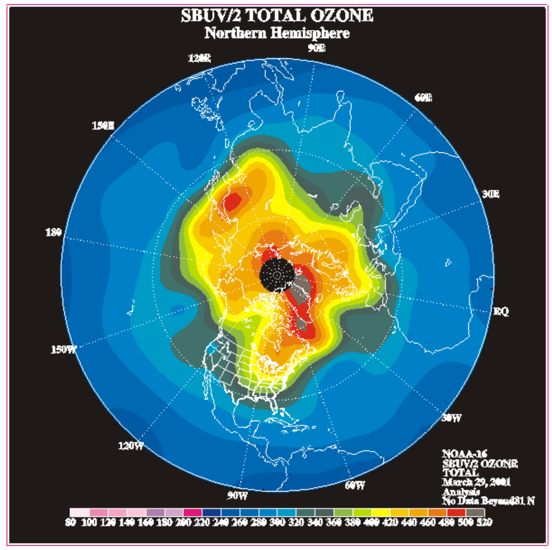
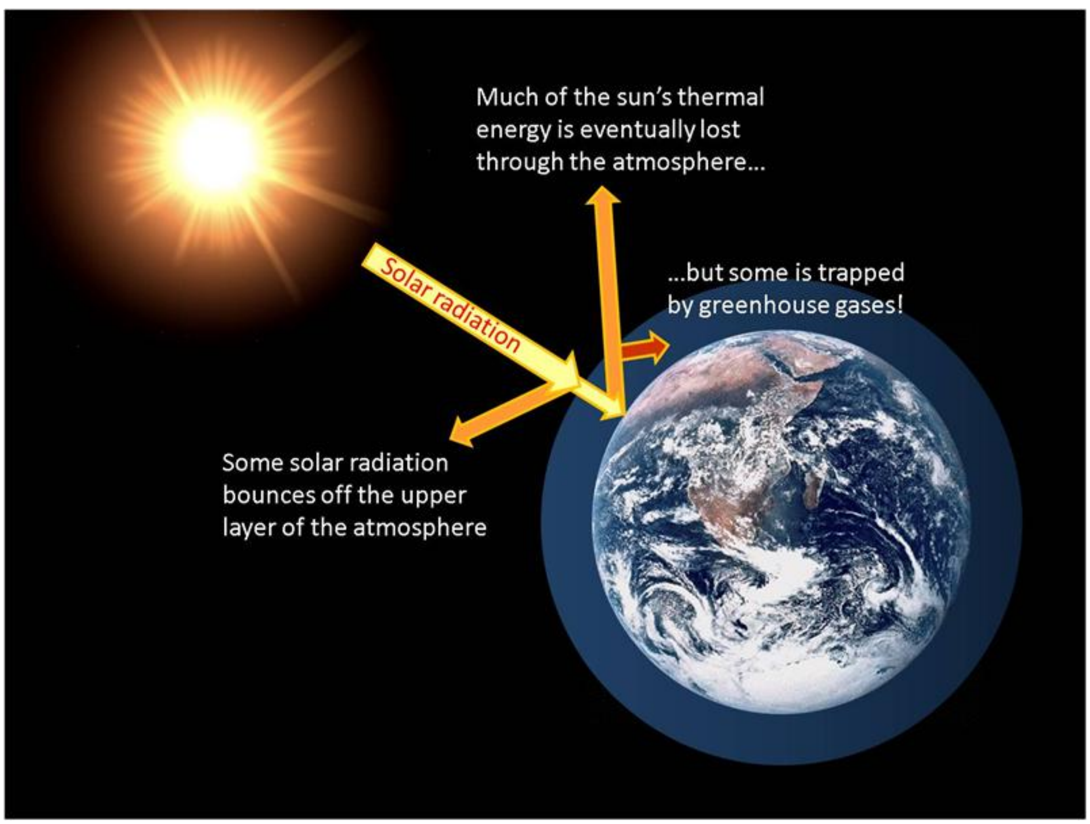
Introduction to Air Conditioning

Environmental Impact Ozone Layer



- Ozone is a protective layer about 15 miles above the earth that absorbs some of the sun's ultraviolet rays.
- Ozone depletion is the destruction of Ozone by the breakdown of certain compounds.
- R12 is a Chlorofluorocarbon (CFC) which destroys Ozone molecules.
- The alternative refrigerant R134a is a HFC (Hydrofluorocarbon) which contributes to the greenhouse effect.

Environmental Effect of Greenhouse Effect



The greenhouse effect is the warming of the earth's atmosphere attributed to a build up of greenhouse gases.

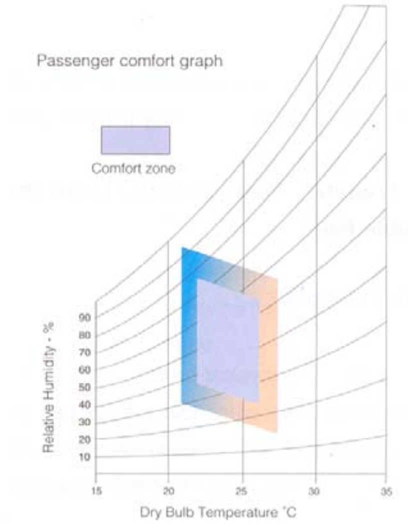
Kyoto Protocol

- The Kyoto Protocol agreed in 1997 was designed to address the greenhouse effect and countries agreed to targets that will reduce overall emissions of greenhouse gases.

- EC regulation 842/2006 objective is to contain, prevent and thereby reduce emissions of HFC'S covered by the Kyoto Protocol.

- The regulation calls for a minimum refrigerant handling qualification for those servicing/repairing air conditioning systems.

Why Air Conditioning?



The average person, sitting at rest, feels comfortable when the surrounding air temperature is 22°C - 26°C, and the relative humidity is 45% - 55%. The "comfort zone" is shown in the adjacent graph.

It is easy to understand that a passenger in and enclosed motor vehicle can sometimes feel uncomfortably hot and sticky due to warm sunshine, high humidity or heat from the engine and other surrounding vehicles in a traffic jam.

What is Air Conditioning?

Air Conditioning is a means of creating and maintaining comfortable conditions within the vehicle. The Air Conditioning system is operational when the engine is running, but functions independently of vehicle speed. It is only possible to "produce cold", i.e., cool a substance, by removing heat from it. The air conditioning system transfers the heat from inside the vehicle to the outside, thus reducing the temperature within.

To accomplish this task the basic natural laws concerning heat, temperature and pressure are used. An appreciation of these principles is necessary to fully understand automotive air conditioning.

Functions of Air Conditioning

To be effective an automotive air conditioning System must perform three distinct functions within the passenger compartment

1. **It must cool the air**
2. **It must dry the air**
3. **It must clean the air**

The Basic Process

To understand the processes taking place within an air conditioning system, it is necessary to explain four fundamental concepts of refrigeration:

1. **Heat Transfer**
2. **Temperature/Heat**
3. **Humidity & Relative Humidity**
4. **Latent Heat/Sensible Heat**

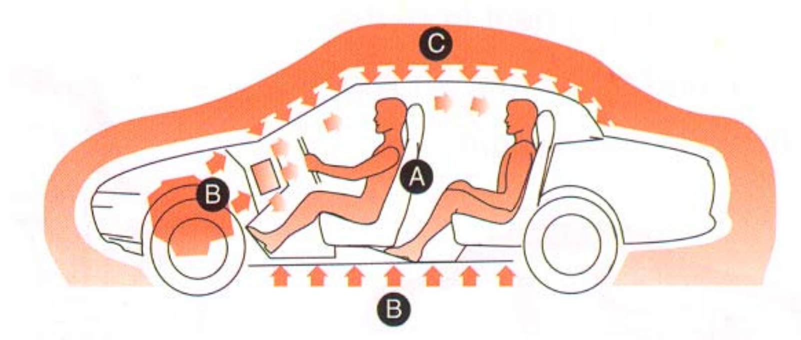
Heat Transfer

Heat transfer is a physical process constantly taking place in the air conditioning system. Heat transfer takes place when two substances at differing temperatures come into contact and heat is transferred from the hotter to the cooler substance. This exchange lasts until temperature equilibrium is established. Heat is normally transferred in three ways:

A-Conduction
Occurs by contact between two bodies (e.g., physical contact – touching a hot surface).

