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April 20, 2020 AHCERT: 200317

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Subject: Request for GHG Credit for Cold Storage Evaporator

1.1 Regulatory Background of this Document

Title 40 of Code of Federal Regulations §86.1869-12, hereby referred to as §86.1869-12, allows manufacturers to generate credits for CO_2 -reducing technologies where the CO_2 reduction benefit of the technology is not adequately captured on the Federal Test Procedure and/or the Highway Fuel Economy Test. These optional credits are referred to as “off-cycle” credits. The manufacturer must use one of the three options specified in 1869-12 to determine the CO_2 grams per mile credit applicable to an off-cycle technology. This application is requesting approval to apply off-cycle credit to all 2017 model year (MY) and later Honda and Acura vehicles for a Cold Storage Evaporator based on the test results and analysis provided.

1.2 Idle Start-Stop Background

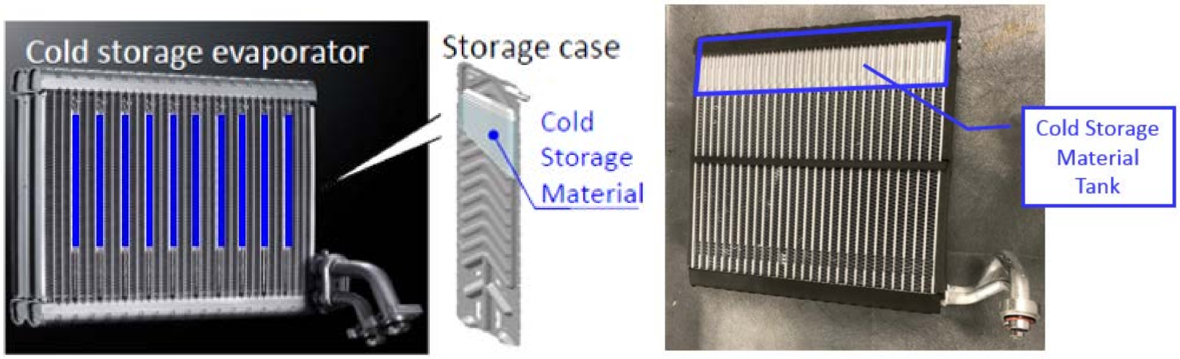
An effective method of reducing emissions and improving fuel economy is application of the Idle Start-Stop system (ISS). This system will turn the engine OFF when the vehicle comes to a stop and certain conditions are judged as OK. The engine off state reduces the load on the vehicle, reducing the overall fuel consumption for the trip. The ISS effectiveness has been well documented (EPA joint TSD, Mercedes & Hyundai/Kia ISS Applications). While there can be an impact in the 2-cycle mode testing, the amount of idle time/duration in the 2-cycle testing is not representative of real world customer driver modes. EPA has recognized this as they established the credit for an ISS in the off-cycle menu (Table II-22). In the Joint TSD (EPA-420-R-12-901), the EPA has suggested that engine idle start-stop technology is theoretically capable of providing up to 3.8 g/mi credit for passenger cars & 6.0 g/mi for light trucks. However, the joint TSD does not consider ISS operation in the hot temperature range (9.7% of vehicle miles travelled) for the achieved credit, and while the EPA accounts for ISS operation in the mid temperature range (30~80°F), there are other conditions (humidity and solar load) that will prevent ISS operation due to unsatisfactory levels of cabin comfort. Also noted in the Joint TSD, the EPA recognizes the possibility of operation in the high temperature range with certain technologies or smart A/C controls. Implementation of the Cold Storage Evaporator allows an ISS to operate effectively in the hot ambient range, as well as increase the operation in mid temperature ranges with higher solar loads. Additionally, it is well understood globally that the average temperature of the U.S. is trending upwards almost every year[1], which only accelerates the importance/effectiveness of the CS Evaporator.

[1] http://www.GlobalChange.gov/climate-change

2 Description of our Methodology

2.1 Cold Storage Evaporator Description

Depending on manufacturer, cold storage tanks are placed either in between refrigerant tubes (type 1) or at the end of the evaporator (with tubes running through it –type 2.)



Type 1 – In-between tanks   Type 2 – End Tank

Figure 1: Cold Storage Evaporator examples

The cold storage material, a paraffin wax, is placed inside the tanks. The wax has chemical properties, that when cooled by the A/C system operation, will "freeze" into a solid state. Once the CS material is frozen, the evaporator is prepared for an Idle Stop (engine/compressor OFF). Once the engine is OFF (ISS operation), the A/C is no longer cooling the evaporator/CS material, thus causing the CS material to begin to "thaw" (changing back to a liquid). The thawing process will help to sustain the evaporator's ability to absorb heat from the cabin air, consequently maintaining a cool air temperature for a longer period of time compared to the non-cold storage evaporator (figure 2.) As the temperature stays cooler longer, the A/C system & related controls are able to keep the cabin comfort experience by the customer for a longer duration. The longer the cabin comfort can be kept, the longer the compressor/engine can be kept OFF.

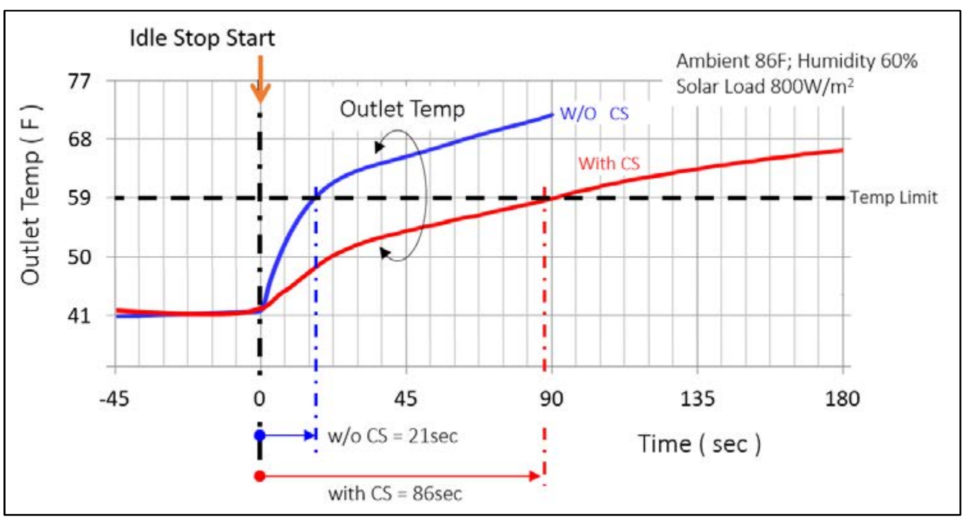


Figure 2: Cold Storage vs. Non-Cold Storage Evaporator warm-up at Engine OFF

2-2. Benefit for Idle Stop-Start System

The basic principle/purpose of introducing the cold storage evaporator is to 1.) extend engine off time without sacrificing cabin comfort and 2.) allow high temperature ISS while maintaining cabin comfort. The engine *could* stay OFF for the same amount of time with cold storage or not, but in warmer conditions, the customer would not be able to stay comfortable without the CS evaporator. Without the Cold Storage Evaporator, extending Engine Off time or allowing high temp operation would result in decreased levels of cabin comfort.

When considering the purpose of the CS evaporator, a benefit can be seen in 2 driving situations. The first is when the vehicle has an extended stop, such as in a heavy city traffic jam. The second is where there are multiple, consecutive stops. In order to quantify the benefit of the cold storage evaporator, we investigated these 2 driving modes in a real world environment.

2-2.1. Extended Stop (Las Vegas Blvd)

One of the more relevant situations showing the benefit of the CS evaporator is driving on Las Vegas Boulevard (i.e. "The Strip") as the typical conditions are hot outside temperatures (> 100°F in the summer) with a high solar load (> 1000 W/m^2) and also has some of the worst traffic in the US (42.5 million visitors in 2019). Also, this mode is increasingly appropriate for the U.S. (not just Las Vegas) as traffic across the country is getting worse every year. From 1982-2017, urban traffic has increased by 15% every 5 years[2].

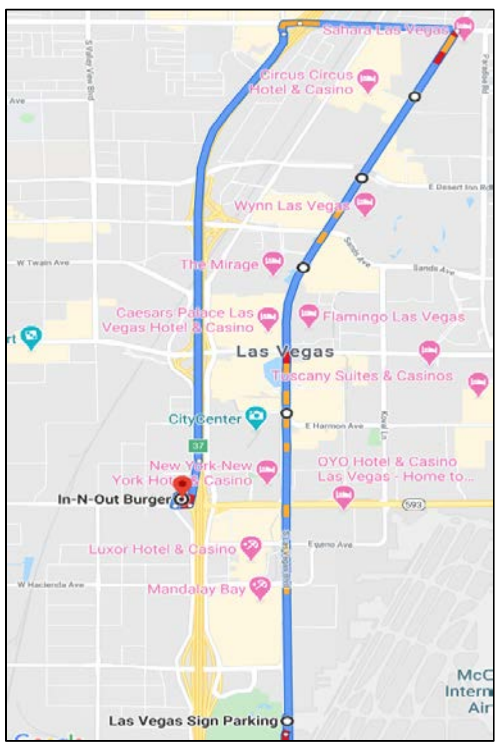


Figure 3: Extended Stop Mode (Las Vegas Blvd.) Route

In September 2019, we conducted on-road testing in Las Vegas to investigate the specifics of this mode. We drove 2 identical Honda Pilots equipped with an ISS system, but replaced 1 vehicle's CS evaporator with a Non-

[2] https://static.tti.tamu.edu/tti.tamu.edu/documents/mobility-report-2019.pdf

CS evaporator. We then drove the Pilots side-by-side in multiple Las Vegas Blvd. cycles (outside temperatures – 81~98°F; solar loads – 0 ~ 1250 W/m^2) to compare the comfort-holding performance of each evaporator. In the on-road testing, the CS evaporator performed significantly better, able to keep the engine OFF ~2x longer than the non-CS evaporator. The non-CS equipped vehicle was also not able to preserve cabin comfort adequately while the engine was OFF. As such, if a Honda vehicle was not equipped with a CS evaporator, ISS operation would be prohibited at high ambient temperatures (> 80°F) and solar loads. While the average stop time on Las Vegas Blvd. was 49 seconds, many of the stop durations exceeded 2 minutes. Both A/C systems were tested during daytime and nighttime, during weekdays and the weekend. See Table 1 for the characteristics of the Extended Stop Drive Mode.

