Motor Vehicle Air Conditioning (MVAC)

System operation and the refrigerant cycle
At Sea level - water boils at 212°F - R-134a boils at -15°F
At Sea level - R-134a boils at -15°F
At 30 psig - R-134a boils at 35°F

The Pressure of the evaporator will control its Temperature
An R134a temperature-pressure chart shows what the refrigerant temperature should be at a specific pressure. This can be helpful in A/C diagnosis.

MVAC systems that are low on refrigerant will have:
Low pressures in Evaporator (low side) and Condenser (high side)

MVAC systems that are overcharges with refrigerant will have:
High pressures in Evaporator (low side) and Condenser (high side)
The correct refrigerant charge ensures maximum heat transfer from the passenger compartment.

<table>
<thead>
<tr>
<th>R134a TEMPERATURE °F (°C)</th>
<th>R134a PRESSURE PSI (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>110 (43)</td>
<td>147 (1012)</td>
</tr>
<tr>
<td>112 (44)</td>
<td>152 (1045)</td>
</tr>
<tr>
<td>114 (46)</td>
<td>157 (1079)</td>
</tr>
<tr>
<td>116 (47)</td>
<td>162 (1112)</td>
</tr>
<tr>
<td>124 (51)</td>
<td>183 (1260)</td>
</tr>
<tr>
<td>126 (52)</td>
<td>188 (1298)</td>
</tr>
<tr>
<td>128 (53)</td>
<td>194 (1337)</td>
</tr>
<tr>
<td>130 (54)</td>
<td>200 (1377)</td>
</tr>
<tr>
<td>135 (57)</td>
<td>215 (1481)</td>
</tr>
<tr>
<td>140 (60)</td>
<td>231 (1590)</td>
</tr>
<tr>
<td>145 (63)</td>
<td>247 (1704)</td>
</tr>
<tr>
<td>150 (66)</td>
<td>264 (1822)</td>
</tr>
</tbody>
</table>

Low charge can freeze the evaporator.

Low charge equals poor heat transfer.

High charge gives poor heat transfer at the evaporator.

<table>
<thead>
<tr>
<th>TEMPERATURE °F (°C)</th>
<th>PRESSURE PSI (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 (-6)</td>
<td>19 (134)</td>
</tr>
<tr>
<td>24 (-4)</td>
<td>21 (144)</td>
</tr>
<tr>
<td>26 (-3)</td>
<td>22 (155)</td>
</tr>
<tr>
<td>28 (-2)</td>
<td>24 (166)</td>
</tr>
<tr>
<td>30 (-1)</td>
<td>26 (177)</td>
</tr>
<tr>
<td>32 (0)</td>
<td>27 (188)</td>
</tr>
<tr>
<td>34 (1)</td>
<td>29 (200)</td>
</tr>
<tr>
<td>36 (2)</td>
<td>31 (212)</td>
</tr>
<tr>
<td>38 (3)</td>
<td>33 (225)</td>
</tr>
<tr>
<td>40 (4)</td>
<td>35 (238)</td>
</tr>
<tr>
<td>42 (5)</td>
<td>37 (252)</td>
</tr>
<tr>
<td>44 (6)</td>
<td>39 (266)</td>
</tr>
<tr>
<td>46 (7)</td>
<td>40 (272)</td>
</tr>
<tr>
<td>48 (8)</td>
<td>42 (285)</td>
</tr>
<tr>
<td>50 (10)</td>
<td>45 (310)</td>
</tr>
<tr>
<td>52 (12)</td>
<td>47 (331)</td>
</tr>
<tr>
<td>54 (14)</td>
<td>49 (352)</td>
</tr>
<tr>
<td>56 (16)</td>
<td>51 (372)</td>
</tr>
<tr>
<td>58 (18)</td>
<td>53 (393)</td>
</tr>
</tbody>
</table>

EVAPORATOR RANGE
Absorbing latent heat turns liquid to vapor

Releasing latent heat turns vapor to liquid
2 types of MVAC systems

All A/C systems use a compressor, condenser, evaporator

Some systems use the **Expansion Valve** with **Receiver/Drier**

Some systems use the **Fixed Orifice Tube** with **Accumulator**
Receiver-Drier

send high pressure liquid to expansion valve
Receiver Drier will separate liquid from vapor refrigerant

Receiver Drier will send liquid refrigerant (high pressure) to the expansion valve

Receiver drier will have desiccant bag.

Some desiccant bags can be changed

Other designs require component replacement

Only older R-12 systems use the sight glass

Vaporized refrigerant collects at top of receiver

Liquid refrigerant sinks to bottom and is sent to expansion valve
Expansion valve CLOSES when evaporator is too COLD
Expansion valve OPENS then evaporator is too WARM
Expansion Valves sense evaporator pressure and will open or close to maintain ideal pressure/temperature.
Receiver - Drier

- Stores liquid refrigerant to supply the expansion valve
- Filters dirt and debris from the system to prevent its circulation.
- Desiccant removes moisture left in system due to improper service.
Integrated Receiver-Drier

Separate Receiver-Drier (Older Vehicles)
Some systems use a fixed orifice tube and Accumulator
Accumulator

Sends low pressure Vapor to compressor

Used with Orifice Tube
Accumulator will separate liquid from vapor refrigerant

Accumulator will send Vapor refrigerant (low pressure) to the compressor

Accumulator will have desiccant bag.

