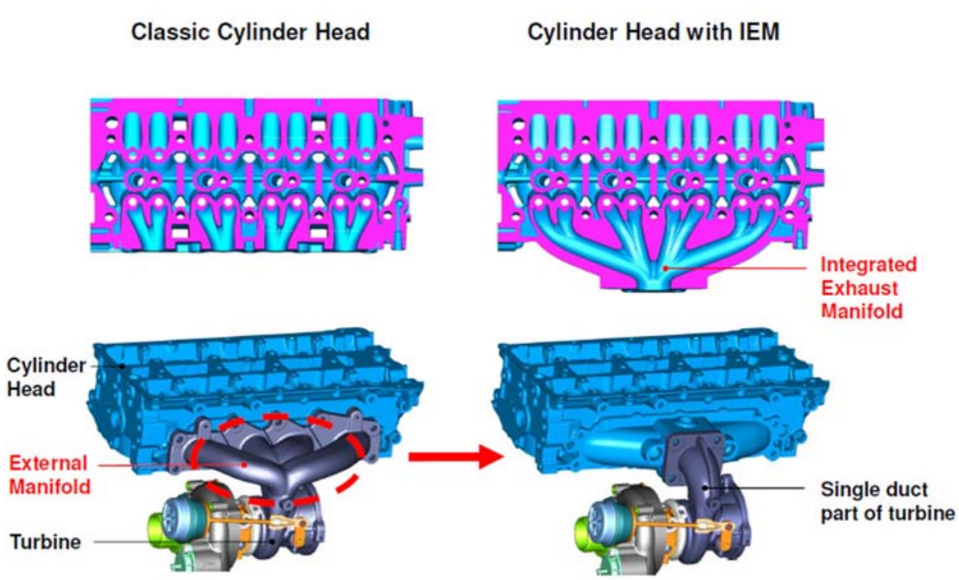
(A) The passenger automobile credit is 1.5 grams/mile.

(B) The light truck credit is 3.2 grams/mile.

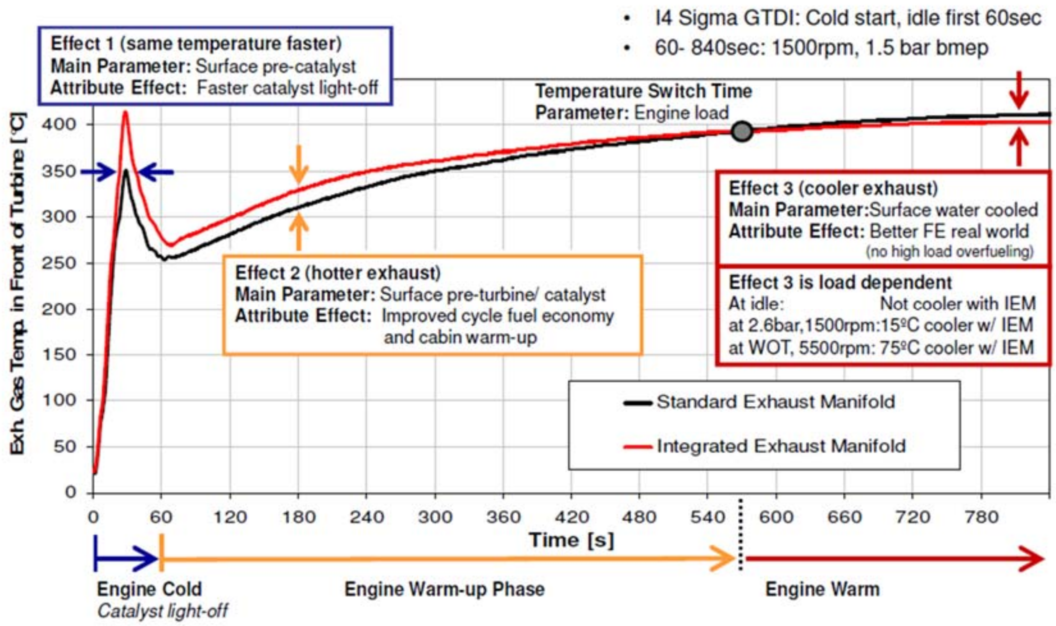
Description of Ford System:

An Integrated Exhaust Manifold is a technology which incorporates a conventional exhaust manifold and cylinder head into a single component. The integrated exhaust manifold features internal cooling jackets which surround the exhaust port runners. Waste exhaust heat is captured and transferred to the coolant and circulated back through the cooling circuit to accelerate engine warm-up time.

Classic Cylinder Head vs. Cylinder Head with IEM (Figure 1.5)



IEM Function (Figure 1.6)



1) Due to higher cold-start exhaust temperatures and faster catalyst warm-up, IEMs enable reduced operation in less efficient modes associated with catalyst light-off strategies.

2) With more heat rejection into the coolant, engine warm-up is accelerated. This reduces total frictional losses and assists the climate control system in heating/defrosting situations.

