

Spring 2011

Hybrid Air Conditioning Systems Overview

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Presented at the Spring 2011 ICAIA Conference.

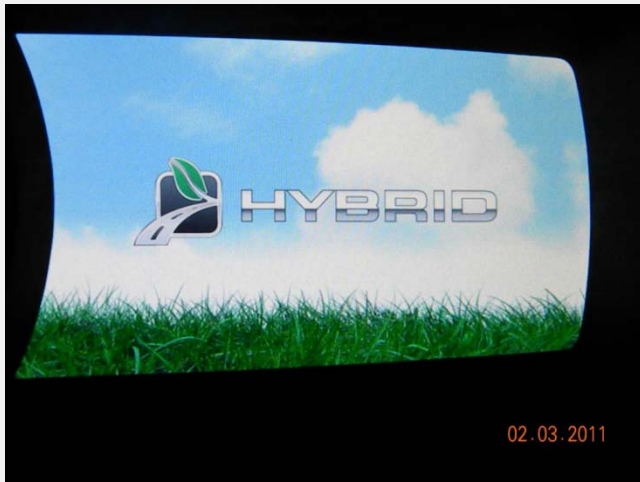
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Talley, Eugene, "Hybrid Air Conditioning Systems Overview" (2011). *Presentations*. Paper 22.

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Hybrid Air Conditioning



**PRESENTED BY EUGENE TALLEY
ASSISTANT PROFESSOR, SIU CARBONDALE
SPRING 2011 ICAIA CONFERENCE**

Hybrid Information



- According to fueleconomy.gov the number of available hybrid models in the U.S. by model year:
 - 2001 4 available models
 - 2006 17 available models
 - 2011 41 available models

Hybrid Information

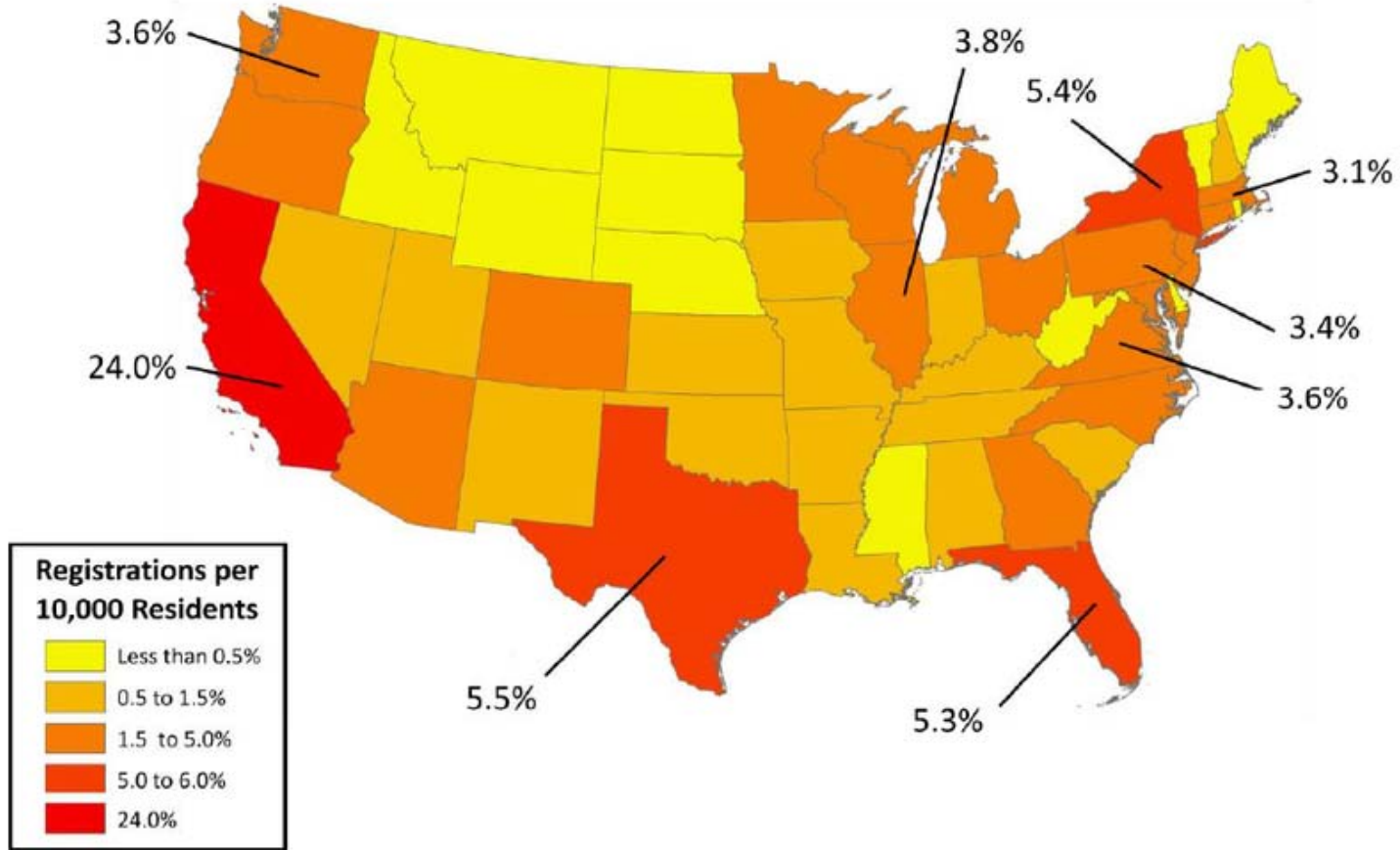


- In 2000 Toyota sold 5,790 hybrids in North America
- In December 2010 Toyota sold 20,518 hybrids in North America
- In North America there are 1.15 million Toyota hybrids alone

Hybrid Information



Figure 3: U.S. Retail Hybrid Registrations: 2007-2009 (Percent of Total Hybrid Fleet)



Source: Polk

Belt Driven A/C Systems



- Systems that are belt driven are not much different than what we have been working on for years.
- Caution still needs to be taken, some vehicles have changed components from one model year to another

Electrically Driven Compressor



- Most popular hybrid vehicles use a electrical compressor now
 - ✦ Toyota Prius
 - ✦ Ford Fusion/Mercury Milan
 - ✦ Toyota Camry/Highlander
 - ✦ Lexus GS 450h
 - ✦ Hyundai Sonata
 - ✦ Chevrolet Silverado/Tahoe/Suburban (and their GMC friends)
 - ✦ Cadillac Escalade
- This is not intended to be a complete list

Why Use Electricity vs. a Belt

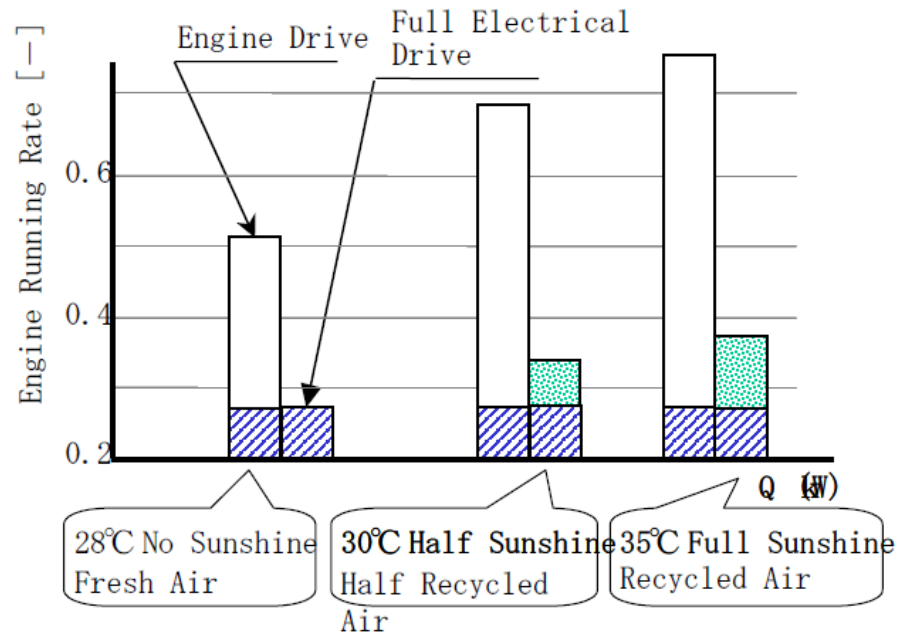
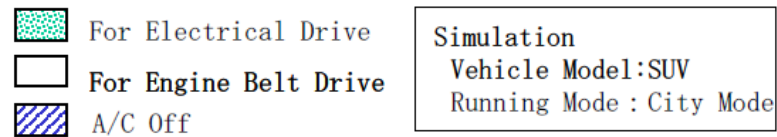


- When a hybrid is stopped, is the engine running?
- With a belt driven compressor, even a variable displacement type, how much control do you have when the cabin is “comfortable”?

