Hella: AC in Hybrid Vehicles

Vehicles with full-hybrid technology use high voltage compressors that are not dependent on the running of the combustion engine. This makes for greater A/C comfort in such vehicles.

A vehicle's interior that has become overheated can now be cooled down to the desired temperature before the start of any journey by using a remote control. This stationary cooling process can only be brought about if sufficient battery capacity is available.

The compressor is controlled with the lowest possible output with the necessary A/C requirements being taken into account. In the high voltage compressors used today, the power is regulated by adjusting the rotary speed in steps of 50 min-1. It is therefore not necessary to have an internal power control

Function and design

In contrast to the 'swash plate' principle, which is primarily used in the belt-driven compressor field, high voltage compressors use the 'scroll' principle to compress the refrigerant. The benefits are that the weight is reduced by approximately 20% and there is a reduction in the cylinder capacity of the same amount, whilst the output remains identical.

In order to generate the right amount of torque for the drive of the electric compressor, a DC voltage of over 200V is used.

Specialist subject

You should be aware that appropriate staff training is required for the servicing of hybrid vehicles, with further skills imperative for those who service and repair the complex thermal management systems found in hybrids. In Germany, for example, those employees who work on high voltage systems are obliged to attend an additional two-day course in order to qualify as an "Electrician for High Voltage Systems".

The course teaches the technician to recognise the risks when working on systems of this kind and also how to switch off all the current to the system for the duration of the work. It is prohibited for people who have not attended specific training courses to work on high voltage systems.

Also, tasks dealing with general servicing and repairs (such as work on exhaust systems, shock absorbers, oil changes and the changing of tyres) may only be carried out by employees who have attended the same course, in order to learn about the risks associated with these types of systems.

Tools of the trade

It is also essential to use tools that comply with the specifications provided by the manufacturer of the hybrid vehicle. During the A/C check and service, steps must be taken to ensure that the electric A/C compressors ARE NOT lubricated with standard PAG oils, as these don't have the necessary insulation properties. POE oil or a special type of PAG oil is normally used instead, as these have the required properties.

Consequently, A/C service units with an internal rinsing function and a separate fresh oil reservoir should be used for the A/C check and service in hybrid vehicles. This then ensures that any mixing of the various types of fresh oil is prevented.

The Hella Tech World Portal contains hundreds of tips and technical hints.

Measuring principle

With the last hot film air-mass sensor generation, the measuring principle has almost not changed at all. The sensor element comprises a micro-mechanical sensor diaphragm whose elements are vapor deposited onto a semiconductor substrate and from an evaluation electronic. On the sensor diaphragm, the hot film is heated to a temperature of approx. 120 °C via the air temperature and kept at a constant temperature. The intake air which flows past cools down the hot film. Two temperature-dependent resistances on the sensor diaphragm record the drop in temperature on the right and left of the heating zone. The temperature difference between both measuring points serves as the variable for the air mass sucked in. The sensor in the integrated evaluation electronics converts the temperature difference at both measuring points into an analog or digital signal, that is then transferred to the control unit. In many cases, the air-mass sensor is also fitted with a separate intake air temperature sensor (NTC). Its signal is however, not required for the calculation of the air mass.