B-Convection
Occurs by a movement of matter (e.g., air movement – feeling warmth from a fan heater).

C-Radiation
Occurs by electromagnetic waves (e.g. solar rays – sun bathing in heat from the sun).

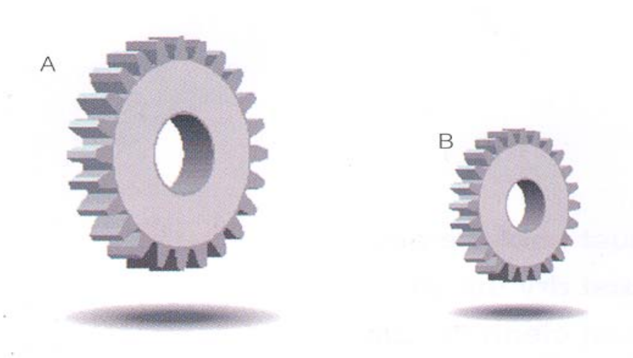


Temperature / Heat

It is important to understand the difference between temperature and Heat.

Temperature is a measure of the intensity of heat. Temperature is usually measured in degrees Celsius (°C)

Heat is a form of Energy, everything contains heat. Heat is measured in "Joules". A more convenient Multiple of this unit is the kilo joule (kJ). 1kJ = 1000 joules.



Two similar objects of different sizes can be of the same temperature, yet contain different amounts of heat.

At the same temperature, Cog "A" will contain more heat than cog "B" because it has a greater mass.

Humidity

Humidity is the term used for the moisture in the air, warmer air can hold more moisture than cooler air.

Relative humidity is the amount of moisture present in the air at a given temperature, the higher the temperature, the more moisture it can hold. Values are expressed as a percentage and are relative to the amount of moisture the air is capable of holding at that temperature.

For example, take a cold glass from the fridge and in no time the surface of the glass is covered in water droplets. Warm ambient air is able to hold more moisture than the cold air contacting the glass; therefore the excess moisture condenses onto the glass

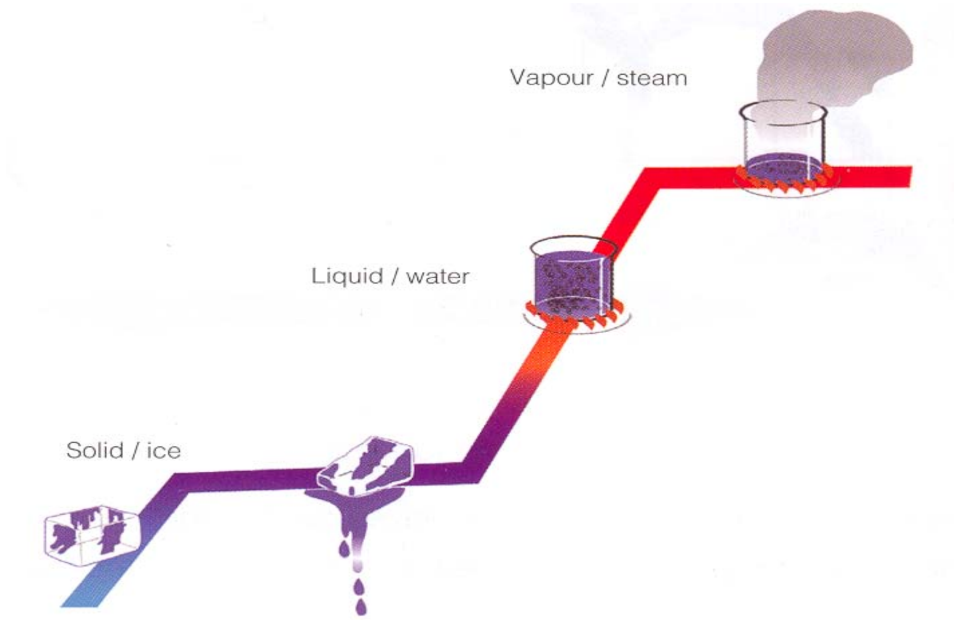
This happens because the humidity around the glass has reached is "Dew point" or 100% humidity and had to give up the excess moisture to the surface of the glass.

Relative humidity is very relevant to comfort, when humidity and the air is already holding a high percentage of moisture, it is very difficult for sweat on human skin to evaporate and loss body heat. The body remains sticky, wet and uncomfortable. In addition to controlling the temperature air conditioning also reduces humidity.

Latent Sensible Heat

To understand the effects of heat we will consider a common substance – **Water.**

Water can exist in any one of three states:



Heat added to a substance will:
Increase the temperature of the substance or change the state of the substance.

The Basic Processes

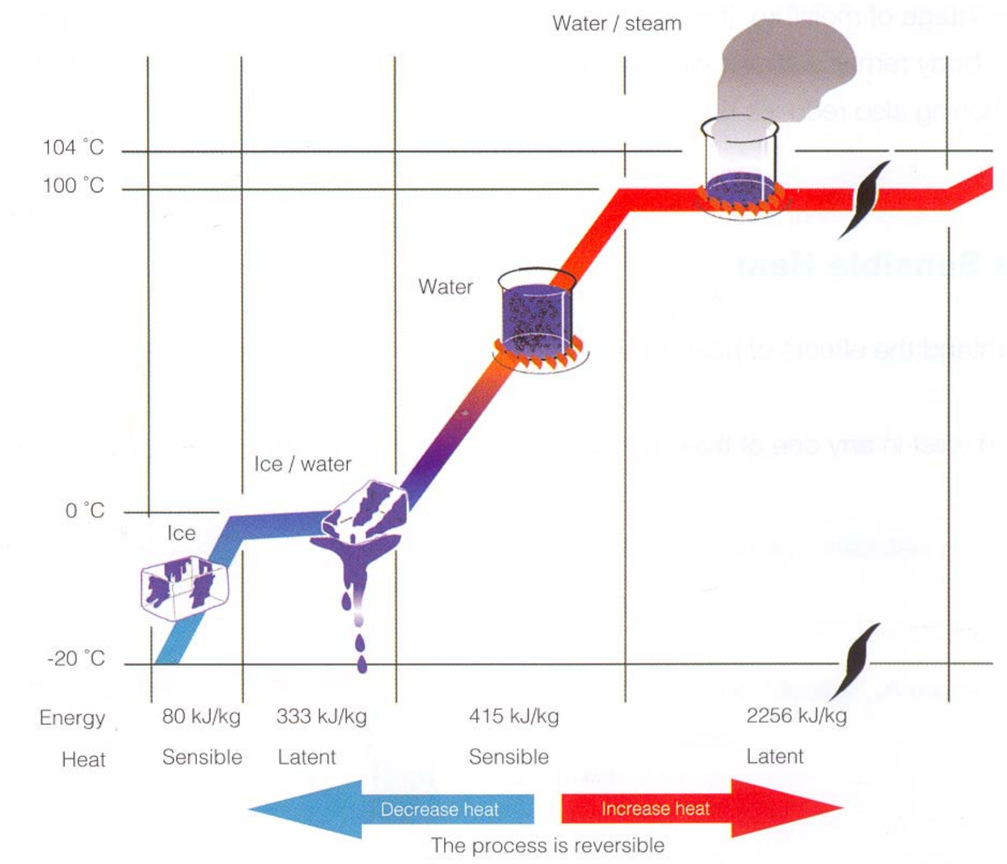
Heat is added to a block of ice at -20°C, the temperature of the ice will increase until it reaches 0°C, the block remains solid. The heat added to increase the temperature is SENSIBLE HEAT, because the change can be measured with a thermometer.