Why Use Electricity vs. a Belt



Merits of Electrically Driven Compressors Impact on Fuel Consumption

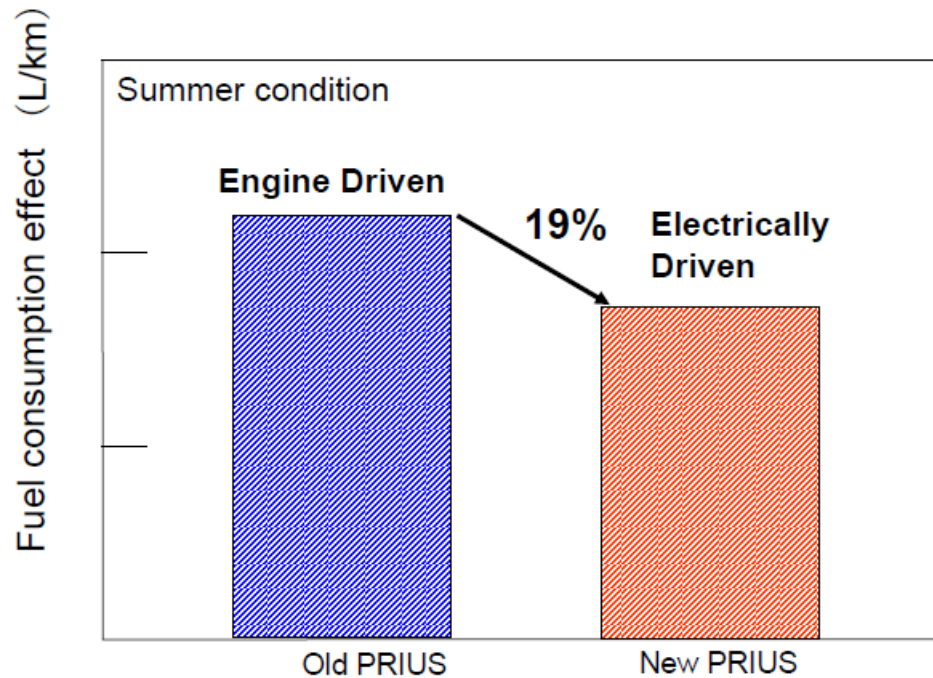


Why Use Electricity vs. a Belt



“new” Prius is the 2004 MY

Fuel Consumption Effect

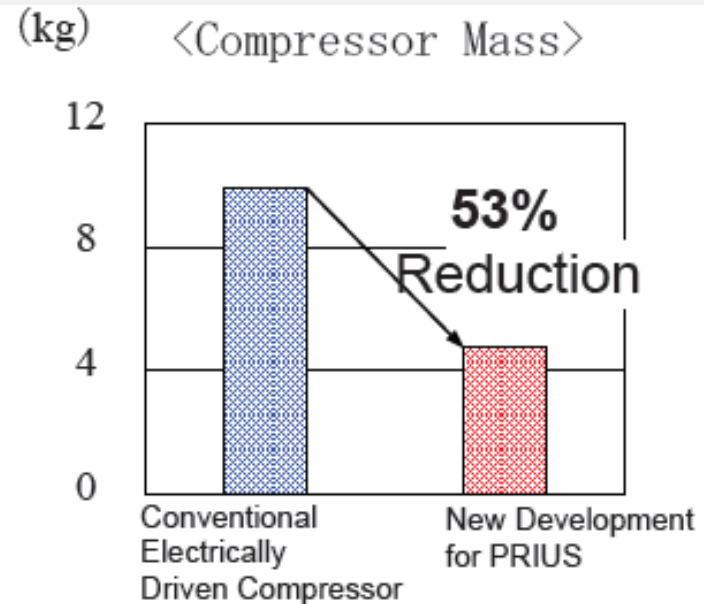
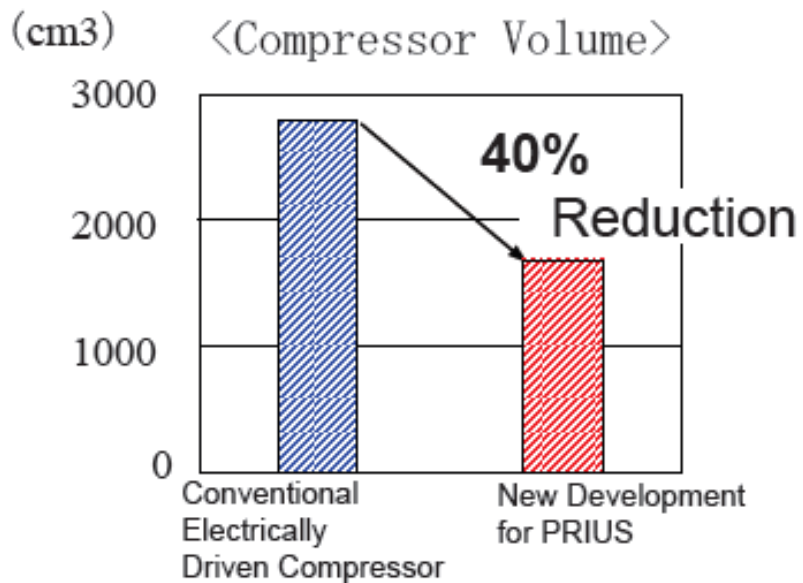


Toyota/Denso

Why Use Electricity vs. a Belt

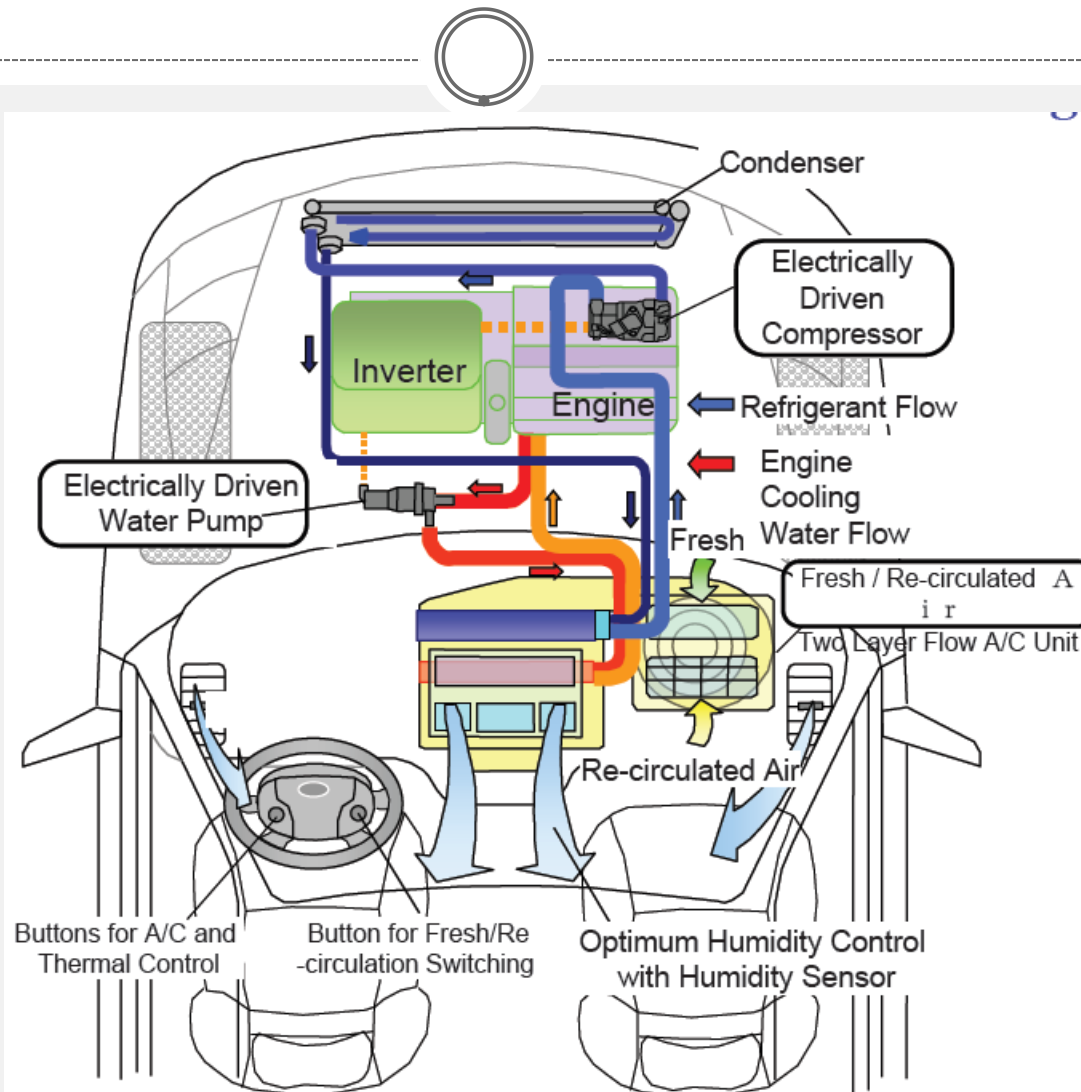


"new" Prius is the 2004 MY



Toyota/Denso

Why Use Electricity vs. a Belt



Why NOT?



- According to Green Car congress the electric compressor can reduce an electric hybrid's range by 18-30% depending on the environment.

Safety



Safety



- There are a variety of vehicle shut off switches, procedures and locations.
- **PLEASE READ YOUR MANUAL BEFORE PERFORMING ANY PROCEDURES!**

Safety



- If a connector to a a/c compressor is disconnected while the vehicle is still “powered up” damage to the connector will occur.
- Connector damage will be the least of your concerns when you are hit with 200-300v DC.

Safety



Heed the
warnings!



