Evacuation: Automotive Air Conditioning Systems

The main purpose of evacuating an automotive air conditioning system is to remove moisture and non-condensables which include air and nitrogen from the pipework and components.

Non-condensables in the system will cause high discharge pressures and therefore inefficient operation.

Moisture in the system will be picked up by the refrigerant and form ice crystals at the expansion device, resulting in a restriction or blockage until it warms up, melts and allows the refrigerant to flow again. This results in intermittent operation of the system. Moisture mixed with refrigerant creates an acid which results in corrosion of steel and to a lesser extent copper and brass. When this acid mixes with refrigerant oil, fine beads of sludge are formed, which reduces the lubricating ability of the oil and blocks fine strainers and expansion devices.

Therefore, it is vital to ensure that all non-condensables and moisture are removed from air conditioning systems by evacuating the system using a high vacuum pump, before the refrigerant charge is added. Evacuation lowers the pressure in the system so any moisture will boil off and the resulting water vapour and non-condensables will be removed. Refer to the table below to see the effect of lowering pressure on the boiling temperature of water.

For example, at normal atmospheric pressure, water boils at 100ºC, but when the pressure is reduced to 17,300 microns (-99 kPa gauge) water will boil at 20ºC.

Boiling Temperature of Water at Given Pressures		
Temperature ºC	**Gauge Pressure kPa**	**Microns of Mercury**
100	0	759,968
90	-31.3	525,526
80	-54.0	355,092
70	-70.1	233,680
60	-81.4	149,352
50	**-89.0**	**92,456**
40	-94.0	55,118
30	-97.0	31,750
20	-99.0	17,300
10	-100.0	9,279
0	-100.7	4,572
-10	-101.015	2,315
-20	-101.185	1,065
-29	**-101.255**	**500**
-30	-101.265	460
-40	-101.305	185
-50	-101.315	68
-60	-101.320	23
-70	-101.323	7

What pressure must the system be evacuated to?

The Australian Automotive Code of Practice 2008 – Control of Refrigerant Gases During Manufacture, Installation, Servicing or De-Commissioning of Motor Vehicle Air Conditioners, which is called up in the Ozone Protection and Synthetic Greenhouse Gas Management Regulations 1995, states the following in Section A.18 Evacuation and Re-gassing Process:

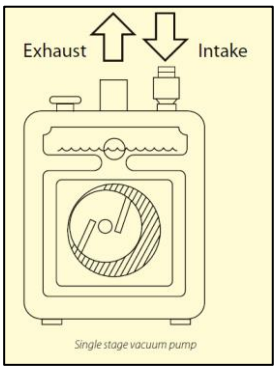
- A.18.2 The equipment must be capable of ensuring the evacuation of air and moisture from the system being serviced, by reducing the system to a gauge pressure of minus 90 kPa, or below. The vacuum pump should operate for a minimum time of 30 minutes before isolating the system.
- A.18.3 The system pressure should be checked one minute after isolating from the vacuum pump and re-checked 5 minutes later. A rise in excess of 2 KPa (15mm Hg) indicates a leak or moisture in the system. The fault must be rectified.

However, a vacuum of only minus 90 kPa is not low enough to enable any moisture in the system to boil off. Per the Boiling Temperature of Water at Given Pressures table, a vacuum of minus 99 kPa (17,400 microns of mercury) is required to enable any water to boil off at 20^{o}C. Therefore, to remove moisture from the system, it must be evacuated to achieve a vacuum of at least minus 99 kPa absolute (17,400 microns) and the vacuum must not rise more than 2 kPa (14,000 microns) in 5 minutes (ideally 30 minutes) once the vacuum pump is isolated from the system and turned off. The vacuum must be measured with an electronic vacuum gauge, not manifold gauges as they are not accurate enough to measure the required vacuum.

What type of vacuum pump should be used?

The 2 main types of high vacuum pumps used in the field during installation and service work are:

1. Single Stage Vacuum Pumps

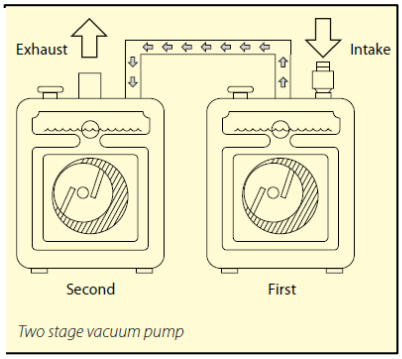


Single stage high vacuum pumps are smaller, lighter in weight and less expensive than two-stage pumps of equal capacity in L/min.

There are single stage vacuum pumps available which can pull down to about 50 microns under ideal laboratory conditions, but this is not achievable in the field as they discharge directly into the atmosphere.

A gas ballast feature helps single stage pumps to keep the oil free of moisture and other contaminants for a longer period of time than similar units without. Most single stage pumps with the gas ballast open will pull down to about 1000 microns. Once this vacuum is achieved the gas ballast can be closed to achieve a lower vacuum.

2. Two Stage Vacuum Pumps



Two stage vacuum pump

Most refrigeration/air conditioning service technicians use a two-stage high-vacuum pump for the bulk of their service jobs as they can achieve a lower vacuum in less time. The exhaust of the first pumping stage is discharged into the intake of the second pumping stage, rather than to atmospheric pressure.

Two-stage high-vacuum pumps with a gas ballast can continuously pull down to 20 microns for prolonged periods of time which will help to ensure that all moisture and non-condensables are removed from a system.