Table 1: Real World Testing Characteristics - Las Vegas Blvd.

# of Runs	On-Road Testing Drive Averages				
	Ambient Conditions	Total Drive Time (min)	Total Drive Distance (mi)	Time at Idle (%)	Time at each Stop (sec)
12	89.5°F; 782 W/m^2	42.4	8.1	44%	48.6

2-2.2. Repeated Stops (Drive-Thru)

Along with increased traffic, an increasing percentage of Americans are prioritizing convenience, which includes utilizing the drive-thru instead of sitting down in the restaurant. In 2018, more than 80% of all new Starbucks stores included the drive-thru option[3]. Additionally, the typical McDonald's Restaurant generates roughly 70% of its business through its drive-thru[4]. Restaurant Business Online recently stated, "This is where the fast-food business is headed: to the automobile[5]."

In our real world testing/investigation (July-December 2019), we observed several drive-thrus (McDonalds, Starbucks, etc.) to understand the characteristics of the average drive thru. During the survey, the average wait time --aggregate for the total drive-- was 8.6 minutes. It consisted of 9 stops, each stop averaging 51 seconds. The results and analysis from our drive thru survey drove the creation of our Repeated Stops drive cycle. We combined the characteristics of drive-thru analysis with the typical daily commute for a Honda employee, driving from their home outside of Marysville into town to pick up a coffee and then onto the highway into work.

Table 2: Drive-thru Study – Waiting Characteristics

	Average Total Wait Time (min)	Average # of stops	Average Time at each Stop (sec)	# of samples
Starbucks (Marysville, OH)	16.8	11	86	12
Chick-Fil-A (Hilliard, OH)	8.2	12	34	4
Wendy's (Urbana, OH)	3.5	5	44	6
Biggby's Coffee (Grd Rapids, MI)	10.2	9	67	2
McDonalds (Marysville, OH)	4.5	7	24	8
Average of All	8.6	8.8	51	32

[3] https://csnews.com/starbucks-include-drive-thru-80-new-locations
[4] https://www.reuters.com/article/us-mcdonalds-meeting-idUSKBN16856Q)
[5] https://www.restaurantbusinessonline.com/financing/despite-efforts-ban-them-drive-thrus-remain-popular

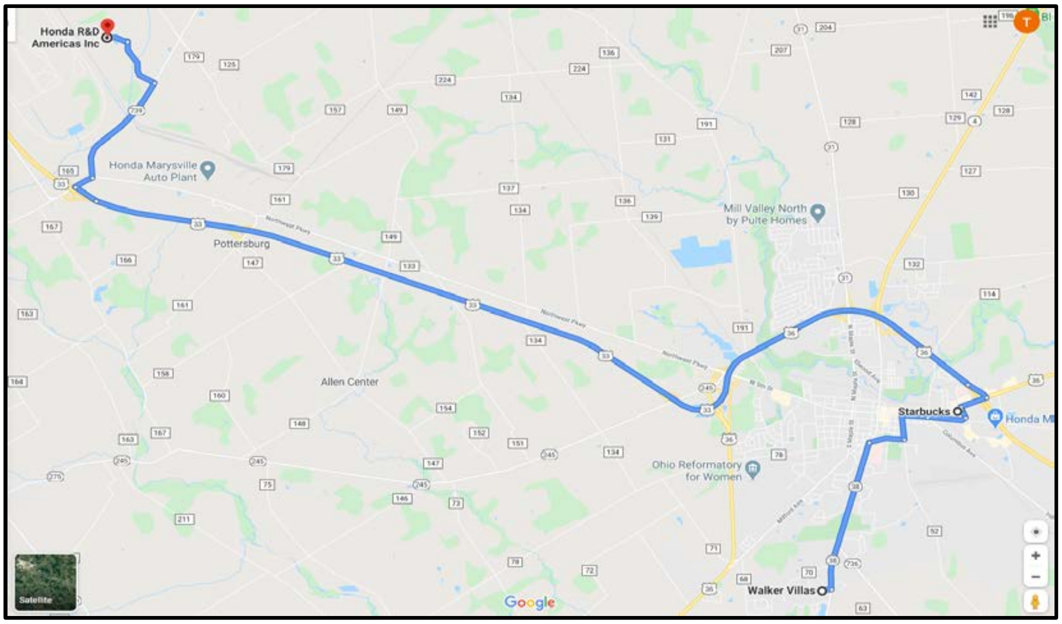


Figure 4: Repeated Stops Commute Route

Table 3: Drive Cycle Characteristics

Drive Mode	Total Time (min)	Total Idle Time (min)	Average Stop Time (sec)	Total Distance (miles)	# of stops
Extended Stop	31.0	10.2 (33%)	56.1	7.0	11
Repeated Stops	25.6	8.7 (34%)	35.0	11.1	15

2-3. <u>Other Considerations</u>

The % of Idle Time of these 2 modes --though slightly higher than the % (33 vs. 22%) stated in the Mercedes & Hyundai applications-- are still representative of the predominate city/drive-thru US drive modes. We wanted to appropriately validate the benefit of the CS evaporator vs. baseline (non-cold storage) by creating methods (Extended Stop & Repeated Stops) that are appropriate for the current situation in the US, not to re-examine the base idle stop credit.

Another note from our investigation: the Non-CS evaporator (not currently in any Honda or Acura ISS vehicles) has a faster rate of temperature rise (at engine off), as a result the cabin comfort deteriorates at a quicker rate compared to the rate of the CS evaporator. As such, during the testing the vehicle controls were set accordingly to maintain satisfactory levels of cabin comfort.

In more severe conditions, A/C systems not equipped with a CS evaporator, ISS operation will be prohibited. The outside temperature and solar load are the 2 main environmental factors that impact the A/C systems engine off performance (Δ°F/sec) and ultimately the cabin comfort (temperature & humidity). When looking at the characteristics of non-CS evaporator, the allowable range for the ISS would be significantly reduced in order to maintain cabin comfort (see figure 3), especially above 80°F (27°C).

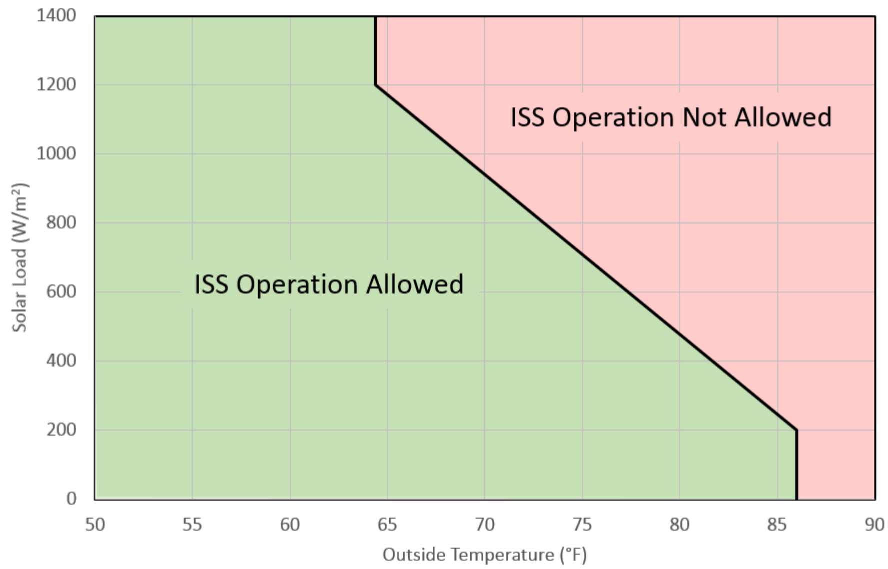


Figure 5: ISS allowable range (without Cold Storage Applied)

3- Cold Storage Evaporator Credit Verification

3-1. Test Conditions/Facility

In order to show the impact (during A/C operation) of the CS evaporator, we tested the following conditions: 68, 77, 86 & 95°F (at 50% RH). Note - below the tested ambient temperatures, the effectiveness of the CS evaporator is almost equivalent to the non-CS evaporator. Each ambient temperature was confirmed with 850W/m^2 solar load (same as AC17 test) and without. The facility used was a 4WD chassis dynamometer with climatic capabilities (temperature, humidity, solar load) and front air flow characteristics that are more accurate compared to the typical emissions dyno. Since we are considering the effect of the CS evaporator on maintaining cabin comfort during an extended ISS duration, the climatic wind tunnel/dynamometer is appropriate for this testing.

Table 4: Climatic Chamber Characteristics

Hot-Cold Chamber 1 (HCC1)

Climate Simulation	Description
Solar	0 ~ 1500 W/m^2
Wind Speed	0 ~ 87 mi/hr (140 km/hr)
Temperature Range	-40 ~ 122°F (-40 ~ 50°C)
Humidity Range	20 ~ 90 %RH
Rated Dyno Power	300 kW Front; 150 kW Rear
Max Speed	125 mph (200 km/hr)

The main factor used to compare CS and non-CS evaporators was the time the engine was allowed to remain off. For ISS operation, the primary criteria for the A/C system to request the engine to restart is the limit of the evaporator temperature. As the temperature reaches the set evaporator temperature limit (dependent on temperature and solar conditions), the A/C system will request the engine to restart to keep the cabin comfortable. Another metric for success was the dew point (DP) of the cabin. The cabin comfort of the non-CS was deemed acceptable if the DP was within ± 2°F of the CS test. Humidity sensors are standard equipment for Honda vehicles with an ISS so the cabin comfort including humidity can be considered. The dew point is limited to < 60~63°F (15~17°C) for Honda vehicles to keep the cabin occupants satisfied.

Dew Point (°F)	Comfort Level
< 50	Dry
50-55	Pleasant
56-60	Comfortable
61-65	Sticky
66-70	Uncomfortable
71-75	Oppressive
76+	Miserable

Figure 6: General Dew Point Comfort Guideline

For each A/C platform, we selected the worst case for A/C operation/performance, which the primary drivers would be cabin size and HVAC air flow. The 3 vehicles selected were the Honda Pilot, Honda Odyssey and Acura RDX. In order to maintain testing consistency of the HVAC performance from Cold Storage to Non-Cold Storage evaporator testing, we also used 1 vehicle (per platform) and switched out the evaporators.