Safety Item Must Haves



Fiberglass Safety Pole



CAT III 1000v Meter

Safety Item Must Haves



Refrigerant Oil

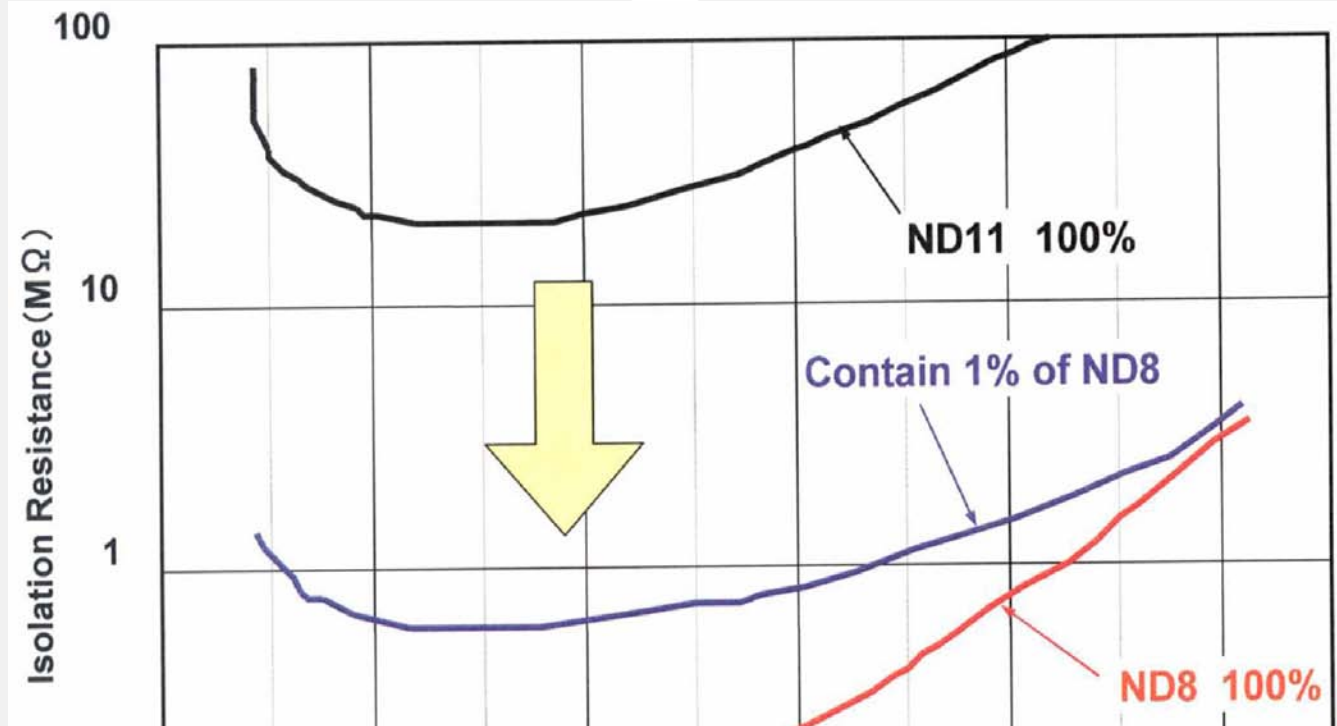


OIL and your Refrigerant Equipment



- Based on recommendations from Honda, Toyota, Ford and GM it is unacceptable to allow even the slightest amount of PAG (or other oil) into the system.
- If you can't flush the lines of you're a/c equipment, you may need a separate machine to work on hybrids!

OIL and your Refrigerant Equipment



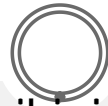
From Denso

OIL and your Refrigerant Equipment



- Two things to note from the previous chart
 - Just one percent of PAG oil can lower the insulation resistance of a compressor from over 10 Megohms to under 1 Megohms
 - If PAG oil is used to completely fill an electric compressor system the insulation resistance can essentially be reduced to zero

OIL and your Refrigerant Equipment



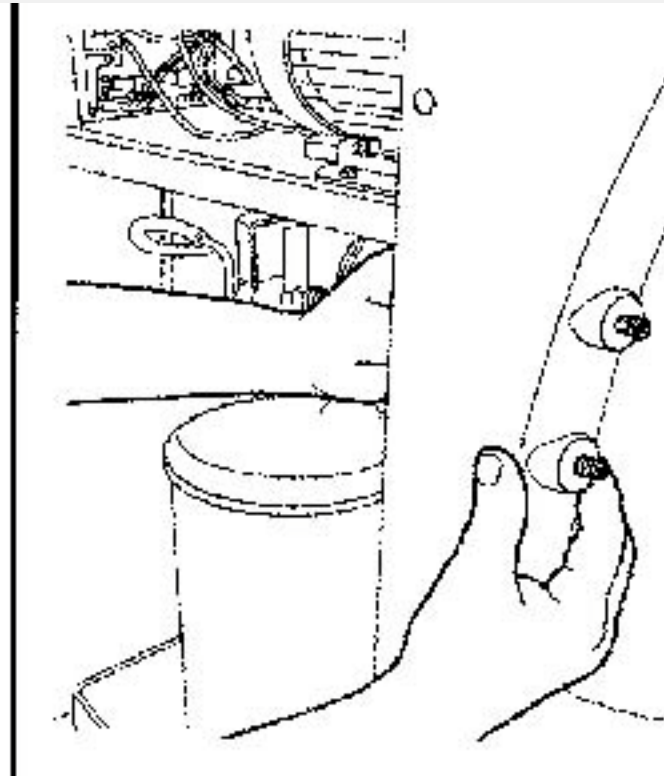
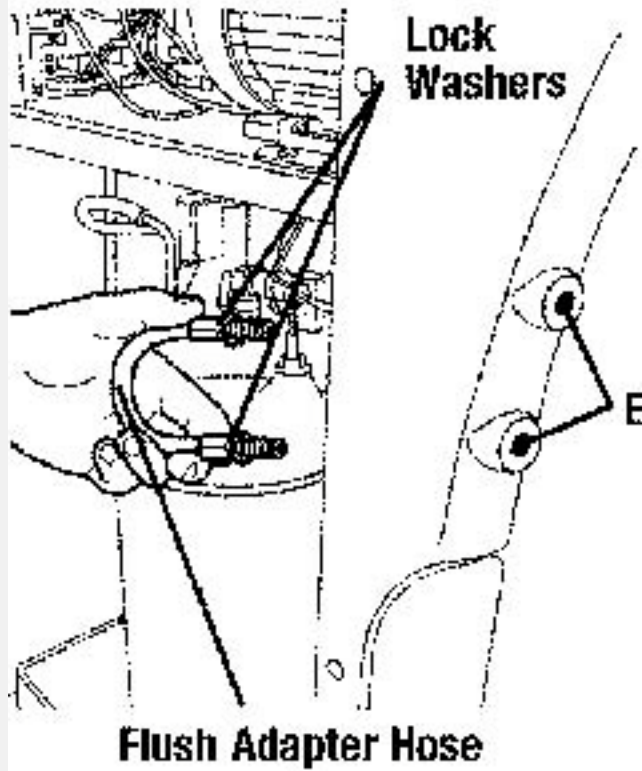
An R/R/R machine that has a built in oil injector which should not be used. It would be too easy to accidentally charge the wrong oil. In addition, flushing lines would be required if you did try and use this on a hybrid.



OIL and your Refrigerant Equipment



Robinair developed a retrofit kit for GM Dealers in order to flush the PAG oil from the machine's internal plumbing and hoses.



OIL and your Refrigerant Equipment



- From MACS:

A New SAE Standard, J2297H, Which Will Cover
Dyes For Electrically Driven Compressors,
Is Currently Being Drafted –
It Will Specify Unique Features
That Will Assure That Any Dye That Meets It,
And That Dye's Delivery System,
Will Be Safe For Use In A/C Systems
That Use Electrically Driven Compressors