Heat is added to the block of ice at 0°C, the ice will change state to water, but the temperature will remain at 0°C. The heat added to change the ice to water is LATENT HEAT, meaning hidden heat, because there is no temperature change, but a change of state.

Heat is added to the water at 0°C, the temperature of the water will increase until it reaches 100°C, whilst remaining in a liquid state. The heat added to increase the temperature is again SENSIBLE HEAT, because the change can be measured with a thermometer.

Heat is added to the water at 100°C, the boiling point of water, the water will change state to steam, but the temperature will remain at 100°C. The heat added to change the water to steam is again LATENT HEAT, because there is no temperature change, but a change of state.

The amount of energy required for each stage is displayed as “Energy”, particular note should be made of the large amount of energy required to “Boil” and “Condense” the substance.



Sensible Heat = A change in temperature that can be measured

Latent Heat = A change in state that can be seen

Pressure

Gauge Pressure

The automotive air conditioning system is a pressurised circuit; correct operating pressures are an important factor in the effective and efficient operation of the system. Gauges are attached to the system to read high and low pressure so a basic understanding of pressure is important. Pressure is the result of a force pushing on an area.

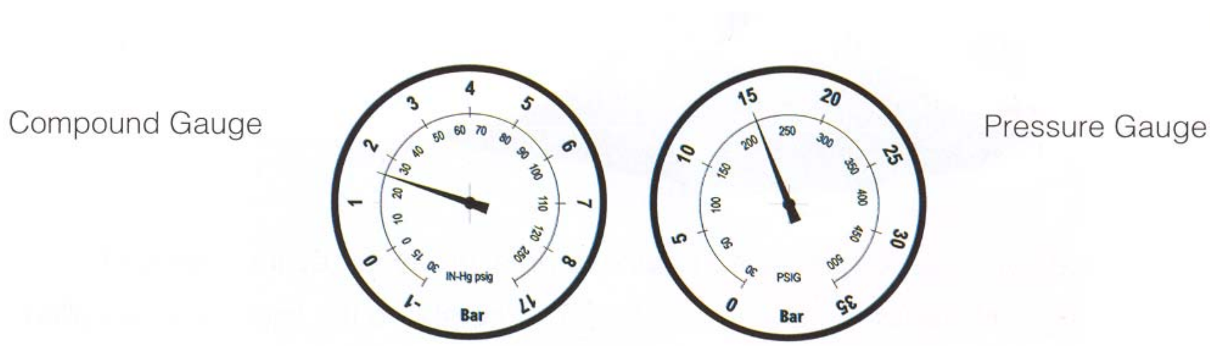
Pressure is normally measured in: **bar, psi or Kpa**

Gauges are calibrated to read zero at atmosphere pressure, pressures below this are called a vacuum.
Vacuum is normally measured in: **Negative bars (-bar), InHg, microns, mbars or torr.**

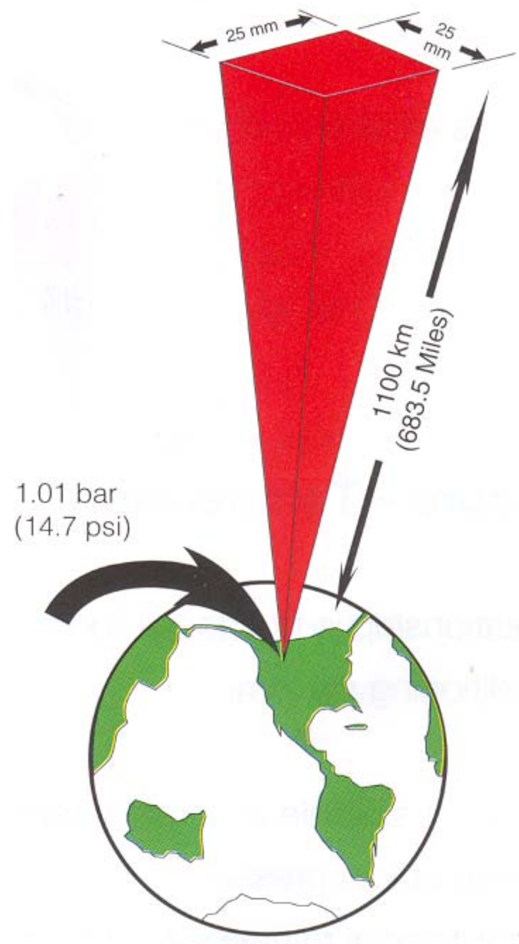
The two pressure gauges used to read system pressures look very similar but differ in certain ways.

Compound Gauge

The compound gauge is used to measure both positive and negative pressure and therefore has a reading scale both above and below zero.



Atmospheric Pressure



Atmospheric pressure is the normal pressure of the air around us.
This is the lower part of the earth's atmosphere extending many miles above us. The weight of approximately 1100 kilometres of Atmosphere Pressing down causes the air around us to be under pressure.
At sea level this pressure is 1.0136 bar or 14.7 psi.

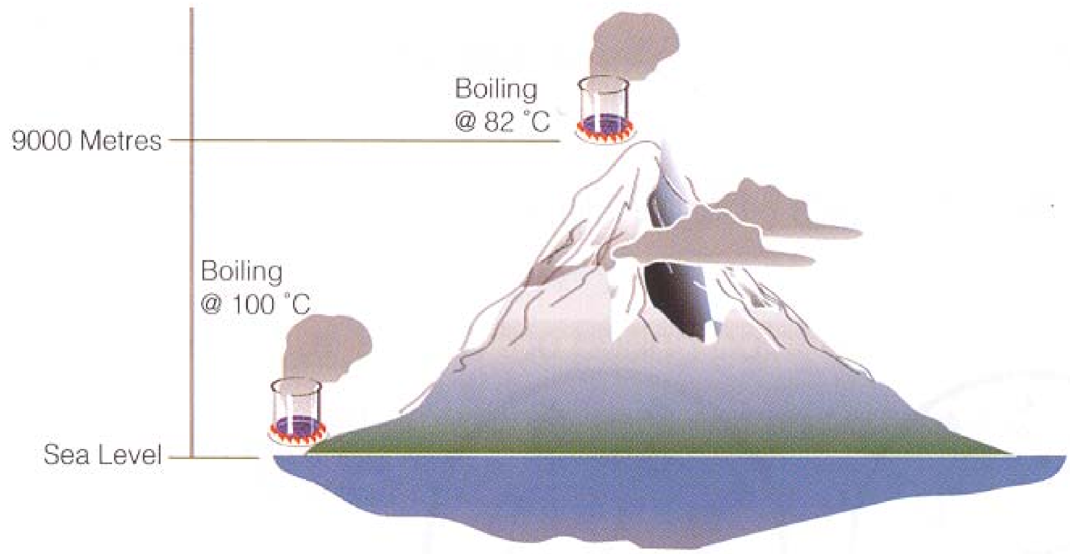
Absolute Pressure

Absolute pressure is measured from a perfect vacuum (i.e., disregarding atmospheric pressure).
Therefore absolute pressure can be calculated by adding atmospheric pressure to a gauge pressure reading.