Table 5: Vehicles Tested

Platform / Evaporator Type	Applicable Vehicles	Tested Vehicle
Light Truck / End tank	Honda Passport, Pilot; Acura MDX	2019 Honda Pilot Touring
Light Truck / In-between tanks	Honda Odyssey	2019 Honda Odyssey Elite
LT & PC / In-between tanks	Acura RDX, TLX	2019 Acura RDX Tech

3-2. Verification of Cold Storage Evaporator Benefit

We tested the following conditions (Table 6) for both the non-CS ("baseline") and the CS evaporators to accurately show the benefit across the temperature range for A/C system operation.

Table 6: Test Condition/Cycle Matrix (o = condition tested)

Solar	Outside Conditions	Repeated Stops	Extended Stop
0 W/m^2	68°F / 50%RH	o	o
	77°F / 50%RH	o	o
	86°F / 50%RH	o	o
	95°F / 50%RH	o	o
850 W/m^2	68°F / 50%RH	o	o
	77°F / 50%RH	o	o
	86°F / 50%RH	o	o
	95°F / 50%RH	o	o

Once all of the testing was complete, we compiled the data and quantified the impact of the CS evaporator vs. the Non-CS evaporator for each platform system. See the following figures & tables for those results. Note – at high ambient/solar conditions, ISS operation would be prohibited for the non-CS (as shown in Figure 5), so the time the engine is off is 0 seconds. Since a % increase cannot be calculated from a baseline of zero seconds (result is ∞), we calculated the CS evaporator result based on the % of time achieved compared to the time of ISS operation with non-CS evaporator (if enabled), with a maximum of 100% possible.

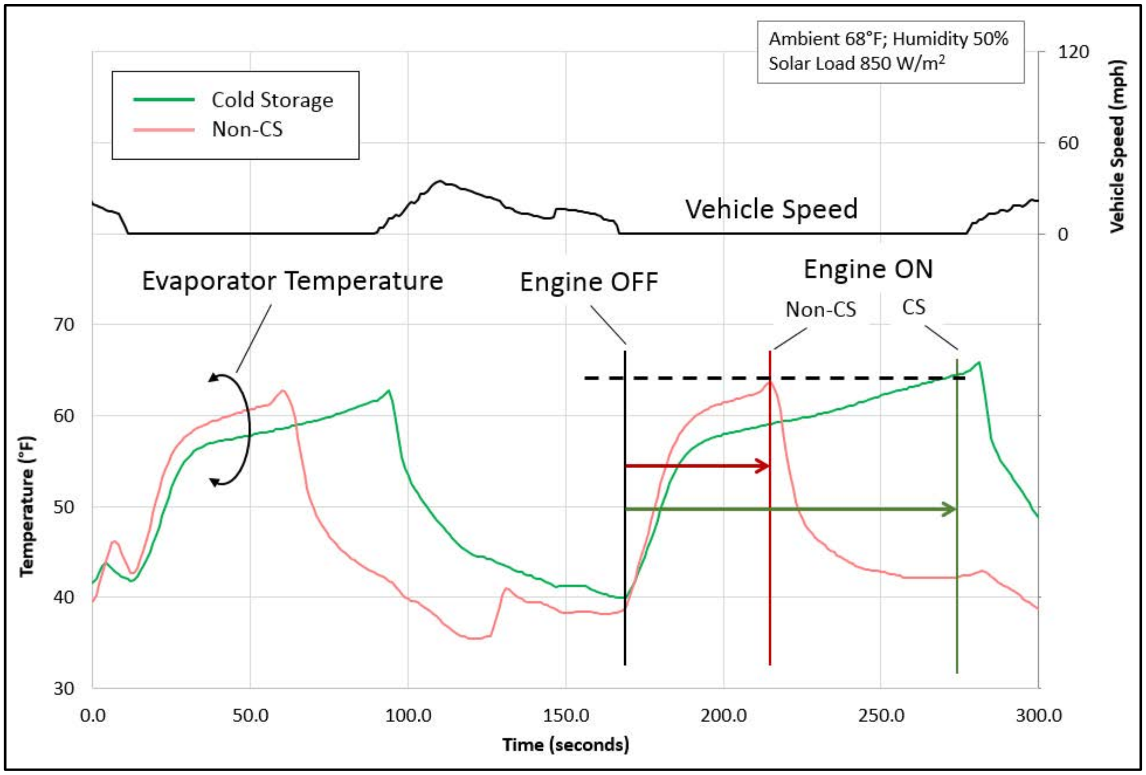


Figure 7: Honda Pilot test result (68°F, 850 W/m^2 example)

Table 7: Honda Pilot Test Results

Solar (W/m^2)	Ambient Conditions	Engine OFF Time (sec)				Condition Impact (%)
		Repeated Stops Cycle		Extended Stop Cycle		
		Non-CS	CS	Non-CS	CS	
0	68°F / 50%RH	364.8	439.5 (+21%)	412.1	597.5 (+45%)	+33%
	77°F / 50%RH	365.6	438.4 (+22%)	409.2	598.0 (+47%)	+34%
	86°F / 50%RH	0	407.8 (+100%)	0	597.7 (+100%)	+100%
	95°F / 50%RH	0	405.3 (+100%)	0	597.2 (+100%)	+100%
850	68°F / 50%RH	339.8	439.0 (+31%)	363.5	594.7 (+64%)	+47%
	77°F / 50%RH	0	398.8 (+100%)	0	594.2 (+100%)	+100%
	86°F / 50%RH	0	398.5 (+100%)	0	582.6 (+100%)	+100%
	95°F / 50%RH	0	364.6 (+100%)	0	548.8 (+100%)	+100%

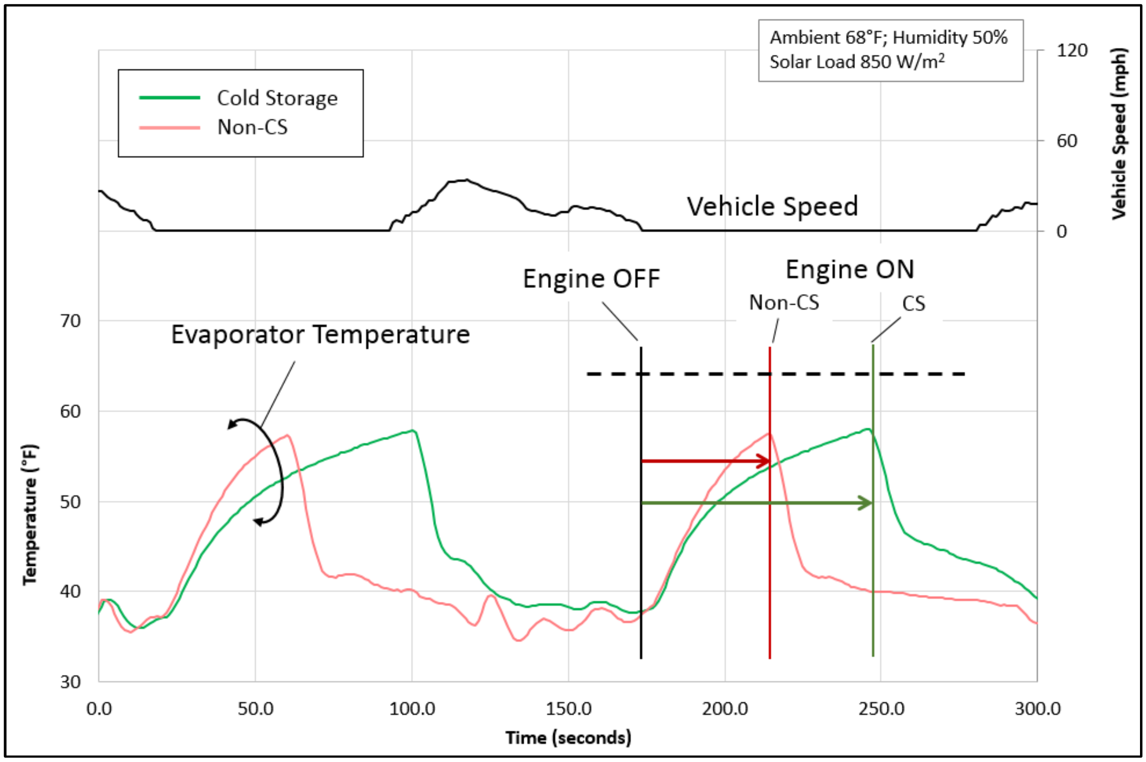


Figure 8: Honda Odyssey test result (68°F, 850 W/m^2 example)

Table 8: Honda Odyssey Test Results

Solar (W/m^2)	Outside Conditions	Engine OFF Time (sec)				Condition Impact (%)
		Repeated Stops Cycle		Extended Stop Cycle		
		Non-CS	CS	Non-CS	CS	
0	68°F / 50%RH	455.3	490.9 (+9%)	519.9	552.9 (+7%)	+8%
	77°F / 50%RH	431.9	478.2 (+12%)	458.5	550.4 (+22%)	+17%
	86°F / 50%RH	0	427.7 (+100%)	0	543.9 (+100%)	+100%
	95°F / 50%RH	0	372.0 (+100%)	0	520.7 (+100%)	+100%
850	68°F / 50%RH	420.3	483.7 (+18%)	405.4	548.2 (+35%)	+26%
	77°F / 50%RH	0	446.8 (+100%)	0	540.4 (+100%)	+100%
	86°F / 50%RH	0	355.1 (+100%)	0	488.4 (+100%)	+100%
	95°F / 50%RH	0	335.0 (+100%)	0	474.7 (+100%)	+100%