OIL and your Refrigerant Equipment

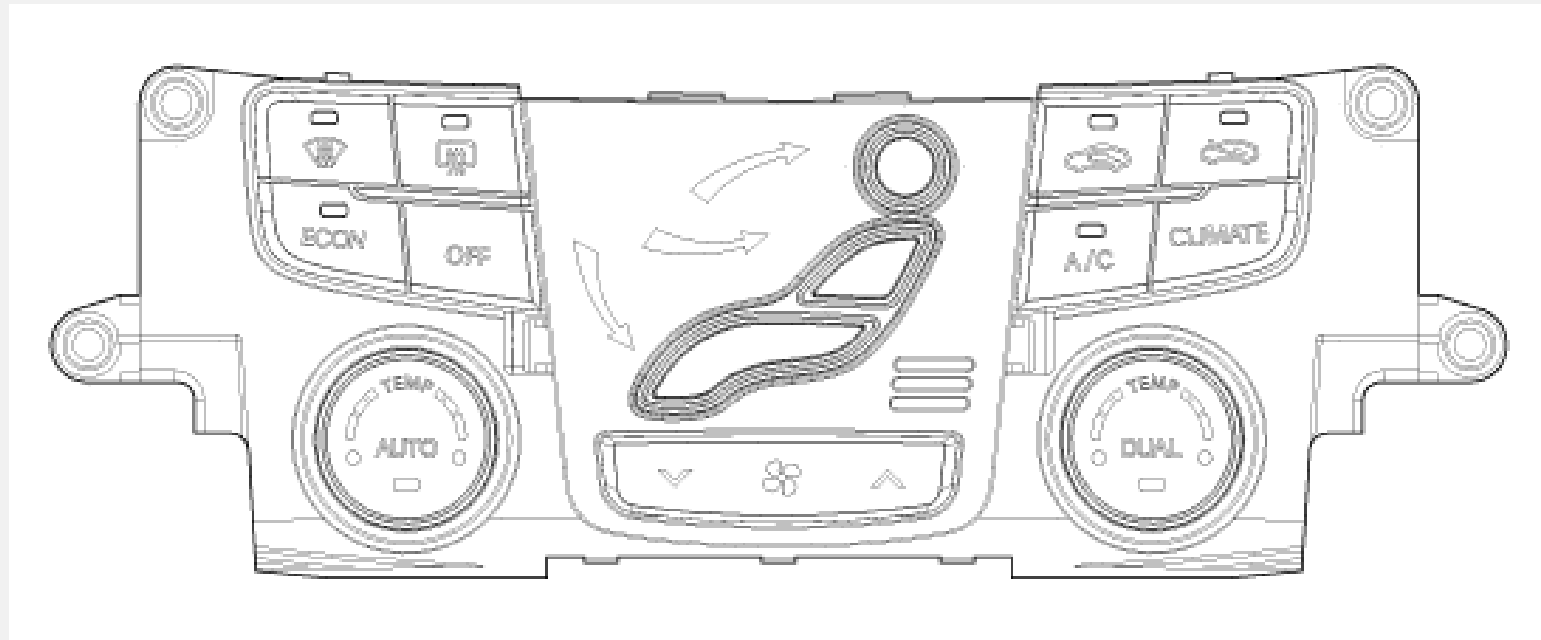


- Even though an SAE standard dye may be available for POE oil, Toyota and Honda have never approved the use of dye in any of their A/C systems
- From the 2011 Fusion Manual: For hybrid vehicles equipped with an electric compressor, additional refrigerant system dye should only be added by installing a new receiver/drier cartridge. Replacement receiver/drier cartridges include a fluorescent dye "wafer" which will dissolve after approximately one hour of continued A/C operation. Fluorescent refrigerant system dye mixed with PAG oil should never be used in hybrid vehicles with an electric A/C compressor.

Hyundai Sonata Hybrid



PVE (Polyvinylether) OIL :
105 ~ 125 cc (3.7 ~ 4.4 OZ.)



Toyota Systems



Toyota Highlander/Camry



- These two systems are very similar
 - Some sensors that would be on a typical vehicle
 - Humidity Sensor
 - Windshield Solar Sensor (for temp and humidity)
 - A 288v DC scroll compressor (internal A/C voltage inverter)
 - An economy button
 - They both require ND-OIL 11
- The rest of the components are very similar to a standard A/C system

Toyota Highlander



Toyota Highlander



n **Selecting Eco Driving Mode**

Use Eco Driving Mode to help achieve low fuel consumption driving trips that involve frequent accelerating and braking.



On/off

When Eco Driving Mode is turned on, the “ECON” indicator will come on.

Press the switch once more to cancel the Eco Driving Mode.

Eco Driving Mode helps you to drive within the variable economy zone. (→P. 171)