To ensure the required vacuums are achieved by the vacuum pump, regular maintenance including oil changes must be performed as moisture from the system will condense into the pump's oil. If it is allowed to remain inside the pump, this moisture will attack the metal components and result in lock ups or loss of efficiency and/or capacity.

The Australian Automotive Code of Practice 2008, states in Section 5 Equipment:

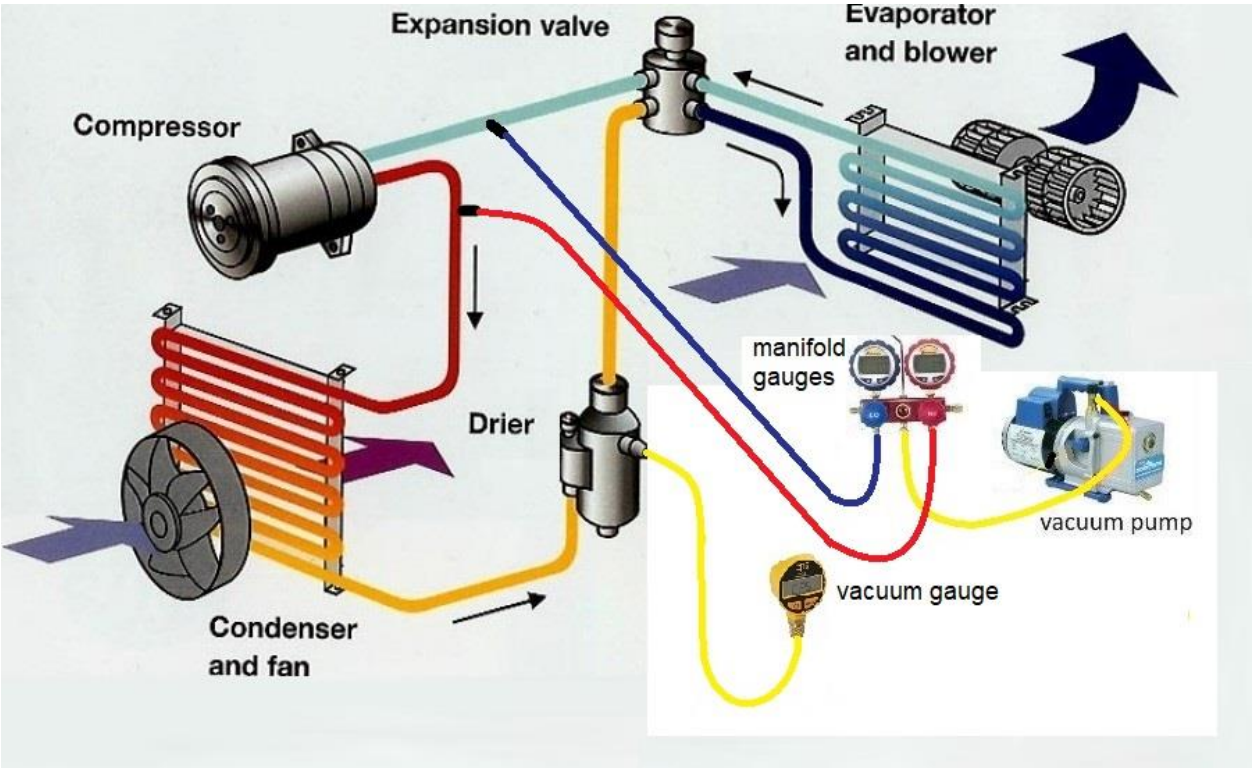
- A.5.4 Vacuum pump oil should be changed either in accordance with the manufacturer's instructions or at regular intervals

How must the vacuum be measured?

Manifold gauges are not accurate enough to measure the required vacuum. The level of vacuum must be measured with an electronic vacuum gauge as they are specifically designed for use with high vacuum pumps and can be accurately read as low as 1 micron. The output can be a digital display or LED sequence display per the examples below.

Where must the vacuum be measured?

When reading vacuum, the closer to the vacuum pump, the lower will be the reading, so the vacuum gauge should be fitted as far away from the pump as possible to accurately measure the vacuum in the system, not at the pump per the example below.



When reading the vacuum created in the air conditioning system, isolate the vacuum pump using an isolation valve and allow the pressure in the system time to stablise before taking a final reading.

If the vacuum pressure continues to rise, it is an indication of a leak. If it does stablise at a pressure which is too high, it is an indication of moisture and more pumping time is required.

SUMMARY

- The main purpose of evacuating an air conditioning system is to remove moisture and non-condensables from the pipework and components by lowering the pressure to enable water to boil off at ambient temperature.
- The system must be evacuated using to achieve a vacuum of at least -99 kPa (17,400 microns of mercury) and the vacuum must not rise more than 2 kPa (14,000 microns of mercury) in 5 minutes once the vacuum pump is isolated from the system and turned off.
- The vacuum must be measured with an electronic vacuum gauge, not manifold gauges as they are not accurate enough to measure the required vacuum.

- The vacuum pump must be rated as suitable for the class of refrigerant, have an appropriate capacity for the system and be serviced per manufactures instructions to ensure its effective operation.
- Two-stage vacuum pumps with a gas ballast can achieve lower vacuums than single stage vacuum pumps.
- The vacuum gauge should be fitted to the system as far away from the pump as possible to accurately measure the vacuum in the system, not at the pump.
- The oil in vacuum pumps must be changed regularly as moisture from the system will condense into it and reduce the pump's efficiency.