Digital signal transmission

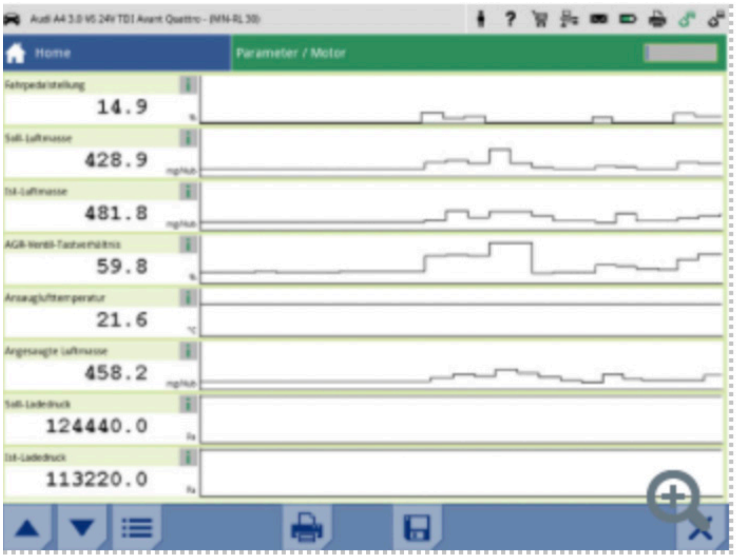
With the first generation of the hot film air-mass sensors, the sensor signal was output in the form of electric voltage that could be between zero and five Volt depending on the air mass being supplied. With the newest generation, the signal for the air mass sucked in is transferred to the control unit in a digital manner of a variable frequency. The temperature of the intake air is usually also transferred digitally, and that being in the form of a pulse width modulation (PWM) signal. The digital signal for the air mass has, depending on the dimensioning of the air-mass sensor, a frequency of 1.5 to 12 kHz. The frequency increases with the increasing air mass. There are however, hot film air-mass sensors where the frequency reduces with increasing air mass. When checking the air-mass sensors, observe the specifications of the respective manufacturers.

With newer air-mass sensor generations, the digital signal for the intake-air temperature has a constant frequency of approx. 19 Hz. Only the duty cycle changes parallel to the air temperature here. The frequency of the intake-air temperature signal has an important additional function: it is used as a time basis for the signal of the air mass by the evaluation electronics in the control unit. In this manner, the signal transmission can be monitored permanently and it can therefore be ensured that the signal frequency output can be allocated to the correct air mass value.

There are many different variants of the hot film air-mass sensor in the newest generations. Depending on the requirements of the manufacturer, they are available with a different number of pins, with or without intake air temperature sensor and with analog or digital signal output.

Check the digital air-mass sensor with workshop equipment

A defective air mass sensor cannot always be recognized straight-away. Possible error symptoms that indicate a malfunction of the air mass sensor are black smoke,
deficiency in performance, emergency run or the entry of an error code in the error memory. To check a hot film air-mass sensor with digital signal output, a diagnostic unit, a multimeter or an oscilloscope – that supports frequency measurement – and a matching test adapter is required.



Starting the troubleshooting is carried out as usual by querying the error memory. The evaluation of the parameters – in particular those of the air mass sucked in and calculated – can provide information on a malfunction of the air-mass sensor (HFM_03). If the suspicion of an error on the sensor is more specific, this can be checked safely in the workshop in just a few steps.

The following steps are necessary for this:

1. Checking of current consumption

For this purpose, one switches off the ignition and using a matching adapter, connects a multimeter into the voltage supply line serially. When the ignition is switched on, a current value of, for example, 32 to 38 mA (observe the manufacturer specifications) can be read from the multimeter. If the quiescent current consumption is less than the setpoint, a broken sensor diaphragm is most probably at hand Some sensor manufacturers specify that the voltage supply must be checked instead of the current consumption. The value measured must then correspond with the on-board voltage.

2. Measuring the zero air with stationary engine

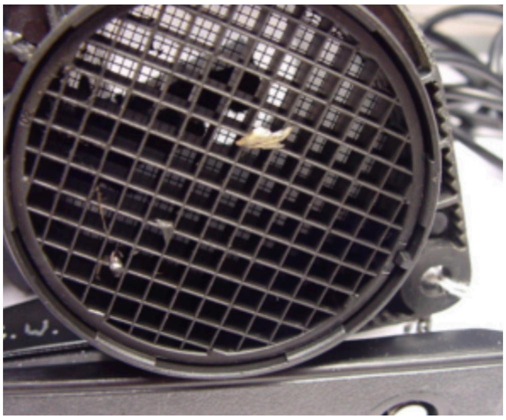
For this purpose, the engine must be switched off and the respective line of the test adapter must be connected to the multimeter for measuring the frequency. As an alternative, diagnostics professionally can also use an oscilloscope. It is only important that during the zero air measurement, that the exhaust gas extraction system is switched off or removed. In this way, one prevents that airstreams distort the measuring result. When the ignition is switched on, a frequency between, for example, 1.76 and 1.93 kHz (observe the manufacturer specifications) must be able to be measured. The frequency when the air mass sucked in increases. This is easy to check by starting the engine after the zero air measurement and a surge of gas is initiated.