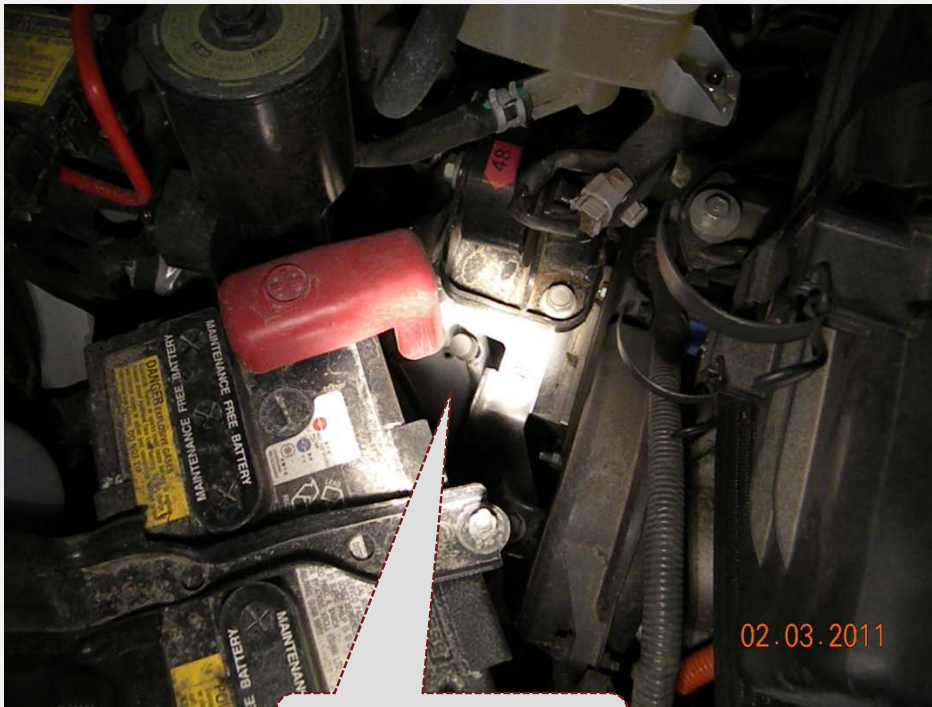
Toyota Highlander



Humidity
Sensor

02.03.2011

Toyota Highlander

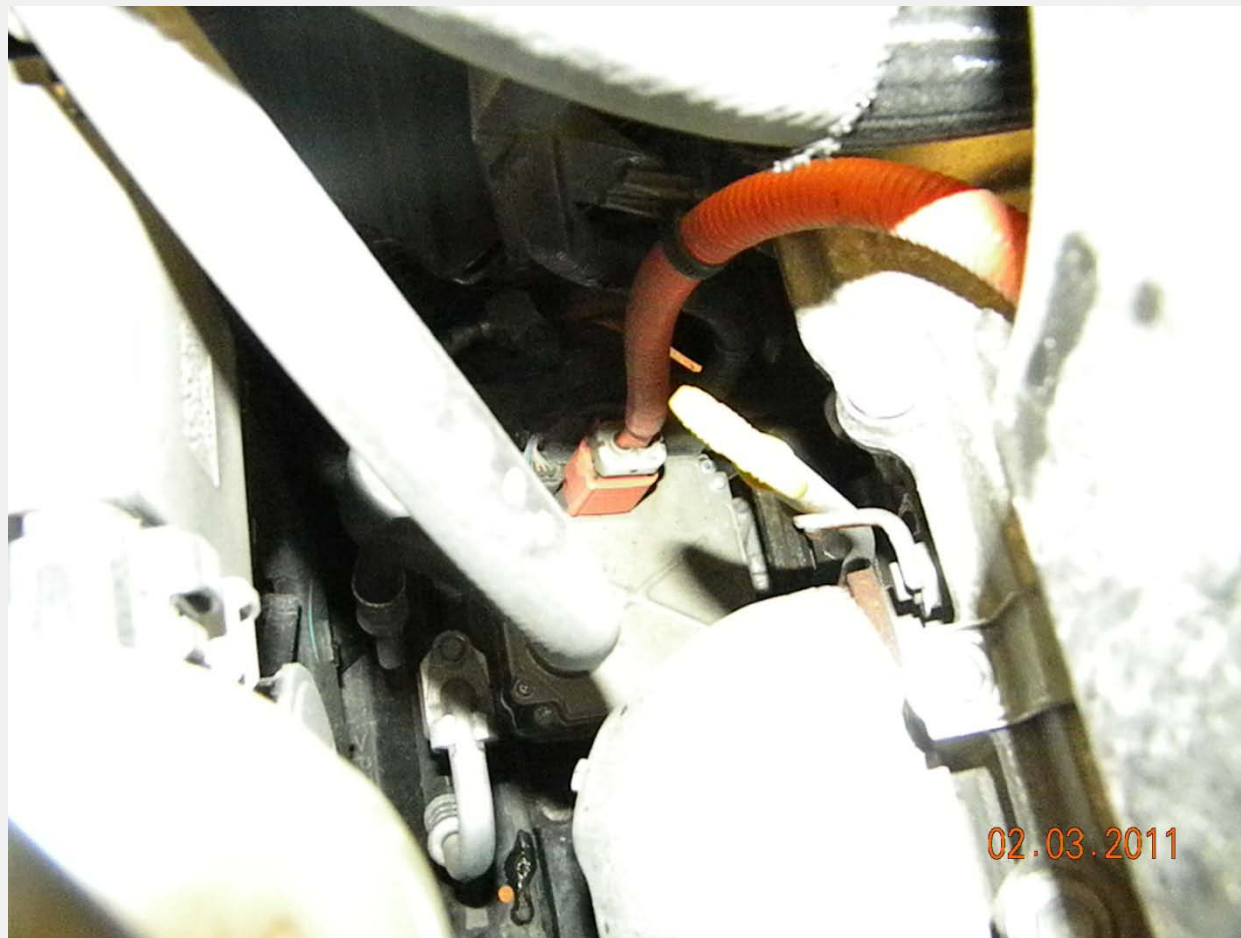


A/C Fitting

Toyota Highlander



Front of
Vehicle



Toyota Camry



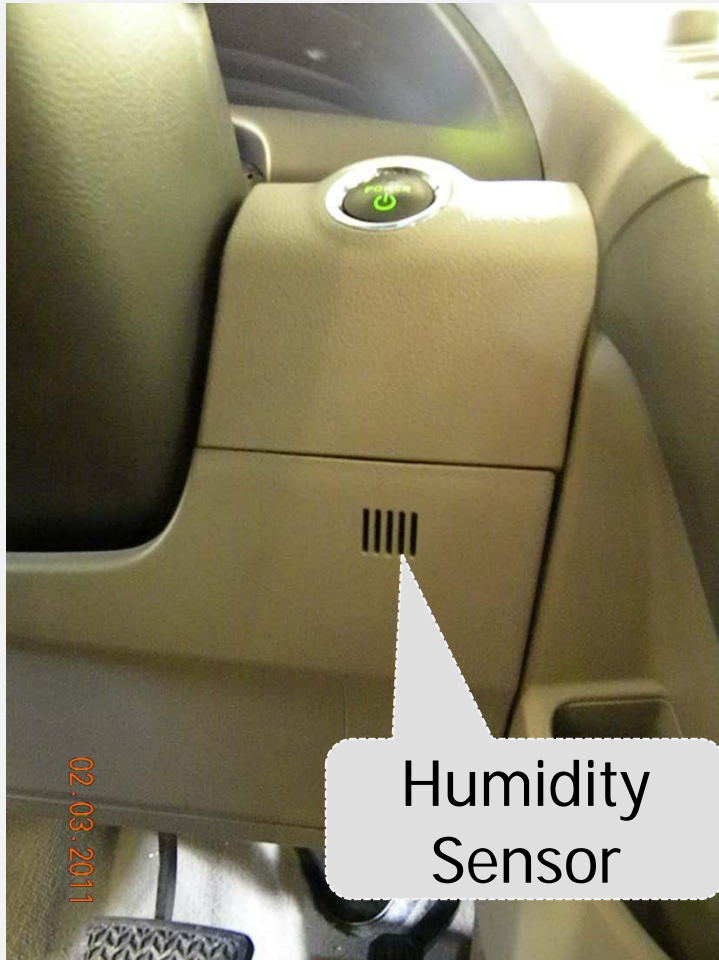
Plasmacluster: is an ion generator which cleans the cabin air by emitting positive and negative ions.

This is a high voltage device and should be serviced as a unit. Do not attempt to clean this with any spray cleaners.



This device may make a quiet whining noise when in operation

Toyota Camry



Toyota Camry



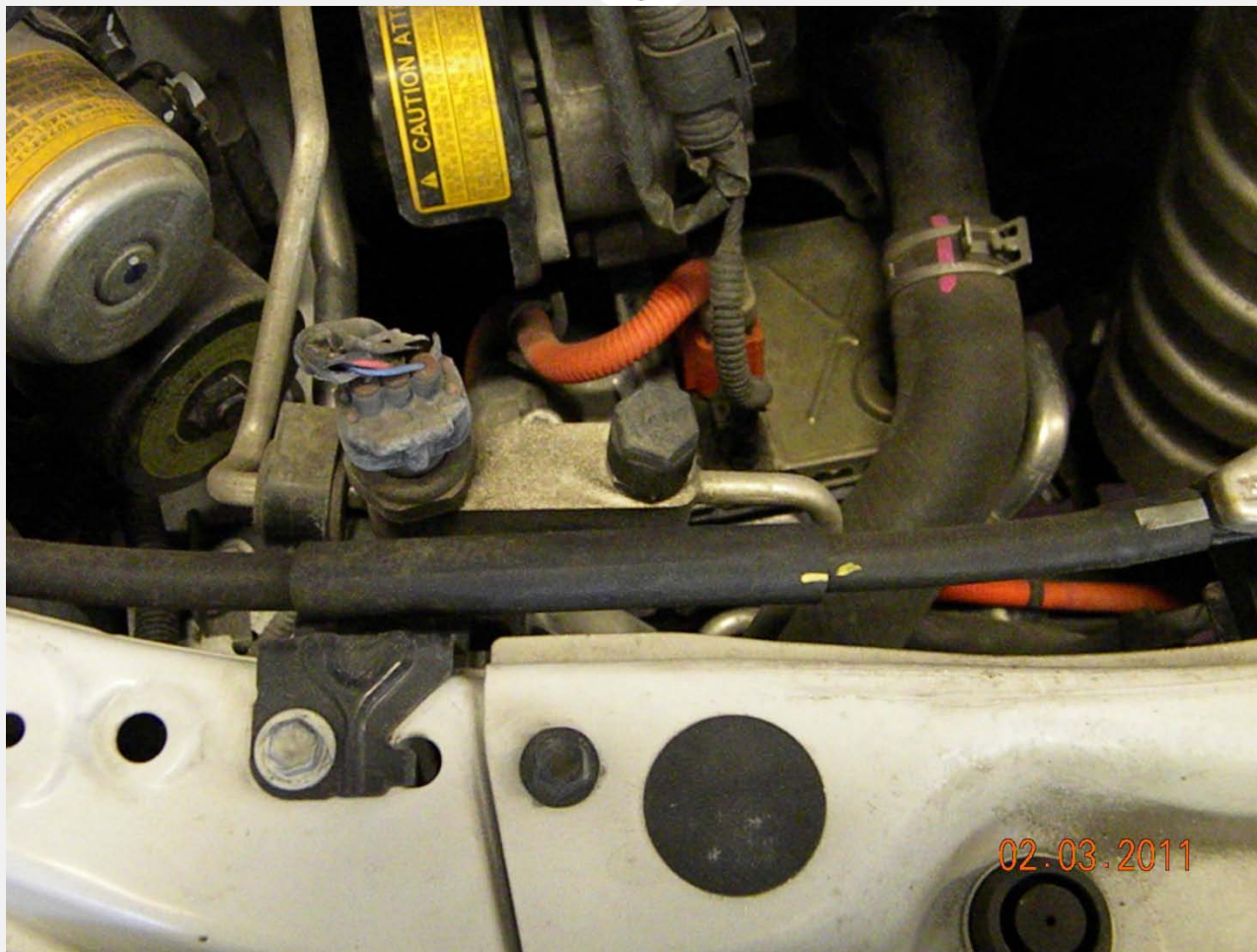
- **“ECO HEAT/COOL” switch**

“ECO HEAT/COOL” mode enables the air conditioning to be operated at a reduced capacity in order to limit use of the hybrid battery (traction battery). The effectiveness of the air conditioning will be lower than normal.

- **On/off**

When “ECO HEAT/COOL” mode is turned on, the switch indicator will come on and the “ECO” indicator will appear on the air conditioning display.