Boiling Point & Pressure

It is accepted that water boils at 100°C at sea level, however, at higher altitudes where the atmospheric pressure is less (due to lesser column of atmosphere above) the boiling point is lower than 100°C. At an altitude of approximately 9,000 metres above sea level, water will boil at only 82°C.

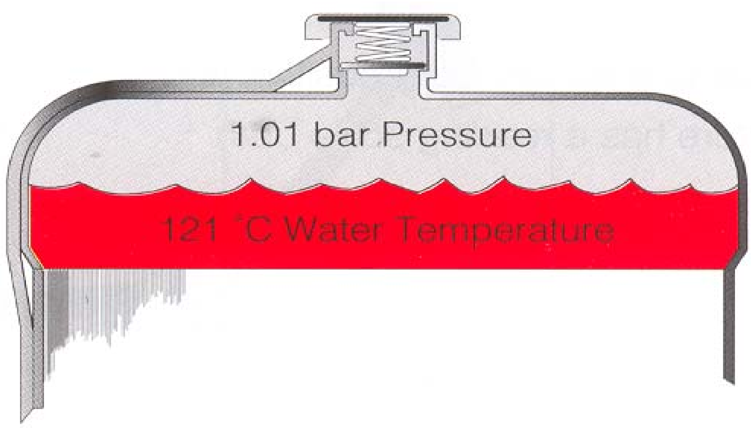
Lower Pressure = Lower Boiling Point



The opposite is also true, whereas at normal atmospheric pressure water evaporates and condenses at 100°C, this temperature depends on the pressure above the liquid, the so called vapour pressure.

Higher Pressure = Higher Boiling Point

A vehicle radiator is a practical example, if the pressure cap maintains an internal pressure of 1.0136 bar, the water within will not boil until a temperature of 121°C is reached.



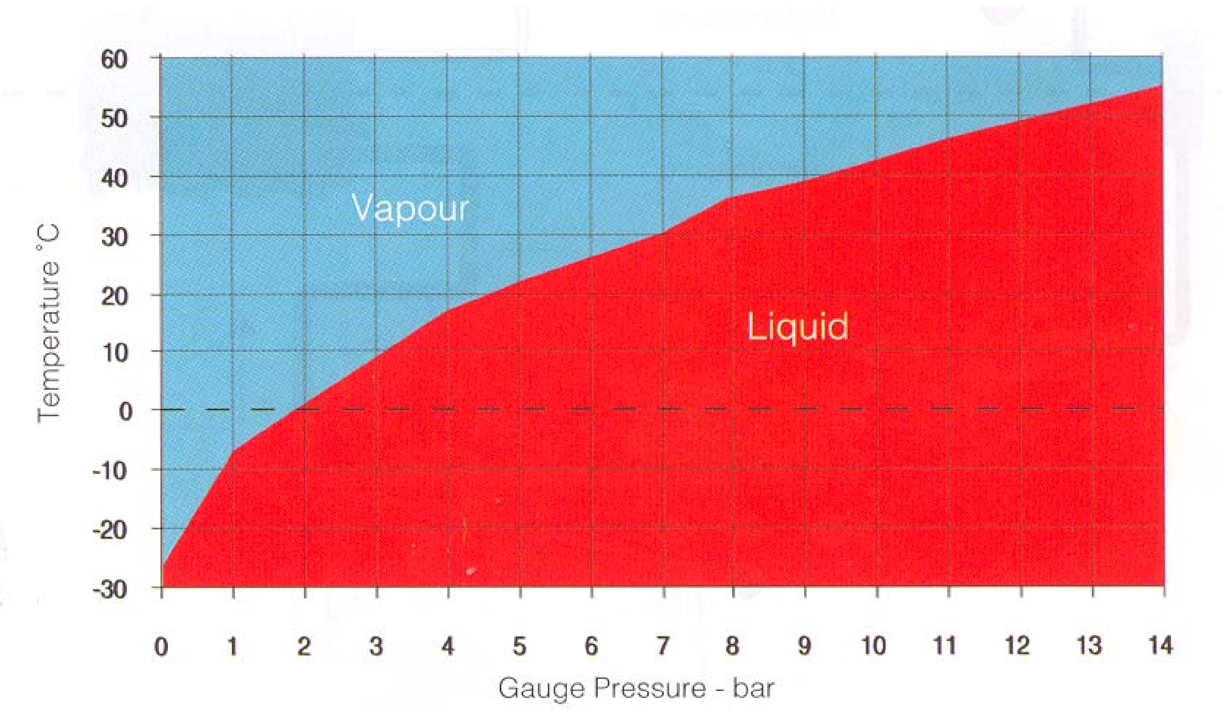
Pressure – Temperature Relationship

This relationship is true for all liquids and is particularly important in the operation of the automotive air conditioning system.

Water is not suitable as a refrigerant in an air conditioning system because its boiling point is too high, even at low pressures. No practical cooling effect could be achieved during evaporation, therefore special refrigerants are used. These refrigerants are gases that have a very low boiling point, approx. -30°C at normal atmospheric pressure

As the actual boiling point of R134a is –26.3°C at normal atmospheric pressure, it can be safely stored under pressure as a liquid, upon release of the pressure the liquid will begin to boil or evaporate.

To do this, R134a requires a very large amount of heat; its latent heat of evaporation, this heat is absorbed from its surroundings which can also drop as low as –26.3°C.



Pressure

Liquid R134a, like water discussed earlier, has the same relationship between its boiling point and pressure.

The lower the pressure of R134a, the lower the boiling point.
The higher the pressure of R134a, the higher the boiling point.

The graph shows the pressure – temperature relationship, or boiling point in relation to pressure, for refrigerant R134a.

Pressure (Con't)

Knowing this relationship gives us a convenient way in which to control the temperature at which R134a changes state, from vapour to liquid or liquid to vapour, within the air conditioning system. Using the graph, extend a line vertically from1.0 bar on the horizontal axis, read off the temperature to the left where the lines intersect. The resultant reading is a cold -9°C.

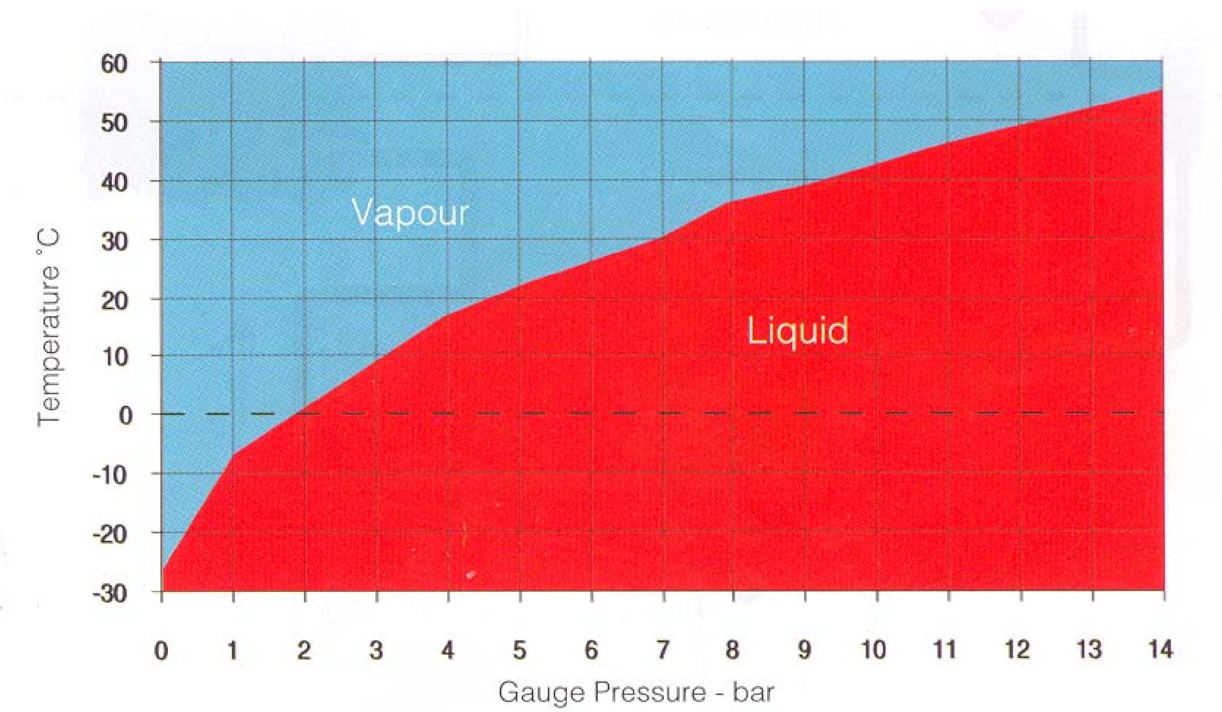
Now perform the same exercise at a pressure of 6 bar, the approximate temperature is now a warm 26°C.