3. Checking the temperature signals

A frequency measurement is also carried out here with ignition switched on and stationary engine. The setpoint is, for example, 18.5 to 20.8 Hz (observe the manufacturer specifications). The frequency of the temperature signal remains constant. The duty cycle of the signal changes proportional to the intake-air temperature. In case the temperature signal is output analog, the resistor of the intake air temperature sensor can be determined in a classic manner using a multimeter. Here, a few exemplary values: at 25 °C the resistance should be about 2 kΩ and at 60 °C 564 Ω. The different test points can be set using a hot air blower. As an alternative, the intake air temperature can also be checked using a diagnostic unit. In doing so, the respective value for the intake-air temperature is read out with the parameters. It must correspond with the ambient air temperature.All test steps on the air-mass sensor can be carried out in an installed state. If the measured values deviate from the setpoints, the air-mass sensor must be renewed.

Find and avoid the cause of damage

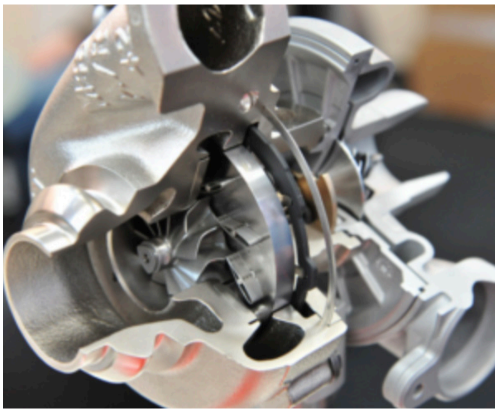
Hot film air mass sensors are highly sensitive sensors. Any type of impurities, being dust particles or humidity damage the sensor diaphragm and lead to incorrect measuring results.



Similar damage is also caused by oil vapor that can completely burn-in to the hot film element over the course of time. In order to avoid damage and the premature failure of the air-mass sensor, we recommend that careful handing is exercised during service and repair work in the area of the intake and air guide system. Thus, during maintenance work, the mechanic must take particular care that the air filter elements are used in original equipment quality, all air lines are absolutely tight and that the air filter housing is also cleaned with care using a lint-free cloth and, where appropriate, avacuum extraction system (no compressed air). If there is a suspicion that humidity has entered the air guide system, all air ducts must be examined additionally and the cause rectified according to manufacturer specifications.

Variants of the boost pressure control

For an optimum function of a supercharged engine, the boost pressure of the exhaust turbocharger must be adapted to the engine load and the engine speed. The simplest form of the boost pressure control is the bypass on the turbine side (bypass channel). In doing so, the turbine is selected as small as possible that the requirements on the torque behaviour is fulfilled at low speeds and a good driving property of the engine is reached. With such a dimensioning, more gas is supplied to the turbine shortly before reaching the maximum torque, that is necessary for generating the boost pressure. Therefore a part of the exhaust gas quantity is guided around the turbine through a bypass after reaching the required boost pressure. The boost pressure control valve that opens and closes the bypass is controlled by a spring-loaded diaphragm depending on the boost pressure.



With modern passenger car diesel engines, the adjustable turbine geometry (VTH) with rotatable guide vanes is state-of-the art for the boost pressure control for many years (Picture 5). The adjustable turbine geometry allows the flow cross-section of the turbine to be adjusted depending on the engine operating point. As a result, the entire exhaust gas energy is used and the flow cross-section of the turbine can be set optimally for every operating point so that, compared with the bypass control, the efficiency of the turbocharger is improved and therefore that of the engine. The ongoing adjustment of the turbine cross-section to the driving state has an effect that the fuel consumption and emissions are reduced. That a low speed already ensure for a high torque of the engine and a carefully matched control strategy a noticeable effect on the improvement in the driving behaviour.