Toyota Camry



Toyota Prius



Plasmacluster similar to Camry



Toyota Prius



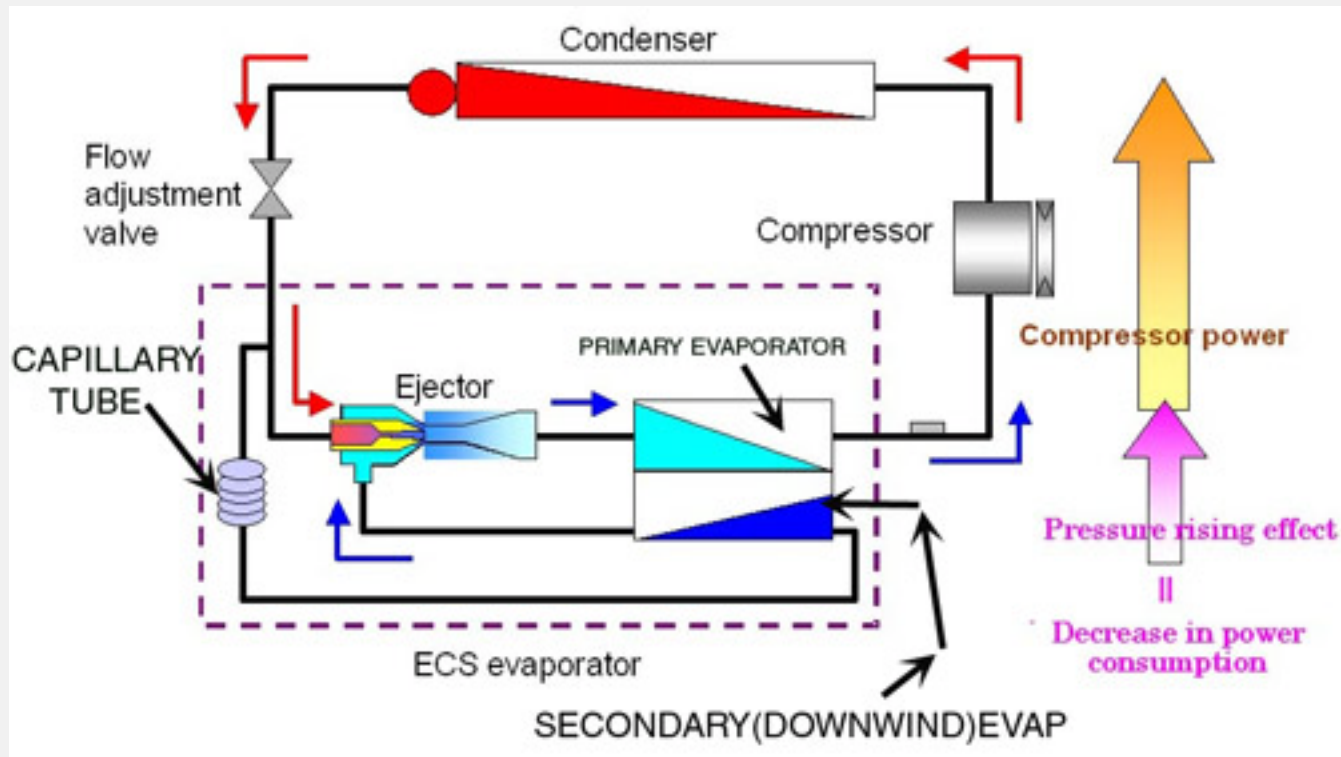
Compressor endview



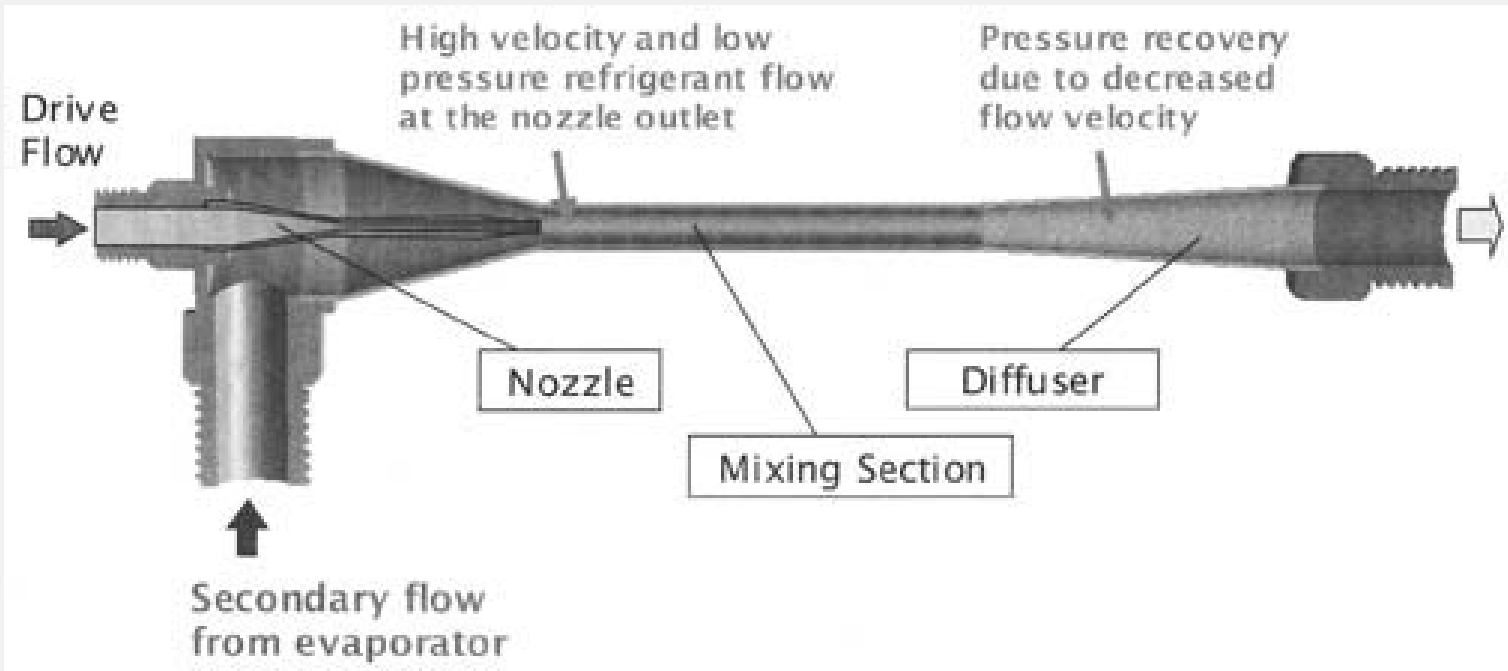
Toyota Prius



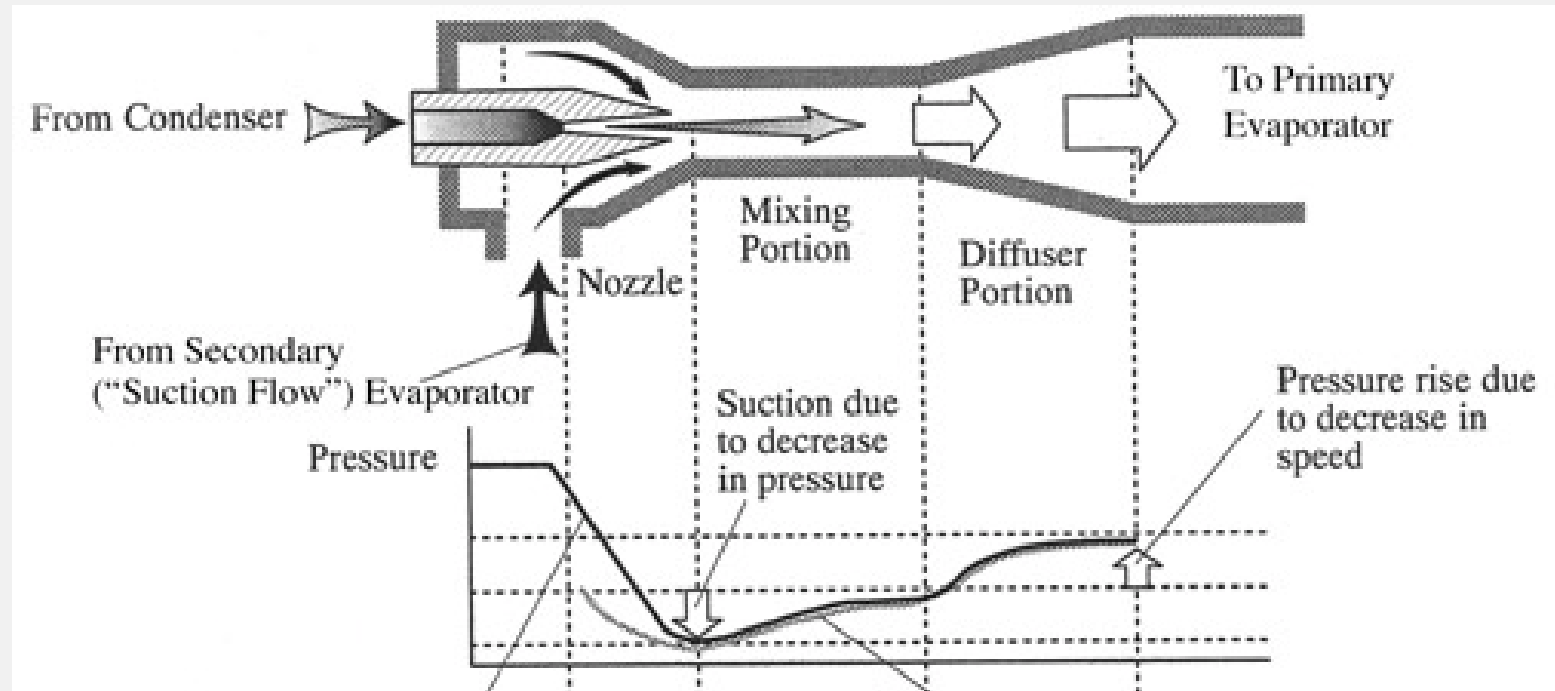
An Ejector system on a 2010 Prius



Toyota Prius



Toyota Prius



Similar to a pressure washer wand with a soap hose attachment

Toyota Prius



A partial cutaway of a 2010 Prius evaporator.

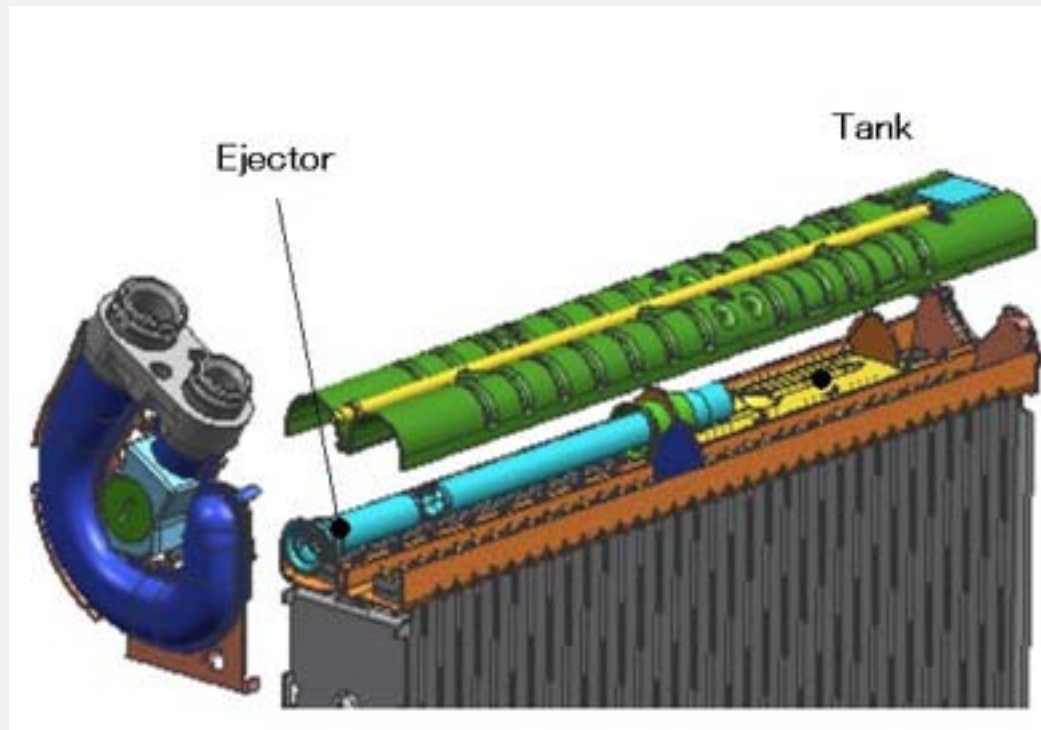
Notice it is split in 2 sections , and with the cutaway you can see the ejector and the capillary tube.