Ford Methodology:

Per the methodology described in the Joint TSD regarding credit determination, we intend to apply the pre-defined credit listed above for each active engine warm-up application per vehicle type (car/truck). The fleet credit will be calculated based on credit for each type of vehicle, vehicle lifetime miles and U.S. sales volume for applicable 2009 and beyond model year products.

Attachment G: Engine Idle Start-Stop

Definition:

Engine idle start-stop means a technology which enables a vehicle to automatically turn off the engine when the vehicle comes to a rest and restarts the engine when the driver applies pressure to the accelerator or releases the brake. Off-cycle engine start-stop credits will only be allowed for a vehicle if the Administrator has made a determination under the testing and calculation provisions in 40 CFR Part 600 that engine start-stop is the predominant operating mode for that vehicle.

Electric heater circulation system means a system installed in a vehicle equipped with an engine idle start-stop system that continues to circulate heated air to the cabin when the engine is stopped during a stop-start event. This system must be calibrated to keep the engine off for a minimum of one minute when the external ambient temperature is 30 °F and when cabin heating is enabled.

Credits:

The passenger automobile credit for engine idle start-stop systems is 2.5 grams/mile, provided that the vehicle is equipped with an electric heater circulation system (or a technology that provides a similar function). For vehicles not equipped with such systems the credit is 1.5 grams/mile.

The light truck credit for engine idle start-stop systems is 4.4 grams/mile, provided that the vehicle is equipped with an electric heater circulation system (or a technology that provides a similar function). For vehicles not equipped with such systems the credit is 2.9 grams/mile.

Description of Ford System:

Ford's engine Stop Start is an energy conserving technology that shuts off the engine when the vehicle is stopped and idling with the foot on the brake (i.e. traffic light) and automatically re-starts it when the driver releases the brake. Vehicles with Start/Stop technology would not fall under the definition and requirements associated with Hybrid Electric Vehicles.

- These systems do not have an electric drive system that provides power/torque for propulsion, i.e., no electric drive assist
- Ford technology is Starter-Assisted Direct Start
  - Utilizes starter motor and combustion to enable rapid restarts
  - As opposed to Direct Start (combustion-only – not starter assist) and Belt-driven Integrated Starter Generator (B-ISG) systems, a.k.a. Belt Alternator/Starter (BAS)
- Synergistic/enabling technology already planned:
  - Direct Injection Engines, Electrical Power Steering, Battery Management Systems (battery current sensor)

  - Ford's strategy includes a smart opportunistic charging feature to temporarily increase the alternator output voltage under certain conditions such as higher speeds and decelerations to help maintain 12V battery charge for engine-off operation.

Key new or upgraded components include:

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  - Hall effect crank sensor, Electric aux transmission fluid pump, Enhanced starter motor and battery, Brake pedal travel and vacuum sensor, Cabin Comfort Sensors, PCM strategy, Instrument Cluster and Stop/Start Menu, may include aux water pump

- Stop Start temporary deactivation capabilities.

  - A temporary deactivation option is provided via a dedicated button

  - Defaults to Stop Start operation after the next key-start

- Predominant Operating Mode is established according to EPA guidance CISD-09-19:

  - For vehicles which default to the "best fuel economy" mode on key-off, manufacturers may perform EPA fuel economy testing in the "best fuel economy" mode because this mode would "reasonably be expected to be followed by the ultimate purchaser under in-use conditions;" ref. 40 CFR 86.128-00.

Ford's HEV and PHEV models also employ equivalent or better start-stop functionality, with a broader range of engine-off capability. Therefore, we believe these models are also eligible for engine idle start-stop credits. According to the Joint Technical Support Document: "HEV and PHEVs can also idle-off and are thus eligible for this credit."

Our electric heater circulation system for conventional start-stop vehicles is an auxiliary water pump which continues to circulate hot coolant through the heater core during engine off. This continued supply of hot coolant allows air taken into the HVAC system to be warmed and then circulated through the cabin. The auxiliary water pump only comes on when the engine is off, and start/stop function is only allowed when the engine coolant is above a temperature threshold.

Similar technology is employed on our HEV and PHEV vehicles and should therefore be eligible for this incremental credit. The two systems are different in that the PHEV has an isolation valve that allows the auxiliary water pump to circulate coolant through a smaller circuit to the heater core and an electrically powered coolant heater, providing more effective heating. For the HEV the main engine coolant pump is electric so it can be run independently of the engine, allowing it to maintain coolant circulation while the engine is stopped.

Ford Methodology:

Per the methodology described in the Joint TSD regarding credit determination, we intend to apply the pre-defined credit listed above for each engine idle start-stop application per vehicle type (car/truck). The fleet credit will be calculated based on credit for each type of vehicle, vehicle lifetime miles and U.S. sales volume for applicable 2009 and beyond model year products.