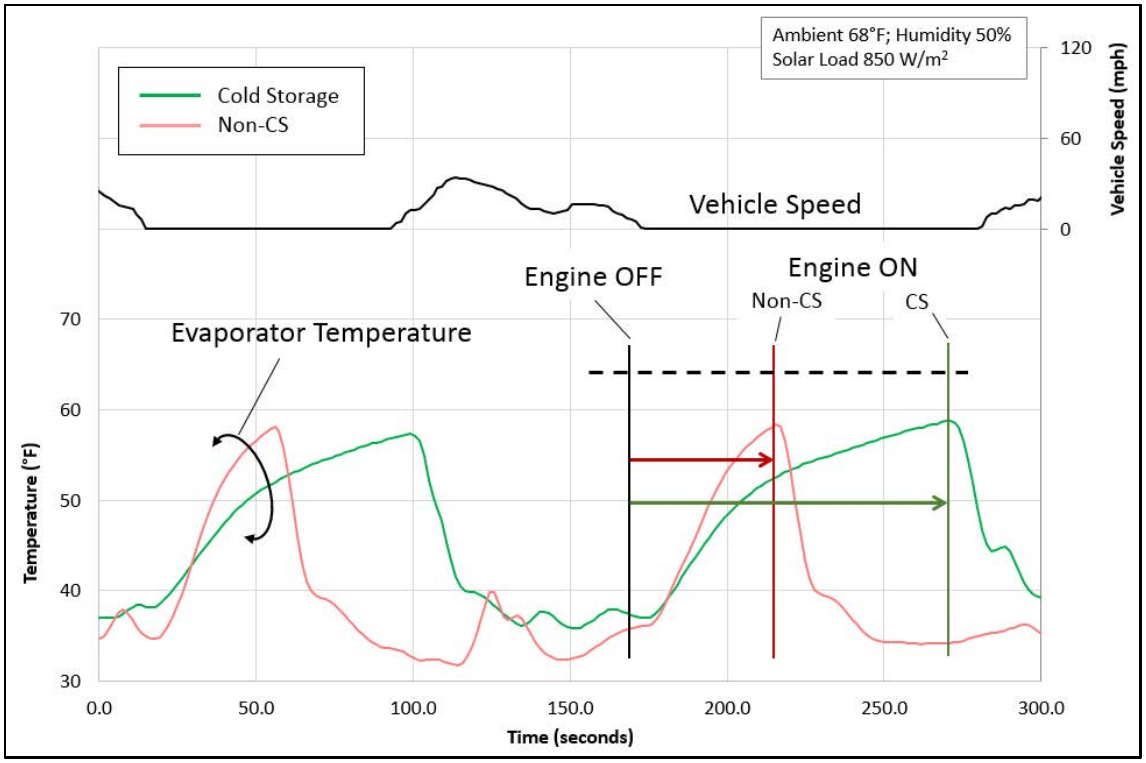


Figure 9: Acura RDX test result (68°F, 850 W/m² example)

Table 9: Acura RDX Test Results

Solar (W/m²)	Outside Conditions	Engine OFF Time (sec)				Condition Impact (%)
		Repeated Stops Cycle		Extended Stop Cycle		
		Non-CS	CS	Non-CS	CS	
0	68°F / 50%RH	427.0	498.9 (+15%)	506.0	555.1 (+11%)	+13%
	77°F / 50%RH	436.2	483.7 (+13%)	451.2	553.7 (+24%)	+18%
	86°F / 50%RH	0	456.1 (+100%)	0	552.9 (+100%)	+100%
	95°F / 50%RH	0	422.6 (+100%)	0	453.0 (+100%)	+100%
850	68°F / 50%RH	394.3	442.9 (+12%)	405.4	554.1 (+38%)	+25%
	77°F / 50%RH	0	468.0 (+100%)	0	552.2 (+100%)	+100%
	86°F / 50%RH	0	428.8 (+100%)	0	554.6 (+100%)	+100%
	95°F / 50%RH	0	414.0 (+100%)	0	399.7 (+100%)	+100%

3-3. Off-cycle Credit for ISS Improvement due to Cold Storage Evaporator

From these results, we determined the overall CS evaporator improvement % by averaging the Δ improved at each temperature with and without solar load. For the calculation, each mode (extended & repeated drive cycles) was assumed to contribute equally to the overall improvement at each temperature as both are found in typical US daily driving. We then weighted each ambient temperature % improvement by vehicle miles travelled (VMT) as a function of ambient temperature. With a total % improvement by climate VMT, we calculated the g/mile improvement vs. the current credit awarded for an Idle Start-Stop System (including heater circulation system) (2.5 PC; 4.4 LT). See below tables for calculated credit.

Table 10: Honda Pilot (Acura MDX, Honda Passport) Credit Calculation

Temp	Solar	Repeated Stops	Extended Stop	% by Ambient	Overall % (by Climate VMT)		Calculated Credit
<0°F	n/a	0%	0%	0%	× (60%) = 0%		+0 g/mile (cold ambient range)
5°F							
14°F							
23°F							
32°F							
41°F							
50°F							
59°F							
68°F	0W	21%	45%	40%	× (15%)	26%	LT Calc – 4.4g x 0.26 = 1.2 g/mile
	850W	31%	64%				
77°F	0W	22%	47%	67%	× (16%)		
	850W*	100%	100%				
86°F*	0W	100%	100%	100%	× (8.4%)		PC Calc – 2.5g x 0.26 = 0.7 g/mile
	850W	100%	100%				
95°F*	0W	100%	100%	100%	× (1.3%)		
	850W	100%	100%				

Table 11: Honda Odyssey Credit Calculation

Temp	Solar	Repeated Stops	Extended Stop	% by Ambient	Overall % (by Climate VMT)	Calculated Credit
<0°F	n/a	0%	0%	0%	× (60%) = 0%	+0 g/mile (cold ambient range)
5°F						
14°F						
23°F						
32°F						
41°F						
50°F						
59°F						
68°F	0W	9%	7%	17%	× (15%)	LT Calc – 4.4g x 0.22 = 1.0 g/mile
	850W	18%	35%			
77°F	0W	12%	22%	58%	× (16%)	
	850W*	100%	100%		22%	
86°F*	0W	100%	100%	100%	× (8.4%)	PC Calc – 2.5g x 0.22 =0.6 g/mile
	850W	100%	100%			
95°F*	0W	100%	100%	100%	× (1.3%)	
	850W	100%	100%			

Table 12: Acura RDX (Acura TLX) Credit Calculation

Temp	Solar	Repeated Stops	Extended Stop	% by Ambient	Overall % (by Climate VMT)	Calculated Credit
<0°F	n/a	0%	0%	0%	× (60%) = 0%	+0 g/mile (cold ambient range)
5°F						
14°F						
23°F						
32°F						
41°F						
50°F						
59°F						
68°F	0W	15%	11%	19%	× (15%)	LT Calc – 4.4g x 0.22 = 1.0 g/mile
	850W	12%	38%			
77°F	0W	13%	24%	59%	× (16%)	
	850W*	100%	100%		22%	
86°F*	0W	100%	100%	100%	× (8.4%)	PC Calc – 2.5g x 0.22 =0.6 g/mile
	850W	100%	100%			
95°F*	0W	100%	100%	100%	× (1.3%)	
	850W	100%	100%			

*If equipped with Non-CS Evaporator, ISS operation would be disabled to maintain cabin comfort.

Table 13: Reference to 17-25MY GHG/CAFE final rule Technical Support Document

Vehicle Miles Traveled (VMT)	Outside Temp (F)	Fraction	Temp Range VMT Fraction
1181.656796	-25	0.00000157	0.21958689 (< 40 deg F)
4400.79767	-20	0.00000585	
12905.217	-15	0.00001714	
40874.20742	-10	0.00005429	
174939.1854	-5	0.00023235	
762497.0884	0	0.00101274	
1915732.576	5	0.00254446	
4924729.91	10	0.00654097	
12353230.63	15	0.01640743	
23259876.93	20	0.03089353	
31418211.75	25	0.04172934	
41033016.47	30	0.05449962	
49426375.28	35	0.06564760	
55404781.78	40	0.07358805	
60396251.48	45	0.08021767	0.68343503 (> 40 deg F, < 80 deg F)
63018086.25	50	0.08369996	
68380740.42	55	0.09082259	
73176481.47	60	0.09719224	
72473451.14	65	0.09625848	
67073984.17	70	0.08908697	
54637578.9	75	0.07256906	
39382139.05	80	0.05230695	
24182451.73	85	0.03211888	0.09697809 (>80 deg F)
7635253.418	90	0.01014106	
1203687.536	95	0.00159873	
593360.565	100	0.00078810	
18352.30991	105	0.00002438	
752904571.9	TotalVMT	1.00000000	

3-3.1 Alternative Method to Calculate Off-cycle Credit for ISS Improvement due to Cold Storage Evaporator

Additionally, to support our main credit calculation, we determined the benefit of the cold storage evaporator in grams per mile based on A-B emissions testing (i.e., technology on and off), similar to other methods for Start-Stop system off-cycle credit submissions. Looking at the time improvement from Cold Storage vs. Non-Cold Storage Evaporators, we calculated the off-cycle credit (see appendix for details) as follows:

$$Reduced\ CO2 = \frac{Engine\ off\ time\ increase\ x\ Idle\ Fuel\ Consumption}{Mileage\ per\ Drive\ Cycle} \times \mathrm{CO2}\ Emission$$

Assumptions:

- *Idling fuel consumption (as tested): Pilot – 0.5 gal/hour; Odyssey – 0.5 gal/hr; RDX – 0.4 gal/hr*
- *Mileage per driving cycle: Extended Stop DC – 7.0 miles; Repeated Stop DC – 11.1 miles*
- *CO_2 Emission of gasoline: 8887 g/gal (source EPA-420-F-14-040a)*
- *Climate Weighting: Vehicle Miles Travelled per Ambient Temperature from TSD (EPA-420-R-12-901)*
- *Idle % Weighting: 22.7% / 33.5% (Idle % from Mercedes & Hyundai Request / Honda DC's Idle %)*
- *City/Highway driving weighting: 55% / 45% (source EPA FE Label Rule)*

Using this method and assumptions, we were able to calculate a CO_2 emissions improvement for each A/C system platform. For the Honda Pilot = 3.2 g/mile, Honda Odyssey = 2.3 g/mile and Acura RDX = 1.9 g/mile, which is almost double the amount determined from the primary calculation.