Toyota Prius



End view of the evaporator to show the ejector



Toyota Prius



- MICRO DUST AND POLLEN FILTER MODE CONTROL
- (a) When the micro dust and pollen filter mode switch is pressed, the micro dust and pollen filter mode control is activated.
- (b) Then, the air vent is switched to FACE mode and recirculated pollen-free air flows in the area around the upper part of the bodies of the driver and front passenger.
- (c) When the micro dust and pollen filter mode switch signal is input to the A/C amplifier, the A/C amplifier controls the compressor with motor assembly, air inlet control servo motor, air outlet control servo motor and blower motor as shown in the timing chart below.
- (d) This control usually operates for approximately 3 minutes. However, when the outside temperature is low (5 C (41 F) maximum), it will operate for approximately 1 minute.
- (e) After this control stops operating, the A/C amplifier controls the air conditioning system using AUTO mode.

Toyota Prius



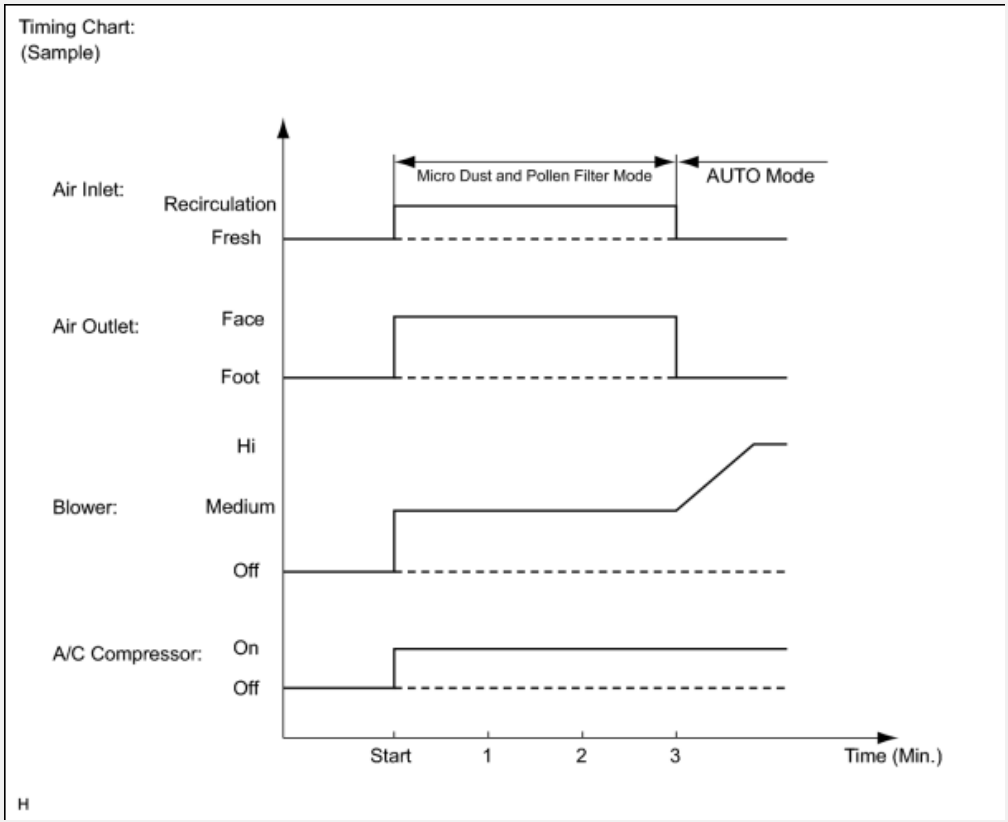
Microdust
and Pollen
Filter Mode



Toyota Prius



Micro Dust and Pollen Filter Mode



Ford Systems



Ford Systems



- The Escape has gone through a variety of changes since it launched.
 - The 2010 Escape now has an electric compressor
- The Ford Escape utilizes a second “zone” for refrigerant to assist in cooling the batteries when necessary. This is similar to a vehicle with rear A/C.

Ford Escape



Example of
a zone valve
on a
2008-2009
system



Ford Escape



2007-2009 ATC Control Head



Notice the term ECON on the lower center button

Ford Escape



2010 ATC Control Head



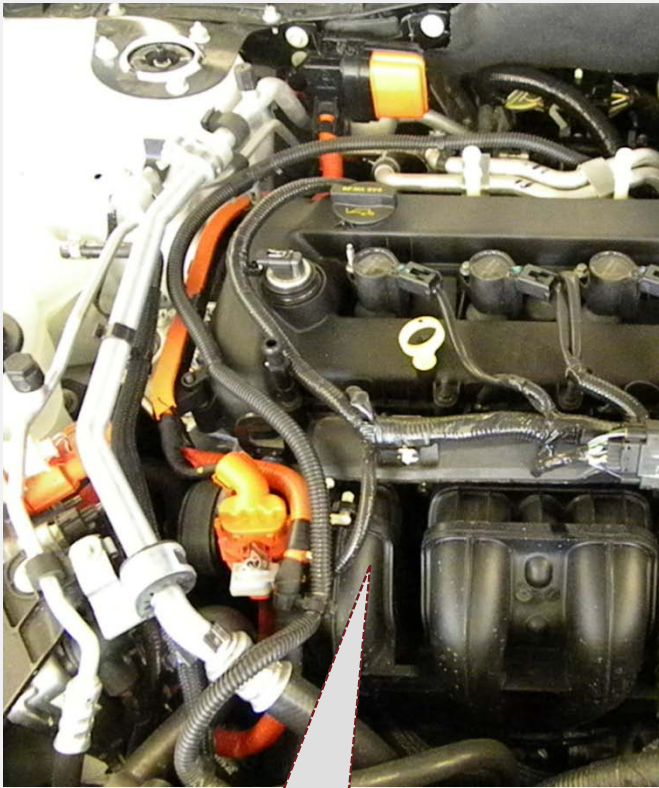
Now the button is labeled MAX A/C

Ford Escape



- **Dual-function pressure switch**
 - One set of contacts is for A/C system high pressure
 - The second set of contacts are used for an input to the PCM, when the pressure reaches a set limit the PCM will activate the high speed cooling fan

Ford Fusion/Escape



Fusion

Escape



Ford Fusion



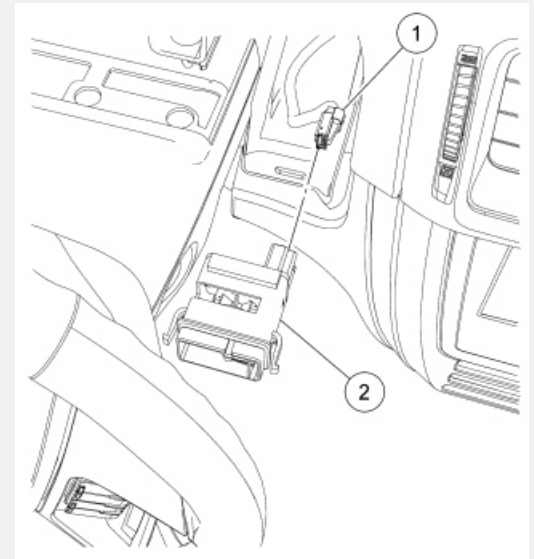
A/C	COMPLIES WITH: SAE CONFORME À LA NORME: J639 CUMPLE CON:	CAUTION: USE ONLY POE REFRIGERANT OIL: ATTENTION : N'UTILISER QUE DE L'HUILE DE RÉFRIGÉRATION POE: PRECAUCIÓN: USE SÓLO ACEITE REFRIGERANTE POE:	MA68EV 3.4 oz (100 cc)
	CHARGE LEVEL: 22 oz CHARGE: (0.64 kg) CARGA DE LLENADO: (1.40 lbs)	DO NOT USE PAG OIL. PAG OIL WILL CAUSE IMMEDIATE COMPRESSOR DAMAGE. NE PAS UTILISER L'HUILE PAG CAR LE COMPRESSEUR SERAIT IMMÉDIATEMENT ENDOMMAGÉ. NO UTILICE ACEITE PAG. ESTE ACEITE CAUSA UN DAÑO INMEDIATO AL COMPRESOR.	
	REFRIGERANT: FRIGORIGÈNE: REFRIGERANTE: R-134A	CAUTION: HIGH PRESSURE SYSTEM TO BE SERVICED ONLY BY QUALIFIED PERSONNEL. ATTENTION : CIRCUIT SOUS HAUTE PRESSION - TECHNICIENS QUALIFÉS SEULEMENT. PRECAUCIÓN: EL SISTEMA DE ALTA PRESIÓN SÓLO DEBE SER REVISADO POR PERSONAL CALIFICADO.	FoMoCo DEARBORN, MICHIGAN