Strategic troubleshooting

Faults on the boost pressure control can usually be recognized by a deficiency in performance. In such cases, vehicle garages should arrange a targeted troubleshooting strategy.

In doing so, the following procedure has been proven in the process.

1. Customer conversation

In doing so, the specialist should find out when and under which conditions the error occurs. Then a test drive should be carried out together with the customer, where the error can be reconstructed. That is indispensable for further ways of troubleshooting and for the success control of the work assigned.

2. Visual inspection

With the subsequent visual inspection, all booster air lines should be checked for damage and a tight seating. This also applies to all vacuum lines, the control valves and pneumatic actuating equipment. Marten damage and porous vacuum hoses lead to malfunction of the boost pressure control. Finally, the connector and electric lines of the control valves should also be checked for a tight fit, interruption or contact resistance.

3. Self-diagnosis

Modern engine control units offer a great diversity of options that test the booster air system through its paces using a diagnostic unit. In this way, the error memory already gives the first indications of possible malfunctions. The clever evaluation of the parameters and the actuation test can limit errors in the booster air system by further options.

4. Pressure tests

Finally, diverse pressure tests on the booster air system have to be carried out for a safe diagnostic. They allow the specialist to check the results of the self-diagnostics for plausibility. The specialist therefore prevents expensive components from being replaced for nothing. Moreover, in pressure tests errors can also be detected in the booster air system that were not detected by the self-diagnostics.

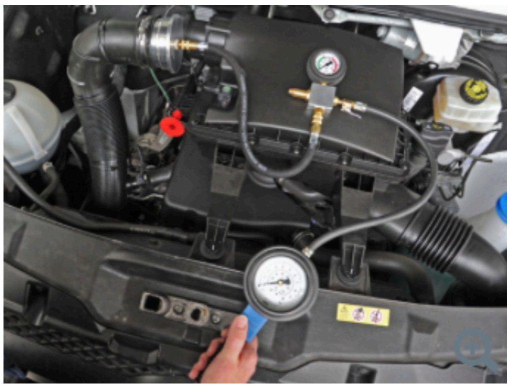
Check boost pressure

In the scope of the pressure test, the actual boost pressure should be determined first. A manometer is required for testing the boost pressure that can measure vacuum as well as overpressure. The manometer is connected to an easily accessible position on the boost pressure circuit using a T-piece and respective stage adapter.

The boost pressure is tested under load. A test drive or, where necessary, running on a dynamometer cannot be avoided for this purpose. In doing so, driving cycles with low engine speeds and higher loads must be strived for with an engine that has reached operating temperature. The boost pressure test using a manometer has many advantages for the garage specialist for troubleshooting.

The specialist can:

- compare the actual boost pressure reached with the setpoints of the manufacturer
- verify the parameters supplied by the control unit for plausibility. malfunctions on the boost pressure sensor can be revealed easily and quickly in this manner
- observe the course of the boost pressure and recognize temporary fluctuations in pressure that result in sporadic drops in performance. The parameters output from the control unit frequently react too sluggish in order to detect temporary fluctuations in pressure in a safe manner.



Do not replace the turbocharger too quickly

If the boost pressure measured does not correspond to the manufacturer specifications, the cause must be determined. Faults on the boost pressure control, leaks on the boost air system or damage on the turbocharger may be causes.

However, before the garage specialist replaces the turbocharger, they must be able to rule out all other error sources. Being electro-pneumatic valves or actuator motors for the boost pressure control, the functions can be tested using the actuator test and if required, a pressure / vacuum pump. Leaks in the boost air pressure can be detected by sealing the air route to be tested using matching adapters and applying pressure (maximum values can be obtained in the manufacturer specifications). The leaking point can be determined by feeling and listening, or by using a leak detection spray.