4- Compliance Statement

Cold Storage evaporators installed on Honda and Acura vehicles meet Honda internal specifications and durability requirements, which meet the durability requirements of 40 CFR §86.1869-12(d) and are not subject to any deterioration factors that may reduce the benefits of the cold storage evaporator. Durability testing has been conducted by suppliers to meet Honda specifications.

5- Reference

- Hyundai Motor Company. "Application for GHG Credit for Idle Stop and Go (ISG) Technology", June 10, 2019.
- EPA Compliance Division. "EPA Decision Document: Mercedes-Benz Off-Cycle Credits for MYs 2012-2016", EPA-420-R-14-025, September 2014.
- EPA Compliance Division. "Joint Technical Support Document: Final Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards", EPA-420-R-12-901, August 2012.

6- <u>Request of EPA's Approval</u>

Based on the vehicle test data shown in this application, combined with the final analysis and technology summary, Honda Motor Company, hereby requests the EPA approve an off-cycle GHG credit of 1.0 grams CO_2 per mile for the Cold Storage Evaporator equipped in MY 18-19 Honda Odyssey, 1.2 g/mile for the MY 17-19 Honda Pilot and Acura MDX & MY 19 Honda Passport AWD, 1.0 g/mi for the MY 19 Acura RDX AWD, 0.7 g/mi for MY 19 Honda Passport FWD and 0.6 g/mi for MY 17-19 Acura TLX & MY 19 Acura RDX FWD.

Respectfully,

Alice Lee

Senior Manager

Product Regulatory Office

American Honda Motor Co., Inc.

Attachment A: Tested Vehicles Details

Vehicles tested in Climatic Chamber for Credit Results:

Vehicle	VIN	Type	Engine	Transmission		Grade	Color
Honda Odyssey	5FNRL6H92LB000009	Minivan	3.5L V6	10AT	FWD	Elite	Platinum White Pearl
Acura RDX	5J8TC2H79KL000048	SUV	2.0L L4	10AT	AWD	Advanced	Lunar Silver Metallic
Honda Pilot	5FNYF6H04KB000046	SUV	3.5L V6	9AT	AWD	Elite	Modern Steel

Attachment B: Idle Start-Stop System Operating Conditions (Cabin Comfort highlighted)

Auto Idle Stop Activates When:

The vehicle stops with the gear position in [D] and the brake pedal depressed.

Auto Idle Stop does not activate when:

- The Auto Idle Stop **OFF** button is pressed.
- The driver's seat belt is not fastened.
- The engine coolant temperature is low or high.
- The transmission fluid temperature is low or high.
- The vehicle comes to a stop again before the vehicle speed reaches 3 mph (5 km/h) after the engine starts.
- Stopped on a steep incline.
- The transmission is in a position other than [D].
- The engine is started with the hood open.
  ▶ Turn off the engine. Close the hood before you restart the engine to activate Auto Idle Stop.
- The battery charge is low.
- The internal temperature of the battery is 14°F (–10°C) or less.
- The climate control system is in use, and the outside temperature is below –4°F (–20°C) or over 104°F (40°C).
- The climate control system is in use, and the temperature is set to **Hi** or **Lo**.
- [icon] is on (indicator on).
- When the rear fan is set to maximum speed.
  ▶ Auto Idle Stop may not activate under other conditions when the rear climate control system is in use.
- When the Intelligent Traction Management is set to **Snow**.

Auto Idle Stop Activates When:

Do not open the hood while the Auto Idle Stop function is activated. If the hood is opened, the engine will not restart automatically.

In this case, restart the engine with the **ENGINE START/STOP** button.

Starting the Engine P. 538

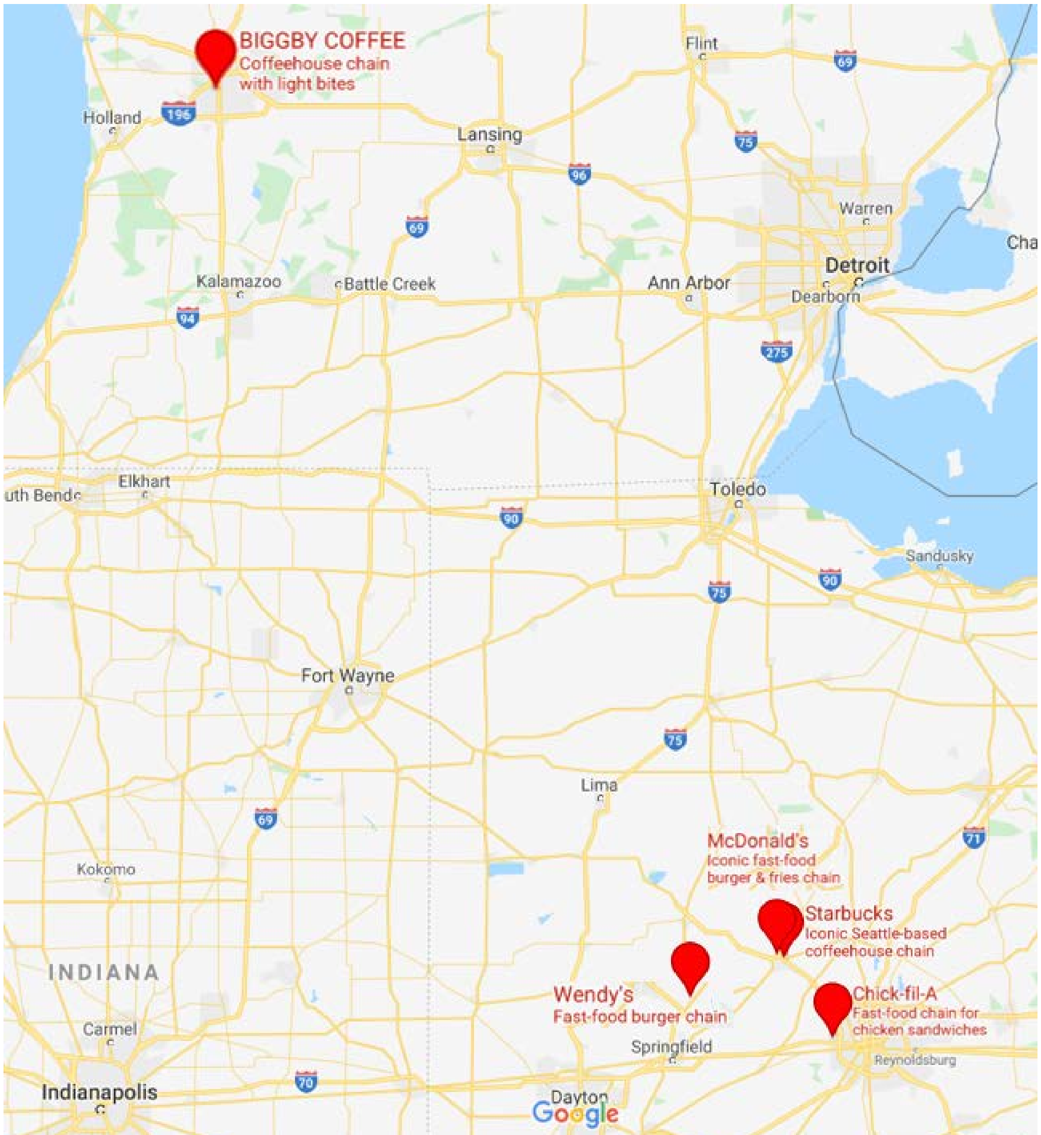
Pressing the **ENGINE START/STOP** button changes the power mode to ACCESSORY even while Auto Idle Stop is in operation. Once in ACCESSORY, the engine no longer restarts automatically. Follow the standard procedure to start the engine.

Starting the Engine P. 538

The engine restarts even if the brake pedal is depressed*1 when:

- The Auto Idle Stop **OFF** button is pressed.
- When a steering wheel is operated.
- The transmission is put into [R], [S], and [P], or taken out of [N] and put into [D].
- The pressure on the brake pedal is reduced and the vehicle starts moving while stopped on an incline.
- The pressure on the brake pedal is repeatedly applied and released slightly during a stop.
- The battery charge becomes low.
- The accelerator pedal is depressed.
- The driver's seat belt is unlatched.
- [icon] is on (indicator on).
- The climate control system is in use, and the difference between the set temperature and actual interior temperature becomes significant.
- The climate control system is being used to dehumidify the interior.
- The rear fan is set to maximum speed.
  ▶ Auto Idle Stop may not activate under other conditions when the rear climate control system is in use.
- When the Intelligent Traction Management is set to **Snow**.

Attachment C: Drive Thru Locations – Sampled July ~ November 2019



Drive-Thru	Address
Starbuck's	1081 Delaware Ave., Marysville, OH 43040
McDonald's	17781 OH-31, Marysville, OH 43040
Chick-Fil-A	1988 Hilliard Rome Rd., Hilliard, OH 43026
Wendy's	734 Scioto St., Urbana, OH 43078
Biggby Coffee	1105 28th St. SW, Wyoming, MI 49509

Attachment D: Las Vegas Blvd. Testing Details– September 2019

Two MY19 Honda Pilot Elites were used for On-road Real World Idle Start-Stop testing.
Both Pilots are equipped with a Tri-Zone (Driver, Passenger, Rear) HVAC System with Automatic Control

Vehicle	VIN	Type	Engine	Transmission		Grade	Color	Evaporator
Honda Pilot #1	5FNYF6H04KB000046	SUV	3.5L V6	9AT	AWD	Elite	Modern Steel	Cold Storage
Honda Pilot #2	5FNYF6H04KB000047	SUV	3.5L V6	9AT	AWD	Elite	Modern Steel	Non-Cold Storage