Some desiccants can be changed, other designs require component replacement

Vaporized refrigerant collects at top of receiver and only low pressure vapor is returned to compressor
Fixed Orifice Tube
Many different types of compressors are used
Most compressors use an electric clutch to cycle compressor ON and OFF to maintain proper evaporator pressure.
Some compressors will not cycle ON/OFF and will vary the piston stroke to maintain evaporator pressure.
Most Clutches are checked using a feeler gauge.
Any time you replace a compressor or clutch, the clearance must be checked.

Loose clearance will cause clutch to make noise, slip, and overheat.

Tight clearance can cause the clutch to stay mechanically engaged

This will raise pressure too high and may cause the pressure relief valve to open.

Most Clutches are checked using a feeler gauge.

Shims available in several thicknesses to adjust the clearance.
A/C Compressors require lubricating oil carried by the refrigerant. Refrigerant oil specifications vary between A/C compressor designs and manufacturers.

Always look up and use the correct oil for your system.

The oil type can be identified by a tag located on the compressor body or in the service manual.
Using the wrong type of compressor oil may cause excessive noise and shorten the A/C compressor’s life.

Refrigerant oil can damage the vehicle’s paint!

Wash off any spilled oil immediately. (wiping up spill will press oil into paint and NOT protect the vehicle)

An open oil can absorb moisture. Keep any remaining oil tightly sealed.
Component Replacement

Completely discharge/recover ALL refrigerant BEFORE opening any line

Tightly plug any open line or component IMMEDIATELY (Moisture will immediately begin to contaminate system when opened)

Use clean refrigerant oil (proper type) to lubricate any O-Rings

O-rings are not interchangeable with other types of O-Ring (such as fuel injector O-Rings)
Component Replacement

The receiver drier’s desiccant only holds a couple tablespoons of moisture.

The Accumulator desiccant only holds a couple tablespoons of moisture.

Replace the desiccant if the system was left open to the air for more than a few hours, such as after collision damage, or older systems that have leaked out all the refrigerant.

Check for contamination (use cotton swab) before deciding to make minor repairs on damaged or older systems.
Hybrid Vehicle A/C system precautions

• Many hybrid vehicles use high voltage to operate the compressor

• Do Not disconnect or work around Orange wiring until you have been properly trained.
Diagnose the HVAC air handling system

Poor Heating or Cooling can be caused by the Heater/Evaporator air handling box.

Often called the Evaporator Housing or Heater Core Housing

Air doors are operated by:
  - Cables
  - Vacuum Motors
  - Electric Motors

Look, listen, feel, for changes in air flow as doors are moved
Air doors control:

Temperature **(Blend Door)**

Fresh or Recirculate Air

**Mode Doors** – Defrost, Floor, Panel
Air Door Quiz
Proper air flow through Evaporator and Condenser is critical for proper cooling.

**EVAPORATOR** air flow  
Check to make sure the Blend Air door is operating.

Check Cabin air filter and any intake air restriction  
(usually leaves building up at base of windshield)

**CONDENSER** air flow  
Check for bent fins or dirt, bugs leaves in front of evaporator

Check to make sure cooling fan is operating
Pressure Testing Refrigerant

Move gauge or recovery valves fully counter clockwise (OFF position) to prevent refrigerant discharge when you connect or disconnect couplers.
With proper charged\ and vehicle cold, the gauges should read close to 70 psi with a 70 degree ambient temperature.
Compare Ambient temperature to Static Charge pressure

### R134a Temperature-Pressure

<table>
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<th>TEMPERATURE</th>
<th>PRESSURE</th>
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<tbody>
<tr>
<td>°F (°C)</td>
<td>PSI (kPa)</td>
</tr>
<tr>
<td>60 (16)</td>
<td>57 (392)</td>
</tr>
<tr>
<td>65 (18)</td>
<td>64 (438)</td>
</tr>
<tr>
<td>70 (21)</td>
<td>71 (487)</td>
</tr>
<tr>
<td>75 (24)</td>
<td>78 (540)</td>
</tr>
<tr>
<td>80 (27)</td>
<td>88 (609)</td>
</tr>
<tr>
<td>85 (30)</td>
<td>95 (655)</td>
</tr>
</tbody>
</table>
Static pressure significantly higher than the chart indicates contaminated refrigerant, too much refrigerant, or air in the system.
If static pressure is below about 30 psi the A/C pressure switch or sensor will prevent A/C compressor operation. (check for leaks)

Tech Note
Never rely on static pressure readings as your only indication of the A/C system's state of charge.
What does the Blower Motor do? How does it get Power and Ground?
High resistance in the ground = low blower motor speed
Low resistance in the ground = high blower motor speed
What does the Compressor Clutch do?
How does it get Power and Ground?