AES-104005-01A

Ford Fusion



Humidity Sensor



Ford Fusion



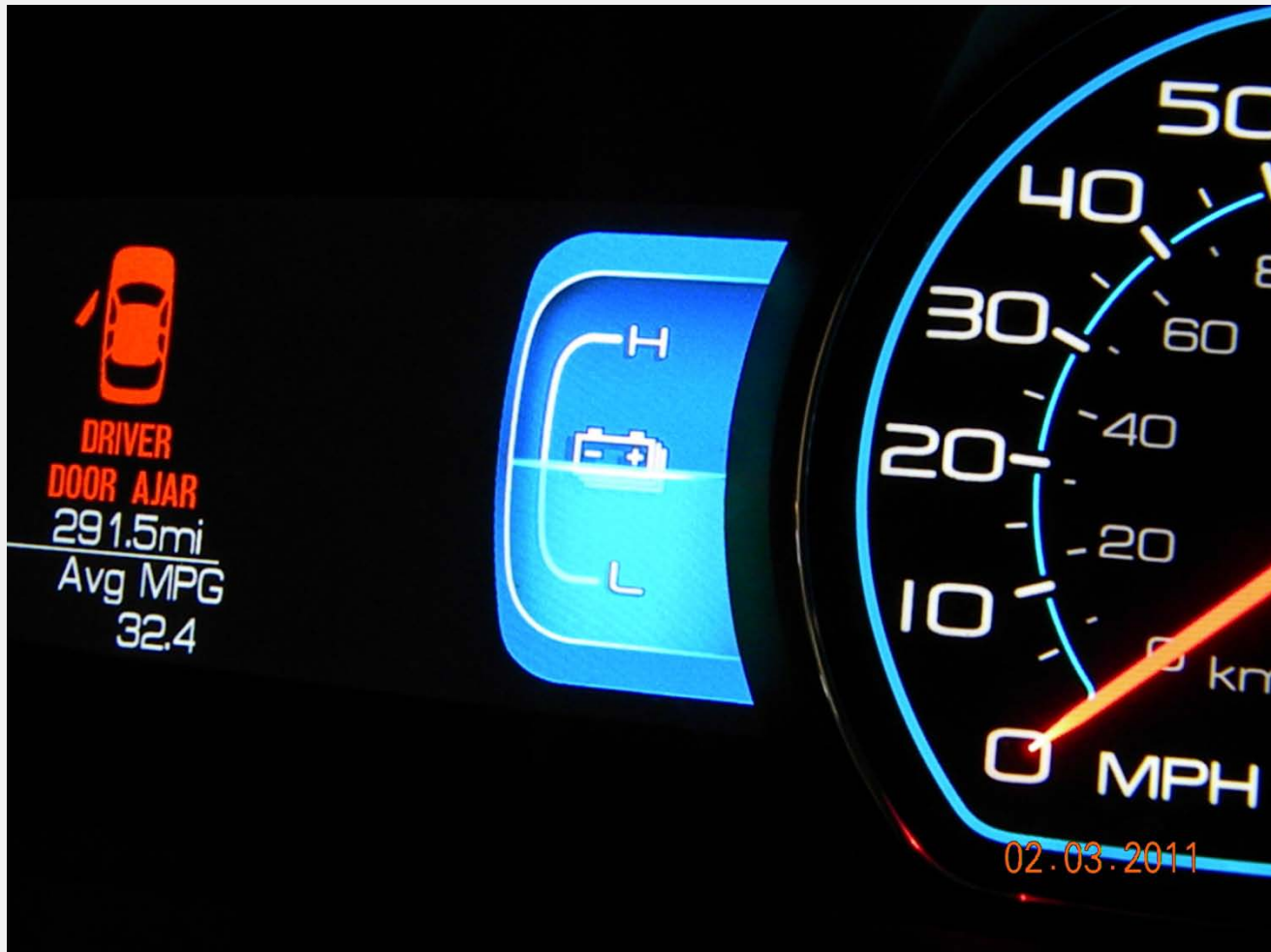
MAX A/C
Button

02.03.2011

Ford Fusion



Ford Fusion



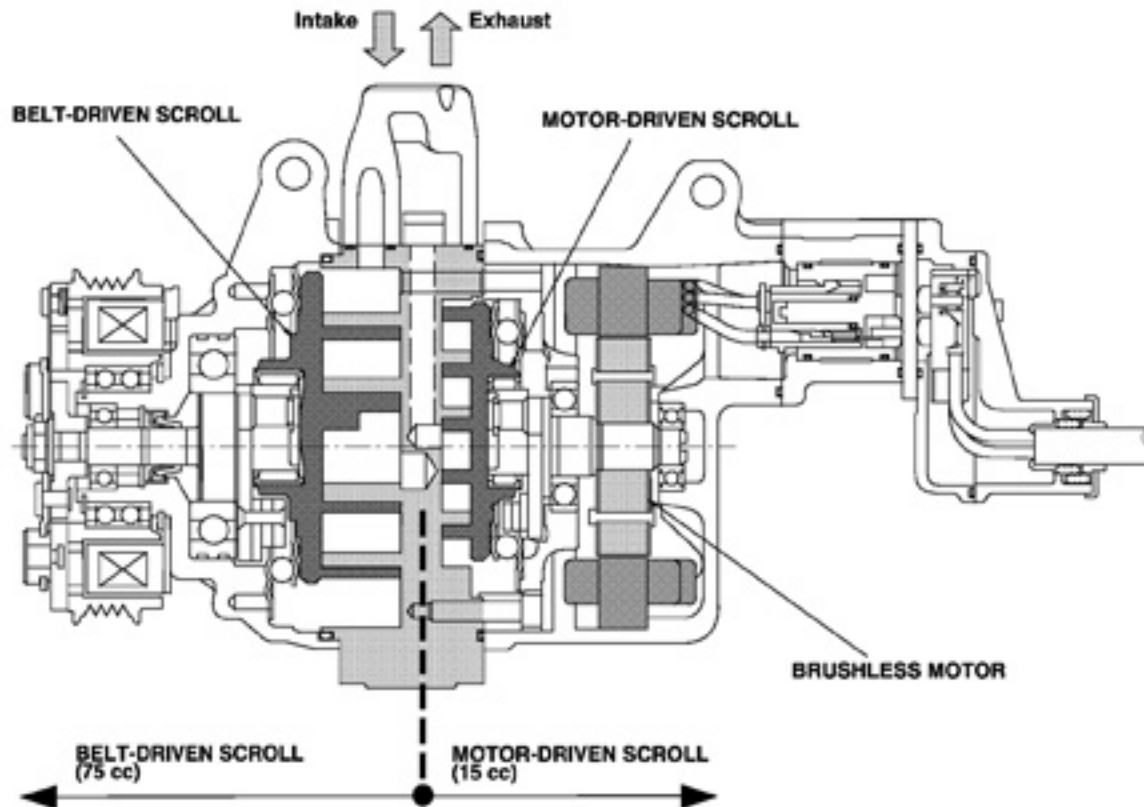
Honda Civic



Honda Civic



Dual Mode Compressor- Belt Driven and Electric Compressor



Honda Civic



If you look at the front of this compressor, you see a belt. But beware, notice the electrical connector on the back.



Hybrid Information



Hybrid Technology is advancing faster
than most of us in the world of
technical instruction can keep up with!

Reference Sites



- www.macsw.org
- Fueleconomy.gov
- www.greencarcongress.com
- <http://www.edmunds.com/ford/escape-hybrid/2010/>
- www.hybridcars.com
- <http://www.sae.org/events/aars/presentations/2004-ishikawa.pdf>
- <http://www.nrdc.org/energy/vehicles/hybrid.asp>

Conclusion



This presentation will be posted at:

<http://opensiuc.lib.siu.edu/>

Google "open SIU"

Questions, Comments: etalley@siu.edu

Prius Additional Information



- EJECTOR CYCLE SYSTEM
- (a) In the conventional refrigerant cycle, liquid refrigerant gas is sent into the evaporator using the expansion valve, generating cold air. However, a rapid decrease in the refrigerant pressure forms swirls, causing energy loss. In this ejector cycle, the energy loss caused by the cooler expansion valve is utilized by the operation of the ejector that injects and expands a high-pressure refrigerant, thus improving energy consumption efficiency.
- (b) The ejector includes nozzle, mixing and diffuser portions.
- (c) A high temperature and pressure liquid refrigerant flowing from the condenser is introduced into the mixing section through the nozzle at high speeds as the nozzle is inwardly tapered. This decreases the refrigerant pressure in the vicinity of the nozzle, introducing low temperature and pressure gaseous refrigerant into the nozzle from the evaporator. Thus, both refrigerants are mixed in the mixing section and are introduced into the diffuser section.
- (d) As the diffuser section is outwardly flared, the refrigerant flow rate in the diffuser decreases and the refrigerant pressure rises.
- (e) Through these operations, the refrigerant pressure in the evaporator on the downwind side can be constantly kept lower than that on the upwind side, creating the lower temperature conditions. Therefore, air cooled by the evaporator on the upwind side can be further cooled by that on the downwind side, thus improving the efficiency of the evaporator.