Table 9 – Driving/Cabin Data for Las Vegas Blvd. Testing – September 2019

Run	Date	Solar (W/m^2)	Ambient (°F)	Total Time (min)	Dew Pt (°F)		Idle Time (sec)		Engine OFF Time (sec)	
					CS	Non CS	CS	Non CS	CS	Non CS
1	9-11-19	899	81.5	41.7	48.7	50.0	953 (38%)	929 (37%)	723 (76%)	327 (35%)
2	9-11-19	1094	84.9	20.8	52.2	50.5	850 (68%)	827 (66%)	588 (69%)	264 (32%)
3	9-11-19	1173	93.6	28.1	54.1	52.0	673 (40%)	680 (40%)	439 (65%)	231 (34%)
4	9-12-19	1126	96.3	26.9	56.5	53.6	832 (52%)	834 (52%)	548 (66%)	261 (31%)
5	9-12-19	0	91.4	39.3	51.8	52.9	978 (41%)	979 (42%)	882 (90%)	403 (41%)
6	9-12-19	875	82.0	50.6	50.4	51.6	909 (30%)	878 (29%)	745 (82%)	342 (39%)
7	9-12-19	1247	97.9	75.0	50.4	49.8	2275 (51%)	2283 (51%)	1478 (65%)	738 (32%)
8	9-12-19	0	94.5	88.3	52.9	51.1	2624 (50%)	2621 (49%)	1927 (73%)	1034 (39%)
9	9-13-19	0	86.9	40.5	52.5	52.9	880 (36%)	818 (34%)	764 (87%)	343 (42%)
10	9-13-19	818	82.8	37.9	48.2	49.8	947 (42%)	912 (40%)	759 (80%)	359 (39%)
11	9-13-19	907	86.2	15.1	49.1	50.2	405 (45%)	404 (45%)	337 (83%)	118 (29%)
12	9-13-19	1249	96.1	44.5	47.5	48.2	975 (37%)	920 (34%)	703 (72%)	297 (32%)
	Average	782	89.5	42.4	48.4	49.6	1099 (18.3min) (43%)		824 (76%)	393 (36%)

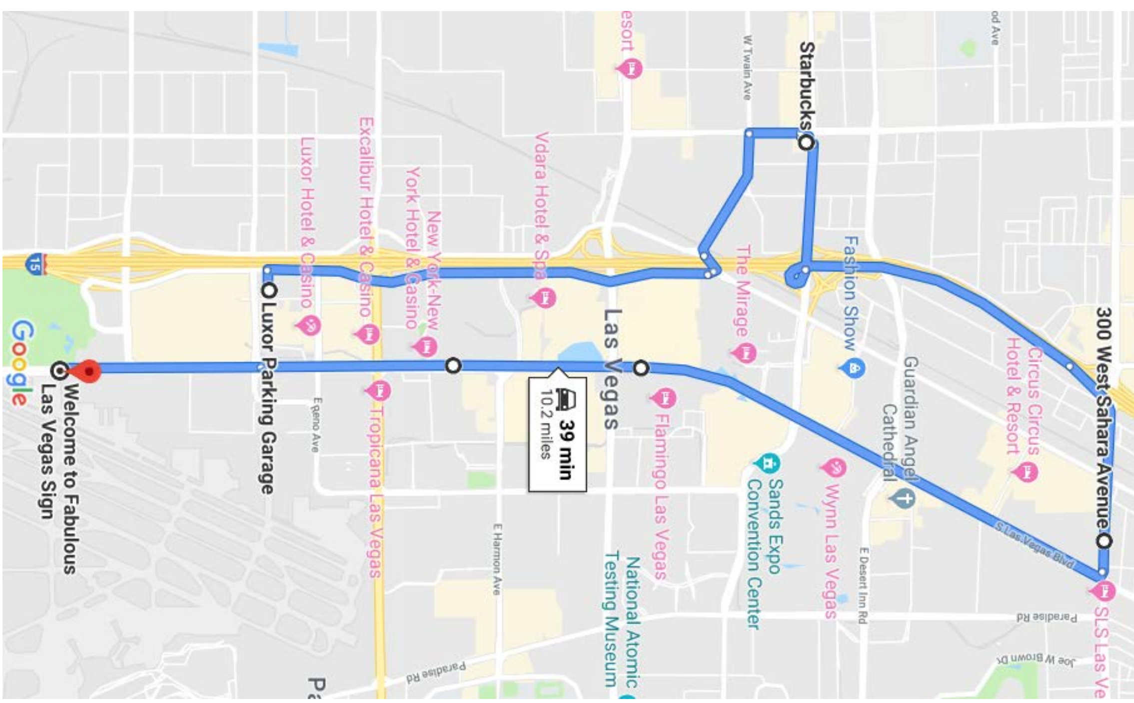
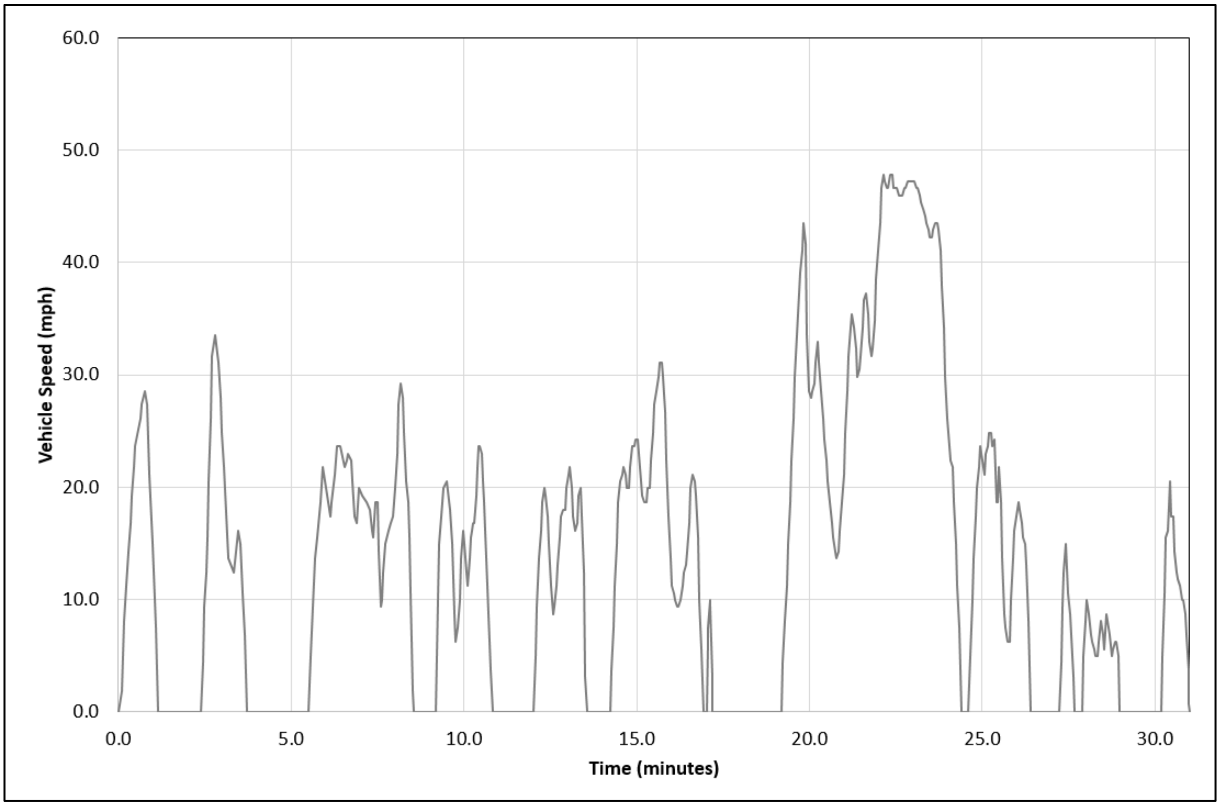
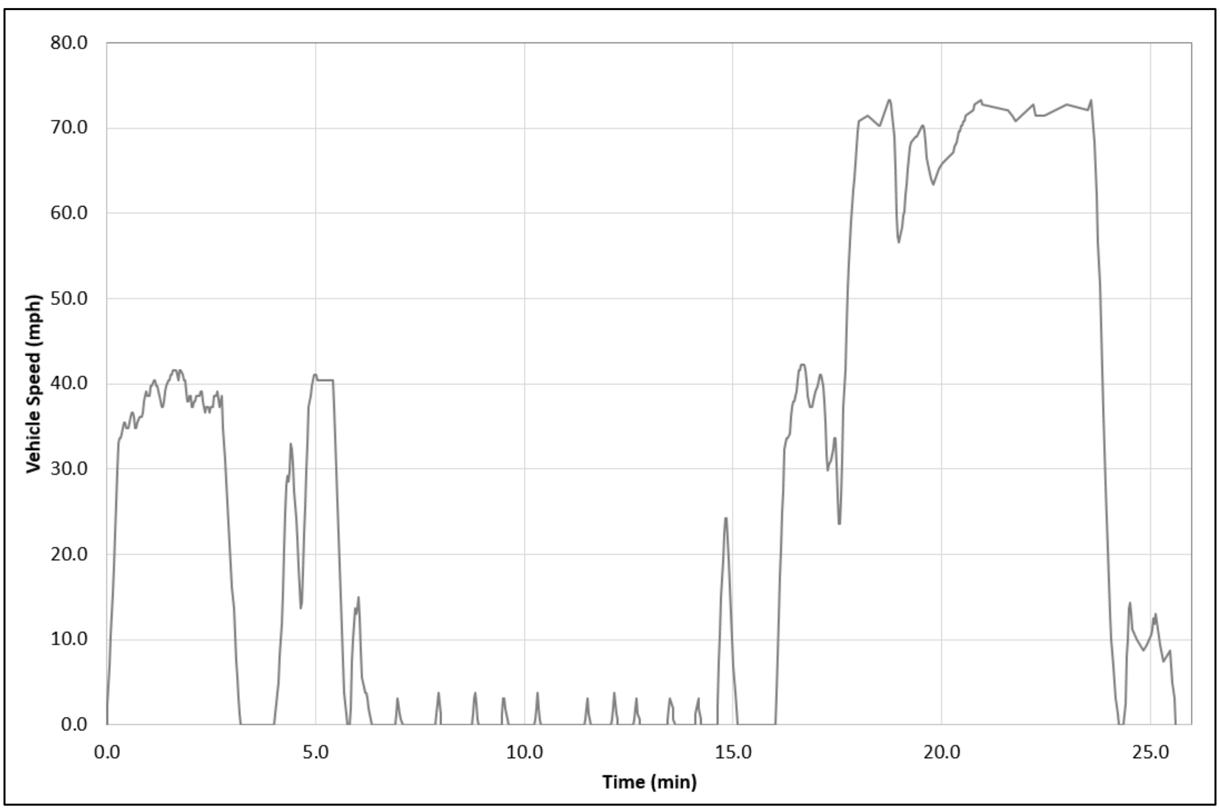