Pressure – Temperature Relationship

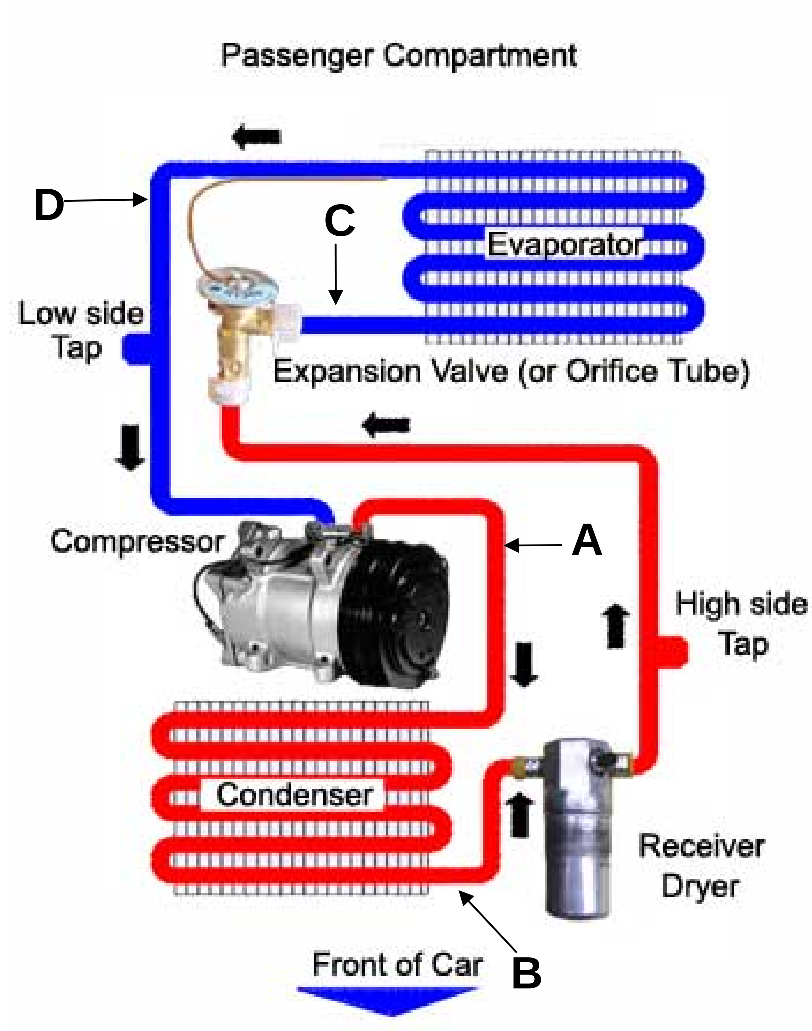
It can be seen from the graph that when R134a boils at around 1.0 – 2.0 bar, it will be at a temperature of approximately –9 ~ 1.0°C and will feel cold! This is precisely what happens within the evaporator of the air conditioning system.

To enable us to change the resulting vapour back into a liquid, it is necessary to pressurise the vapour to, let's say, 12 bar. Refer again to the graph and draw a vertical line from 12 bar on the horizontal axis, read off the temperature to the left where the lines intersect.

The R134a is in a state of vapour above 50°C, if the vapour is cooled to below 50°C it will condense back into a liquid. This is precisely what happens in the condenser of the air conditioning system.



System Layout



A - High Pressure Gas

B - High Pressure Liquid

C - Low Pressure Liquid

D - Low Pressure Gas

Compressor

Commonly referred to as the heart of the system, the compressor is a belt driven pump that is fastened to the engine. It is responsible for compressing and transferring refrigerant gas.
The A/C system is split into two sides, a high pressure side and a low pressure side; defined as discharge and suction. Since the compressor is basically a pump, it must have an intake side and a discharge side. The intake, or suction side, draws in refrigerant gas from the outlet of the evaporator. In some cases it does this via the accumulator.
Once the refrigerant is drawn into the suction side, it is compressed and sent to the condenser, where it can then transfer the heat that is absorbed from the inside of the vehicle.

Condenser

This is the area in which heat dissipation occurs. The condenser, in many cases, will have much the same appearance as the radiator in you car as the two have very similar functions. The condenser is designed to radiate heat. Its location is usually in front of the radiator, but in some cases, due to aerodynamic improvements to the body of a vehicle, its location may differ. Condensers must have good air flow anytime the system is in operation. On rear wheel drive vehicles; this is usually accomplished by taking advantage of your existing engine's cooling fan. On front wheel drive vehicles, condenser air flow is supplemented with one or more electric cooling fan(s).
As hot compressed gasses are introduced into the top of the condenser, they are cooled off. As the gas cools, it condenses and exits the bottom of the condenser as a high pressure liquid

Evaporator

Located inside the vehicle, the evaporator serves as the heat absorption component. The evaporator provides several functions. Its primary duty is to remove heat from the inside of your vehicle. A secondary benefit is dehumidification. As warmer air travels through the aluminium fins of the cooler evaporator coil, the moisture contained in the air condenses on its surface. Dust and pollen passing through stick to its wet surfaces and drain off to the outside. On humid days you may have seen this as water dripping from the bottom of your vehicle. Rest assured this is perfectly normal.
The ideal temperature of the evaporator is 32° Fahrenheit or 0° Celsius. Refrigerant enters the bottom of the evaporator as a low pressure liquid. The warm air passing through the evaporator fins causes the refrigerant to boil (refrigerants have very low boiling points). As the refrigerant begins to boil, it can absorb large amounts of heat. This heat is then carried off with the refrigerant to the outside of the vehicle. Several other components work in conjunction with the evaporator. As mentioned above, the ideal temperature for an evaporator coil is 32° F. Temperature and pressure regulating devices must be used to control its temperature. While there are many variations of devices used, their main functions are the same; keeping pressure in the evaporator low and keeping the evaporator from freezing; a frozen evaporator coil will not absorb as much heat.

Thermal Expansion Valve "TXV"

A common refrigerant regulator is the thermal expansion valve, or TXV Commonly used on import and aftermarket systems. This type of valve can sense both temperature and pressure, and is very efficient at regulating refrigerant flow to the evaporator. Several variations of this valve are commonly found. Another example of a thermal expansion valve is Chrysler's "H block" type. This type of valve is usually located at the firewall, between the evaporator inlet and outlet tubes and the liquid and suction lines. These types of valves, although efficient, have some disadvantages over orifice tube systems. Like orifice tubes these valves can become clogged with debris, but also have small moving parts that may stick and malfunction due to corrosion.

Receiver Drier

The receiver-drier/suction accumulator is used on the high side of systems that use a thermal expansion valve. This type of metering valve requires liquid refrigerant. To ensure that the valve gets liquid refrigerant, a receiver is used. The primary function of the receiver-drier is to separate gas and liquid.
The secondary purpose is to remove moisture and filter out dirt. The receiver-drier usually has a sight glass in the top. Under normal operating conditions, vapour bubbles should not be visible in the sight glass. There are variations of receiver-driers and several different desiccant materials are in use. Some of the moisture removing desiccants found within are not compatible with R-134a. The desiccant type is usually identified on a sticker that is affixed to the receiver-drier. Newer receiver-driers use desiccant type XH-7 and are compatible with both R-12 and R-134a refrigerants.
If the air conditioning system has been open or leaking for 4 hours, (times vary according to manufacturer) it will have allowed moisture to get in, the receiver drier must be renewed. The receiver drier can only hold a limited amount of moisture; additional moisture can lead to icing and ultimately blockage of the expansion valve.

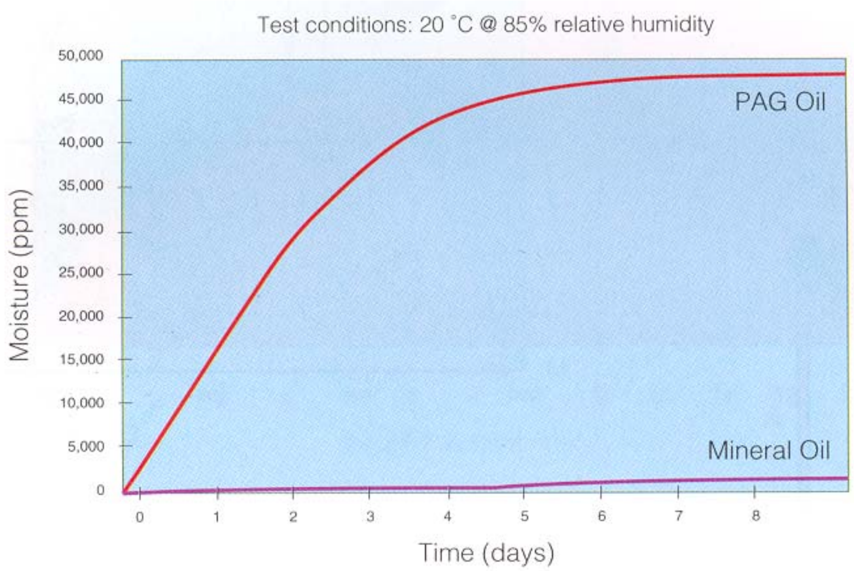
Lubrication

Compressors are lubricated with special refrigerant oils that are vital to the efficient operation and longevity of the compressor. These oils are designed to mix with the refrigerant and be carried around the air conditioning system. R12 systems use a mineral oil and R134a systems use synthetic PAG (polyalkyleneglycol) oil. Both oils are available in different viscosities.

PAG (polyalkyleneglycol) oil used in mobile air conditioning systems is normally one of the following viscosities:

ISO- 46, 100, 150

PAG oil is extremely hygroscopic and can absorb several thousand parts per million more moisture than mineral oils when exposed to conditions such as high humidity. This means it will absorb moisture from the air, so containers must be kept sealed. They are also prone to oxidation and may react adversely with residual R12.
Do not mix the refrigerant oils for R134a and R12.



The graph above give an indication of the problems expected due to the hygroscopic characteristic of PAG oil. Although not recommended, mineral oil can be left open with no significant problem but you can see the immediate problem of moisture absorption with PAG oils. An acceptable level by the compressor's manufacturers for moisture in virgin oil is only 1000ppm.

Some oil is lost whenever air conditioning system components are replaced. The following table is a general indication of the amount to add depending on the component being replaced.

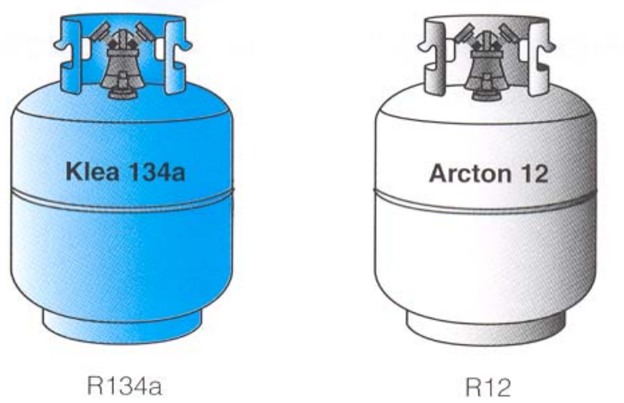
Expansion valve/orifice tube	**Nil**
Receiver drier	**Add 15 ml**
Condenser	**Add 30 ml**
Evaporator	**Add 50 ml**
Hose/Pipe	**Add 10 ml**
Accumulator	**(Add new oil to the equivalent of oil drained from the old Compressor component, plus a further 28 ml)**
Rapid discharge	**50 ml**

Note: These figures are approximate; manufacturer's guidelines should be followed whenever possible. Vehicles involved in accidents where the A/C system has been damaged would probably have had a rapid refrigerant discharge. System lubricant would also have been lost under these circumstances and must be replaced.

Refrigerants

Current mobile air conditioning systems are designed to operate using R134a.
At the present time R134a is the only refrigerant approved by the OEMs (Original Equipment Manufacturers). R12 was the industry standard until 1992. Production of R12 was banned in 1995.

As of October 1st 2000 it became illegal to trade R12. From the 1st of January 2001 it became illegal to service R12 systems. As a consequence mobile air conditioning systems designed to use R12 must be retrofitted to R134a.



Health & Safety

These safety procedures must be followed when using any refrigerants.

1. Wear protective goggles, also wear gloves made from fuoroelastomer, **leather or fabric gloves are not suitable,** also wear protective clothing

2. Avoid contact with unprotected skin, refrigerants can cause severe frostbite.

3. Do not expose refrigerant to a naked flame or smoke whilst using refrigerant, it can produce toxic gases (phosgene, fluorine). Tiny concentrations of these gases are readily identifiable by their pungent smell.

4. Do not weld on or near the A/C system unless it is drained of the refrigerant. Use caution if steam-cleaning, avoid heating air conditioning components.

5. Refrigerant is heavier than air. Consequently, there is a danger of suffocation near the ground or in service pits. Always ensure adequate ventilation when handling refrigerants.

6. When handling refrigerant containers, do not expose to sunlight or heat, protect against frost, transport upright, do not drop, always ensure valves are closed.

First Aid

As a general rule, in the event of refrigerant contacting the eyes, the following first aid procedures can be followed:

- **Rinse the eye continually with water to raise the temperature.**
- **Transport the patient to the nearest medical facilities.**
- **Do not attempt to treat it yourself, other than rinsing with water.**

Care must be taken when placing a vehicle into a bake oven. System safety parameters should be observed.

Refrigerants

Refrigerant R134a

From 1991 refrigerant R134a has been progressively introduced by all motor manufacturers into automotive air conditioning. R134a as a hydrofluorocarbon is chlorine free and therefore does not deplete the ozone layer. It is however harmful to the environment because it contributes to the greenhouse effect.