Figure 8 – Example Route for Las Vegas Blvd. Testing – September 2019

Attachment E: Extended Stop Drive Cycle



Attachment F: Repeated Stops Drive Cycle



Attachment G: Honda Pilot Testing Details

Evaporator	Solar	Temp	Total Drive Time (seconds)	Vehicle Speed=0 Time (sec)		Engine OFF Time (sec)		Dew Point (°F)	Cabin Temperature (°F) Sensor	Cabin Temperature (°F) Thermocouple Average
CS Evaporator	No Solar	68°F	1538	526.5	34.2%	439.5	83.5%	52.3	80.7	75.6
		77°F	1538	525.4	34.2%	438.4	83.4%	51.3	80.6	75.0
		86°F	1538	532.1	34.6%	407.8	76.6%	50.3	80.6	75.1
		95°F	1538	529.3	34.4%	405.3	76.6%	50.1	79.8	72.2
	850W Solar	68°F	1537	529.6	34.5%	439.0	82.9%	51.7	80.4	76.9
		77°F	1538	527.1	34.3%	398.8	75.7%	50.2	80.0	76.0
		86°F	1538	533.5	34.7%	398.5	74.7%	49.6	80.3	75.6
		95°F	1538	529.4	34.4%	364.6	68.9%	50.2	80.6	75.9
Non CS Evaporator	No Solar	68°F	1537	528.5	34.4%	364.8	69.0%	51.5	81.3	76.4
		77°F	1537	533.6	34.7%	365.6	68.5%	50.8	80.6	76.4
		86°F	1536	527.2	34.3%	0.0	0.0%	50.8	78.3	73.9
		95°F	1539	529.9	34.4%	0.0	0.0%	49.4	79.4	73.8
	850W Solar	68°F	1535	535.2	34.9%	339.8	63.5%	52.5	79.2	78.2
		77°F	1537	532.0	34.6%	0.0	0.0%	49.1	79.3	76.8
		86°F	1536	525.3	34.2%	0.0	0.0%	48.2	79.0	76.7
		95°F	1539	528.5	34.3%	0.0	0.0%	48.0	79.2	76.4
Average			1537.4	529.6	34.4%					

Repeated Stop Testing – Honda Pilot

Evaporator	Solar	Temp	Total Drive Time (seconds)	Vehicle Speed=0 Time (sec)		Engine OFF Time (sec)		Dew Point (°F)	Cabin Temperature (°F) Sensor	Cabin Temperature (°F) Thermocouple Average
CS Evaporator	No Solar	68°F	1865	620.7	33.3%	597.5	96.3%	48.6	78.2	75.4
		77°F	1865	620.3	33.3%	598.0	96.4%	48.7	79.3	75.5
		86°F	1865	619.9	33.2%	597.7	96.4%	47.7	79.3	75.4
		95°F	1864	616.1	33.1%	597.2	96.9%	49.1	79.6	74.0
	850W Solar	68°F	1865	620.3	33.3%	594.7	95.9%	51.4	79.5	77.2
		77°F	1864	622.9	33.4%	594.2	95.4%	48.8	79.9	76.6
		86°F	1862	615.9	33.1%	582.6	94.6%	49.4	79.6	76.2
		95°F	1865	616.8	33.1%	548.8	89.0%	50.6	79.5	75.6
Non CS Evaporator	No Solar	68°F	1863	618.6	33.2%	412.1	66.6%	47.9	79.2	75.8
		77°F	1863	622.1	33.4%	409.2	65.8%	50.5	80.6	75.4
		86°F	1865	623.1	33.4%	0.0	0.0%	49.3	80.3	76.6
		95°F	1864	622.7	33.4%	0.0	0.0%	47.9	79.9	74.9
	850W Solar	68°F	1865	621.0	33.3%	363.5	58.5%	50.3	80.7	78.0
		77°F	1866	624.4	33.5%	0.0	0.0%	48.0	79.9	76.7
		86°F	1866	624.2	33.5%	0.0	0.0%	47.6	79.5	76.8
		95°F	1865	621.8	33.3%	0.0	0.0%	48.3	81.4	76.9
Average			1864.5	620.7	33.3%					

Extended Stop Testing – Honda Pilot

Attachment H: Honda Odyssey Testing Details

			Total Drive Time (seconds)	Vehicle Speed=0 Time (sec)		Engine OFF Time (sec)		Dew Point (°F)	Cabin Temperature (°F) Sensor	Cabin Temperature (°F) Thermocouple Average
CS Evaporator	No Solar	68°F	1536	525.1	34.2%	490.9	93.5%	50.1	80.8	76.9
		77°F	1535	524.6	34.2%	478.2	91.2%	50.8	81.2	77.4
		86°F	1536	522.7	34.0%	427.7	81.8%	50.5	82.2	79.5
		95°F	1536	512.2	33.3%	372.0	72.6%	50.1	80.9	79.8
	850W Solar	68°F	1536	519.7	33.8%	483.7	93.1%	50.5	80.5	79.7
		77°F	1536	533.9	34.8%	446.8	83.7%	50.5	81.0	79.2
		86°F	1536	517.5	33.7%	355.1	68.6%	49.2	81.2	81.2
		95°F	1535	522.7	34.1%	335.0	64.1%	49.8	80.4	79.9
Non CS Evaporator	No Solar	68°F	1535	530.3	34.5%	455.3	85.9%	49.3	79.3	76.1
		77°F	1535	528.3	34.4%	431.9	81.8%	50.7	79.7	76.2
		86°F	1535	520.1	33.9%	0.0	0.0%	50.5	80.7	77.7
		95°F	1536	524.1	34.1%	0.0	0.0%	50.4	79.3	78.0
	850W Solar	68°F	1534	530.4	34.6%	420.3	79.2%	50.1	80.7	78.9
		77°F	1536	524.8	34.2%	0.0	0.0%	49.9	79.6	77.6
		86°F	1536	518.2	33.7%	0.0	0.0%	49.7	79.4	80.0
		95°F	1534	518.6	33.8%	0.0	0.0%	49.7	78.6	78.2
Average			1535.1	524.4	34.2%					

Repeated Stop Testing – Honda Odyssey

			Total Drive Time (seconds)	Vehicle Speed=0 Time (sec)		Engine OFF Time (sec)		Dew Point (°F)	Cabin Temperature (°F) Sensor	Cabin Temperature (°F) Thermocouple Average
CS Evaporator	No Solar	68°F	1864	612.7	32.9%	552.9	90.2%	48.3	80.6	77.6
		77°F	1861	612.8	32.9%	550.4	89.8%	47.2	79.4	75.9
		86°F	1861	611.6	32.9%	543.9	88.9%	48.2	80.4	79.2
		95°F	1863	612.4	32.9%	520.7	85.0%	49.1	82.2	78.7
	850W Solar	68°F	1864	613.9	32.9%	548.2	89.3%	48.0	81.2	80.2
		77°F	1861	617.5	33.2%	540.4	87.5%	47.7	80.0	80.0
		86°F	1863	612.7	32.9%	488.4	79.7%	47.5	80.8	79.8
		95°F	1864	613.5	32.9%	474.7	77.4%	47.6	80.7	80.6
Non CS Evaporator	No Solar	68°F	1864	614.4	33.0%	519.9	84.6%	49.0	81.4	79.0
		77°F	1862	621.5	33.4%	458.5	73.8%	48.4	80.6	77.9
		86°F	1863	617.7	33.2%	0.0	0.0%	49.9	78.4	77.8
		95°F	1865	608.1	32.6%	0.0	0.0%	48.0	80.4	77.0
	850W Solar	68°F	1862	613.5	32.9%	405.4	66.1%	47.2	81.9	80.1
		77°F	1861	609.8	32.8%	0.0	0.0%	46.3	80.5	78.9
		86°F	1864	611.2	32.8%	0.0	0.0%	47.6	79.3	78.6
		95°F	1863	611.2	32.8%	0.0	0.0%	46.4	78.9	78.6
Average			1863.0	613.4	32.9%					

Extended Stop Testing – Honda Odyssey

Attachment I: Acura RDX Testing Details

			Total Drive Time (seconds)	Vehicle Speed=0 Time (sec)		Engine OFF Time (sec)		Dew Point (°F)	Cabin Temperature (°F) Sensor	Cabin Temperature (°F) Thermocouple Average
CS Evaporator	No Solar	68°F	1537	520.3	33.9%	498.9	95.9%	49.1	80.4	79.2
		77°F	1535	512.1	33.4%	483.7	94.5%	48.9	81.4	77.0
		86°F	1536	510.1	33.2%	456.1	89.4%	49.7	80.6	76.5
		95°F	1536	519.9	33.8%	422.6	81.3%	50.6	80.8	76.1
	850W Solar	68°F	1536	523.0	34.0%	442.9	84.7%	50.8	80.2	78.7
		77°F	1537	529.2	34.4%	468.0	88.4%	48.2	81.4	79.7
		86°F	1535	511.1	33.3%	428.8	83.9%	49.7	80.6	79.8
		95°F	1536	511.7	33.3%	414.0	80.9%	50.7	80.7	78.8
Non CS Evaporator	No Solar	68°F	1539	513.9	33.4%	427.0	83.1%	48.5	82.2	80.1
		77°F	1539	519.6	33.8%	436.2	83.9%	49.8	82.3	77.4
		86°F	1538	520.2	33.8%	0	0.0%	50.2	82.2	78.4
		95°F	1538	510.3	33.2%	0	0.0%	49.4	81.7	77.9
	850W Solar	68°F	1538	519.7	33.8%	394.3	75.9%	49.8	82.0	80.4
		77°F	1539	506.0	32.9%	0	0.0%	49.9	82.9	81.7
		86°F	1538	512.6	33.3%	0	0.0%	49.4	82.6	80.7
		95°F	1538	514.6	33.5%	0	0.0%	50.0	82.0	80.3
Average			1537.2	515.9	33.6%					