R134a and R12 have similar reactions to temperature and pressure, i.e. the higher the pressure the higher the boiling point.

At normal atmospheric pressure R134a has a boiling point of –26.3°C.

G.W.P

G.W.P means Global Warming Potential. The higher the G.W.P the higher the contribution to the global greenhouse effect/global warming.
The basic provisions of Directive 200640EC calls for a control on the emissions of fluorinated greenhouse gases (R134A) with a G.W.P higher than 150. From the 1st January 2008, EC or National type approval will not be granted to vehicles fitted with an A/C system designed to contain a fluorinated greenhouse gas with a G.W.P higher than 150, unless the leakage rate does not exceed either 40 grams per year for a single evaporator system or 60 grams from a dual evaporator system.

Another regulation brought in (No 842/2006) describes the prevention and minimisation of the emissions of fluorinated greenhouse gases and states that personnel recovering or handling refrigerant, must have a refrigerant handling certificate by **July 2010**.

R134a has the following characteristics:

- It is odourless.
- Non-toxic in low concentrations.
- Incombustible, except in certain concentrations when mixed with air.
- Only miscible with synthetic PAG (polyalkyleneglycol) lubricants, not with mineral oils.
- Is heavier than air, hence the danger of suffocation near the ground.
- Non explosive.
- Readily absorbs moisture.
- Does not attack metals.
- Attacks R12 hoses and o-rings, specific hoses and o-rings are required for R134a.

Note: Service and repair operations on air conditioning systems filled with R134a must only be carried out using approved tools, measuring equipment and lubricants for use on R134a systems.

Service Equipment

Purpose & Operation

The refrigerant in an air conditioning system must be recovered before repairs can be carried out to components in the system. The refrigerant must never be released into the atmosphere, but must be recovered and can be recycled with the aid of special servicing units.

Servicing units are required for R12 and R134a as the connectors are of different diameters. Some servicing units can be switched over to either gas, the different refrigerants must not be mixed.

R12 systems normally have high and low pressure service connections of the screw type, ¼" SAE – flare, always check with the manufacturers.

R134a systems normally have high and low pressure service connections of the quick connection type, always check with the manufacturers.

The basic operations required to service an automotive air conditioning system are:

- **Refrigerant Recovery**
- **System Evacuation**
- **Adding Oil**
- **Charging Refrigerant**

Service Equipment

- **Refrigerant identifier**
- **Refrigerant recovery unit with oil separator and recovery cylinder**
- **The respective service couplings and hoses to connect to the system**
- **Manifold gauge set**
- **Deep vacuum pump**
- **Lubricant oil injector**
- **Charging cylinder or scale to measure the quantity of refrigerant required**
- **Suitable leak detection equipment**
- **Electronic thermometer**
- **Belt tension gauge**

Leak Detection

Refrigerant leaks must be located and repaired; a system which is low on refrigerant will not operate efficiently and may suffer long term damage leading to costly repairs.

Air moisture can enter a system with a leak, causing corrosion and significantly reduce the service life of the receiver drier or suction accumulator. Compressor lubrication depends on refrigerant circulation; a system operating with a low charge of refrigerant will suffer poor oil circulation resulting in premature compressor failure.

Visual Inspection

When a leak develops in an air conditioning system, it is common for some oil (which is carried with the refrigerant) to escape along with the refrigerant. The presence of oil at a joint or fitting is a good indication of a leak at that point.

Note: Wipe all oil from fittings before leak testing with an electronic leak detector.

Ultrasonic Leak Detector

This type of leak detection allows you to check for leaks under negative or positive pressure.

This gives you the ability to check for leaks during system evacuation and recharging.

The advantage with this type of leak detector is that you can also detect failing solenoids, valves and bearings.

This type of reliable technology is accurate, versatile and easy to use and has many varied applications.

Electronic Leak Detectors

The most common type of leak detector is the electronic type. It is very accurate, portable and safe to use. Most are adjustable to eliminate background contamination helping you to pinpoint the leak. The system must contain refrigerant to enable leak detection.

Remember:

- Always check beneath fittings or components, refrigerant is heavier than air.
- Clean all fittings before leak detecting.
- Do not allow tip to contact fittings, false readings can occur, keep the tip clean and dry.

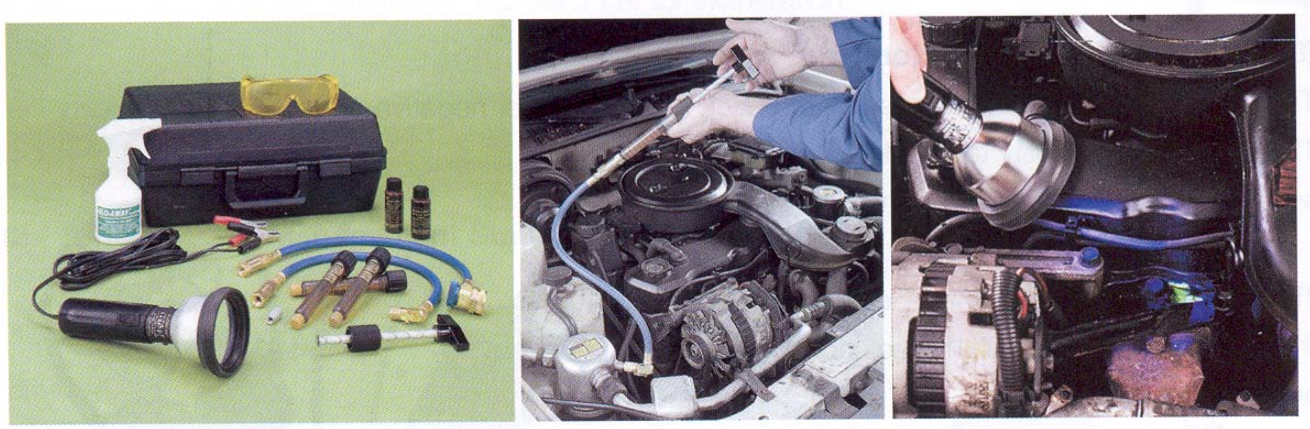
Ultra Violet Leak Detection

Some leaks only occur under certain conditions, such as when the car is being driven or when parked overnight. To provide a method to find this type of leak it is possible to put a special dye into the system which will show up under ultra violet light at the point of leakage. The dye does not affect the operation of the system and is left in the system for life, thus making future leaks easily traceable.

Several OEMs use the dye as standard on new vehicles, when added to the system the dye will circulate and penetrate the system through distribution with the refrigerant oil.

The ultra violet fluorescent dye is by far the most accurate method of leak detection available today, the initial cost can be quickly recovered as the labour time spent locating leaks is dramatically reduced.

Tracerline product



Bubble Spray

An alternative method of leak detection other than previously mentioned is the use of a commercial bubble spray. When the spray is applied to the area of the suspected leak, bubbles reveal the location of the leak. A leak may take some time to appear, be patient and be prepared to wait approximately 10 – 15 min for a result.

Oxygen Free Nitrogen

To provide a leaking system with pressure to enable leak detection using bubble spray, the use of oxygen free nitrogen to a maximum pressure of 10 bar is used.

Refrigerant Identification

Most good quality refrigerant identifiers are accurate and simple to use, they can be mains or battery powered, or can be connected to the vehicle battery. Always follow the equipment manufacturer's instructions. A sample of refrigerant should be taken from the low side (vapour) service port of the air conditioning system.

The analysis should indicate the amount of R134a, R12, R22 and Air (as%), whilst warning of the presence of flammable hydrocarbons. It should also indicate if the contents are suitable for recovery. The ability to provide a print out is an added benefit, producing a hard copy of test results for your customer and vehicle service records.