Repeated Stop Testing – Acura RDX

			Total Drive Time (seconds)	Vehicle Speed=0 Time (sec)		Engine OFF Time (sec)		Dew Point (°F)	Cabin Temperature (°F) Sensor	Cabin Temperature (°F) Thermocouple Average
CS Evaporator	No Solar	68°F	1863.0	610.2	32.8%	555.1	91.0%	47.1	80.4	77.2
		77°F	1861.0	616.4	33.1%	553.7	89.8%	46.9	82.1	77.4
		86°F	1863.0	615.0	33.0%	552.9	89.9%	47.5	83.5	77.4
		95°F	1865.0	615.1	33.0%	453.0	73.6%	50.1	81.8	77.8
	850W Solar	68°F	1863.0	613.8	32.9%	554.1	90.3%	48.5	82.9	81.0
		77°F	1861.0	616.1	33.1%	552.2	89.6%	46.1	82.6	79.4
		86°F	1863.0	616.8	33.1%	554.6	89.9%	47.7	83.2	78.7
		95°F	1861.0	612.4	32.9%	399.7	65.3%	49.3	82.0	81.3
Non CS Evaporator	No Solar	68°F	1863.0	616.3	33.1%	506.0	82.1%	49.1	81.9	79.1
		77°F	1865.0	623.3	33.4%	451.2	72.4%	48.7	83.6	79.2
		86°F	1865.0	609.5	32.7%	0.0	0.0%	48.4	83.1	78.9
		95°F	1862.0	610.4	32.8%	0.0	0.0%	48.6	80.6	77.5
	850W Solar	68°F	1863.0	618.8	33.2%	405.4	65.5%	48.2	83.4	81.4
		77°F	1864.0	610.9	32.8%	0.0	0.0%	47.9	82.8	80.9
		86°F	1864.0	613.0	32.9%	0.0	0.0%	46.6	83.8	80.5
		95°F	1862.0	613.9	33.0%	0.0	0.0%	48.7	80.9	79.9
Average			1863.0	614.5	33.0%					

Extended Stop Testing – Acura RDX

Attachment J: Cold Storage Material Details

Item	CS Material #1	CS Material #1
Thermal Conductivity (W/m-K)	0.14 ~ 0.28	0.2
Latent Heat (kJ / kg)	162	240
Flash Point (°C)	130	118
Melting Point (°C)	10	5
Viscosity (mm^2/s)	2.5 (40°C)	18.92 (@25°C)

Attachment K: Alternative Calculation Method

Alternative Calculation – Honda Pilot

❑ GHG Credit Calculation – Pilot Double Check

Time Increase		20C; 50%		25C; 50%		30C; 50%		35C; 50%	
		0W	850W	0W	850W	0W	850W	0W	850W
EX DC		185.4	231.2	188.8	221.2	187.7	227.4	207.0	297.3
		9.9%	12.4%	10.1%	11.9%	10.1%	12.3%	11.1%	15.9%
RS DC		74.7	99.2	72.8	109.6	19.2	93.6	61.4	121.9
		4.8%	6.4%	4.7%	7.1%	1.2%	6.1%	4.0%	7.9%

$$Reduced\ CO_2 = \frac{Engine\ OFF\ time\ increase \times Idle\ Fuel\ Consumption}{Mileage\ per\ DC} \times CO_2\ Emissions$$

Assumptions:

- Idle Fuel Consumption – **0.5** gal/hr
- Mileage per driving cycle (**7.0** miles/EX DC; **11.1** miles/RS DC)
- CO2 emission of gas – 8887 g/gal (EPA-420-F-14-040a)
- Idle % Ratio weighting [**22.7%** (EPA approved Idle%); **33.5% (Honda DC Idle%)]**
- City/Hwy driving weighting 55%/45% (EPA FE Label Rule)

Input	Mercedes (as approved by EPA)	Hyundai-Kia (proposed in application)
Idle Time Fraction	22.7	22.7
System Effectiveness	52%	59.4%
Driver Disablement	11%	1.6%
Credit (g/mi)	~3.5-4.5	3.7-3.8

CO_2 Reduction (g/mile)	20C; 50%		25C; 50%		30C; 50%		35C; 50%	
	0W	850W	0W	850W	0W	850W	0W	850W
EX DC	32.7	40.8	33.3	39.0	33.1	40.1	36.5	52.4
RS DC	8.2	10.9	8.0	12.1	2.1	10.3	6.8	13.4

CO_2 Reduction (g/mile)	20C; 50%	25C; 50%	30C; 50%	35C; 50%
Avg / Temp	23.2	23.1	21.4	27.3

Avg of DC's (g/mile)	20C; 50%	25C; 50%	30C; 50%	35C; 50%
	3.4	3.7	1.8	0.3
Climate Weighting	14.5%	16.2%	8.4%	1.3%

Climate weighted CO_2 reduction = 9.2 g/mile

Idle % Ratio weighting

22.7%
33.5%

City/Hwy Ratio weighting

City	Hwy
55% x 5.8	45% x 0

8.8 x 67.8% = 6.2 g/mile

6.2 x 55% = 3.4 g/mile

Pilot Final Weighted CO_2 reduction = 3.4 g/mile

❑ GHG Credit Calculation – Odyssey Double Check

Time Increase	20C; 50%		25C; 50%		30C; 50%		35C; 50%	
	0W	850W	0W	850W	0W	850W	0W	850W
EX DC	33.0	142.8	91.9	133.5	73.3	201.0	262.5	202.3
	1.8%	7.6%	5.0%	7.2%	4.0%	10.8%	14.1%	10.8%
RS DC	35.6	63.4	46.3	87.4	104.5	88.9	88.6	100.1
	2.3%	4.1%	3.1%	5.7%	6.8%	5.8%	5.8%	6.6%

$$\text{Reduced } CO_2 = \frac{\text{Engine OFF time increase x Idle Fuel Consumption}}{\text{Mileage per DC}} \text{ x } CO_2 \text{ Emissions}$$

Assumptions:

- Idle Fuel Consumption – 0.5 gal/hr
- Mileage per driving cycle (7.0 miles/EX DC; 11.1 miles/RS DC)
- CO2 emission of gas – 8887 g/gal (EPA-420-F-14-040a)
- Idle % Ratio weighting [22.7% (EPA approved Idle%); 33.5% (Honda DC Idle%)]
- City/Hwy driving weighting 55%/45% (EPA FE Label Rule)

Input	Mercedes (as approved by EPA)	Hyundai-Kia (proposed in application)
Idle Time Fraction	22.7	22.7
System Effectiveness	52%	59.4%
Driver Disablement	11%	1.6%
Credit (g/mi)	~3.5-4.5	3.7-3.8

CO_2 Reduction (g/mile)	20C; 50%		25C; 50%		30C; 50%		35C; 50%	
	0W	850W	0W	850W	0W	850W	0W	850W
EX DC	5.8	25.2	16.2	23.5	12.9	35.4	46.3	35.7
RS DC	4.0	7.0	5.1	9.7	11.6	9.9	9.9	11.1

CO_2 Reduction (g/mile)	20C; 50%	25C; 50%	30C; 50%	35C; 50%
Avg / Temp	10.5	13.7	17.5	25.7

Avg of DC's (g/mile)	20C; 50%	25C; 50%	30C; 50%	35C; 50%
	1.5	2.2	1.5	0.3
Climate Weighting	14.5%	16.2%	8.4%	1.3%

Climate weighted CO_2 reduction = 5.5 g/mile

Idle % Ratio weighting: 22.7% / 33.5%

City/Hwy Ratio weighting:

City	Hwy
55% x 4.2	45% x 0

5.5 x 67.8% = 3.7 g/mile → 3.7 x 55% = 2.0 g/mile

Odyssey Final Weighted CO_2 reduction = 2.0 g/mile

Alternative Calculation – Honda Odyssey

❑ GHG Credit Calculation – RDX Double Check

Time Increase	20C; 50%		25C; 50%		30C; 50%		35C; 50%	
	0W	850W	0W	850W	0W	850W	0W	850W
EX DC	49.1	148.7	102.5	145.3	171.0	267.2	89.6	127.0
	2.6%	8.0%	5.6%	7.8%	9.2%	14.4%	4.8%	6.8%
RS DC	71.9	48.6	47.5	118.3	53.6	140	127.7	128.9
	4.7%	3.2%	3.2%	7.7%	3.5%	9.2%	8.3%	8.4%

$$\text{Reduced } CO_2 = \frac{\text{Engine OFF time increase x Idle Fuel Consumption}}{\text{Mileage per DC}} \text{ x } CO_2 \text{ Emissions}$$

Assumptions:

- Idle Fuel Consumption – 0.4 gal/hr
- Mileage per driving cycle (7.0 miles/EX DC; 11.1 miles/RS DC)
- CO2 emission of gas – 8887 g/gal (EPA-420-F-14-040a)
- Idle % Ratio weighting [22.7% (EPA approved Idle%); 33.5% (Honda DC Idle%)]
- City/Hwy driving weighting 55%/45% (EPA FE Label Rule)

Input	Mercedes (as approved by EPA)	Hyundai-Kia (proposed in application)
Idle Time Fraction	22.7	22.7
System Effectiveness	52%	59.4%
Driver Disablement	11%	1.6%
Credit (g/mi)	~3.5-4.5	3.7-3.8

CO_2 Reduction (g/mile)	20C; 50%		25C; 50%		30C; 50%		35C; 50%	
	0W	850W	0W	850W	0W	850W	0W	850W
EX DC	6.9	21.0	14.5	20.5	24.1	37.7	12.6	17.9
RS DC	6.4	4.3	4.2	10.5	4.8	12.5	11.4	11.5

CO_2 Reduction (g/mile)	20C; 50%	25C; 50%	30C; 50%	35C; 50%
Avg / Temp	9.7	12.4	19.8	13.3

Avg of DC's (g/mile)	20C; 50%	25C; 50%	30C; 50%	35C; 50%
	1.3	2.0	1.7	0.2
Climate Weighting	14.5%	16.2%	8.4%	1.3%

Climate weighted CO_2 reduction = 5.2 g/mile

Idle % Ratio weighting: 22.7% / 33.5%

City/Hwy Ratio weighting:

City	Hwy
55% x 3.4	45% x 0

5.2 x 67.8% = 3.5 g/mile → 3.5 x 55% = 1.9 g/mile

RDX Final Weighted CO_2 reduction = 1.9 g/mile

Alternative Calculation – Acura RDX