Refrigerant Recovery

Any refrigerant removed from an air conditioning system must never be released to the atmosphere but must be recovered for recycling or safe disposal. Recovery is normally performed through the “low side” service port to reduce the quantity pf oil removed with the refrigerant. The oil amount must be corrected when recharging the system, therefore the refrigerant and oil should be separated to determine the quantity of oil removed from the system.

Upon completion of refrigerant recovery, the residual pressure within the system should be approximately –0.5 bar (15”Hg), the lower vacuum will ensure adequate removal of refrigerant from the remaining oil.

As a consequence of refrigerant recovery it is necessary to understand and know how to determine the safe total and allowable filling weight of a recovery cylinder.

Firstly calculate the weight of the contents:

Net Weight	**=**	**Gross Weight**	**-**	**Tare Weight**
(Contents)	**=**	**(Total cylinder weight)**	**-**	**(Empty cylinder weight)**

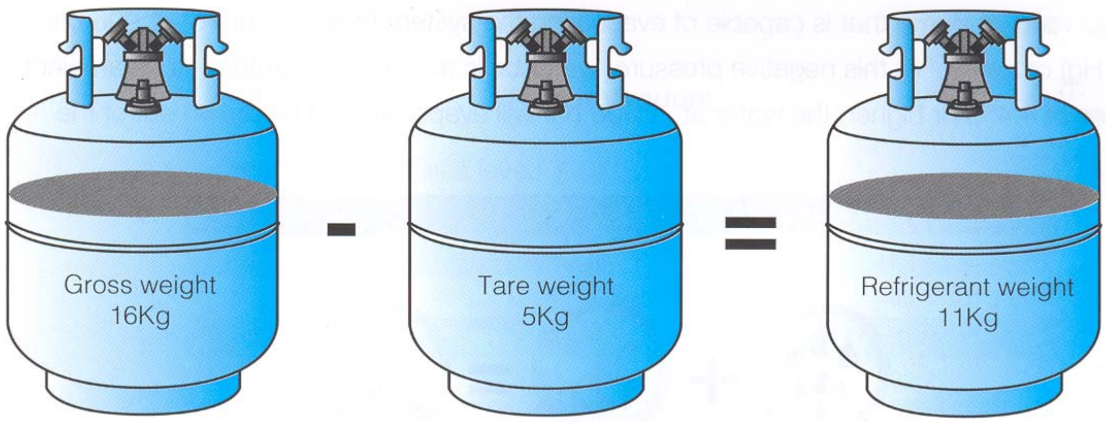
Service Procedures

The tare weight is printed on the side of the cylinder along with other information as shown, note the maximum fill weight of the specific refrigerant.

Caution: The maximum fill weight shown on the cylinder is for virgin refrigerant, to allow for oil and other contaminants etc. the maximum fill weight must be reduced by 25%. In other words multiply the max. fill weight by 0.75 for the maximum safe weight of recovered refrigerant. The weight of the contents of the cylinder must be subtracted from the maximum allowable fill weight to determine the additional weight of refrigerant the cylinder is safely able to hold.

Example: A cylinder of R134a weighs 16kg, the tare weight is 5kg, therefore the refrigerant weight is:

Gross weight	**-**	**Tare weight**	**=**	**Refrigerant weight**
16	-	5	=	11kg of R134a in the cylinder



The maximum fill weight for virgin R134a is 24kg; therefore the maximum fill weight for recovered R134a is 24 x 0.75 = 18kg.

Additional amount of refrigerant that can be added to the cylinder

Max fill weight	**-**	**Refrigerant weight**	**=**	**Additional weight**
Virgin R134a 24	-	11	=	13 kg
Recovered R134a 18	-	11	=	7 kg

Refrigerant Management Stations usually have inbuilt safety systems which automatically determine safe recoverable allowances.

Service Procedures

Initial Charging with Refrigerant

The quantity of refrigerant necessary for optimum performance is determined by the system manufacturer and should be shown in the respective manual, installation instructions or label affixed to the vehicle.

There are two acceptable methods for charging a system accurately, these are:

1. **A high precision electronic scale which weighs the refrigerant into the system.**
2. **A manual metering cylinder calibrated for temperature/pressure variations.**

Charge approximately 20% of the full amount of refrigerant through the high side service port, or follow the service equipment manufacturers instructions. As the refrigerant is in its liquid state it must be introduced on the high (outlet) side of the compressor, introducing liquid into the low side (inlet) of the compressor can cause damage when the compressor is operated.
Recharging on the low side of the A/C system is only permitted when no high side service port is available.

Leak Check

Perform a leak check using a good quality leak detector, follow the manufacturer's instructions. If any leak is detected, the refrigerant charged must IMMEDIATELY be recovered and the leak repaired. The procedure starting with evacuation must then be repeated.

Completing the Refrigerant Charge

If a partial recharge was carried out, charge the remaining balance back into the A/C system. System pressures and operation can now be checked.

Final Leak Check

Perform a full leak check using a good quality leak detector, follow the manufacturer's instructions. If any leak is detected, the refrigerant charged must IMMEDIATELY be recovered and the leak repaired. The procedure starting with evacuation must then be repeated.

Practical Exercises
Working Practice

- Ensure that protective covers are applied to the vehicle before commencing any work.

- Ensure the vehicle cannot be accidentally started. This is to prevent the possibility of personal injury and damage to service hoses if the service connectors are close to fans, belts etc.

- Make sure that tools, measuring equipment and parts to be fitted are clean & dry.

- Keep all necessary equipment and tools within easy reach so that the system is not left open any longer than is absolutely necessary.

- Before undoing any refrigerant lines, joints or connectors, clean off any dirt, moisture, oil etc. in order to prevent contamination of the system.

- All open connections should be capped or plugged (air tight) immediately to stop dirt, air or moisture getting into the system. Air inside the circuit will damage the system and reduce system performance and reliability.

- Any o-rings disturbed by undoing unions must always be renewed after lubricating with refrigerant oil prior to fitment. When removing o-rings from couplings, care must be taken not to scratch the sealing face.

- It is recommended that the receiver drier/suction accumulator is replaced if the system has been open to the atmosphere for more than 4 hours (depending on the manufacturer), is physically damaged or has been in service for more than 2 years.

- Do not remove plugs from new components until each component is ready to be installed into the A/C system, this will limit the amount of air and moisture entering the system.

- When adding refrigerant oil, ensure that any filling equipment (hose, container, etc.) is clean and dry. The oil container must be sealed immediately after use.

- To ensure the system works correctly after servicing, the system must be evacuated (vacuumed) for a minimum of 30 minutes after reaching target vacuum before recharging. This will remove (by dehydration) any moisture from the system.

- One of the most important requirements when filling the air conditioning system is to use clean refrigerant. Any foreign matter including air, moisture, dirt etc. in the air conditioning circuit will have an adverse effect on refrigerant pressures and impair the system performance.

- After every repair or service procedure, the system must be leak checked to identify any leaks that may be present. If any leaks are found, the refrigerant within the system must immediately be recovered and the leak repaired.

(MSDS) Material Safety Data Sheet - R134a

1 Identification of the substance preparation/company undertaking

2 Composition/information on ingredients

3 Hazards identification

4 First aid measures

5 Fire-fighting measures

6 Accidental release measures

7 Handling & storage

8 Exposure controls/personal protection

9 Physical & chemical properties

10 Stability & reactivity

11 Toxicological information

12 Ecological information

13 Disposal considerations

14 Transport information

15 Regulatory information

16 Other information

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Typical waste transfer note