WORKSHOP MANUAL E ENGINE 90-93 ELECTRICAL 90-91 SERVICE SCHEDULES B4 TOOLS ELECTRICAL 92-93 ELECTRICAL 94-96 ENGINE 94-98 PARTS CATALOGUE 09 10 ELECTRICAL 97-98 20

An insight into Boost Control System Operation and Fault Diagnosis (post VIN 24519)

Applicable to

All Bentley Turbo R motor cars post vehicle identification number (VIN) *SCBZR04A0KCH24519*

Introduction

The purpose of this Product Support Information Sheet is to assist the workshop technician in understanding the principles of Electronic Boost Control Systems along with the correct methods of Fault Diagnosis, including:-

- 1.) Correct tools required.
- 2.) Initial questions to ask the customer in order to assist in the initial diagnosis.
- 3.) Basic checks to be carried out.
- 4.) In depth fault diagnosis flow diagrams.

The advent of electronic systems to control mechanical operations, ie. Engine Management, Boost Control etc., has improved the overall reliability of these systems. However, should a fault become noticeable, diagnosis can be difficult as electronic controls use electrical signals which cannot be seen visually; it is therefore important that the technician has a good working knowledge of the system being tested along with being conversant in the use of electronic test equipment.

Tools and equipment

In addition to the normal technician's tools, some special tools and equipment are required to check the operation of the Boost Control System when diagnosing faults.

These should include the following:

Digital multimeter (see fig.

E17-1

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E17-1 Digital multimeter E17-1)

This should be a good quality meter capable of accurately reading all three electrical parameters, volts, amps, ohms. It should have a minimum impedance of 10 MOhms. It is necessary for various functional checks and for fault diagnosis.

Mityvac vacuum pressure pump (see fig.

E17-2

001655

E17-2 Mityvac vacuum pressure pump E17-2)

This vacuum pump/air pressure pump is ideal for applying vacuum or pressure to components such as the dump valve switch and the air pressure transducers during basic checks.

Combination vacuum pressure gauge (see fig.

E17-3

001656

E17-3 Combination vacuum pressure gauge E17-3)

An accurate vacuum pressure gauge is used for checking the vacuum or pressure applied to components during basic checks.

Pressure gauges

Pressure and vacuum gauges are essential pieces of test equipment for the maintenance of modern cars.

Correctly used and understood, they enable a technician to check the following operational parameters of the boost control system of Bentley Turbo R cars from VIN 24519.

Boost pressure.

Air pressure transducer characteristics.

'Absolute' pressure and 'Gauge' pressure

It should be remembered that the ambient pressure of the atmosphere can have an effect on your readings.

Some gauges, referred to as 'Absolute' gauges are designed and calibrated to read the pressure from an absolute zero point.

Therefore, when they are exposed to ambient pressure, they will show a reading corresponding to the ambient air pressure of the surroundings. This will change as ambient pressure changes or if the gauge is moved to a lower or higher altitude.

Other gauges provide 'Gauge' pressure readings. These gauges are designed to read zero when exposed to ambient atmospheric pressure. Any reading recorded on such a gauge shows the pressure recorded in addition to the ambient pressure.

For example if the boost pressure of a car is set at 317 mB 'Gauge' pressure and the ambient pressure happens to be 1013 mB, then an 'Absolute' pressure gauge will read 1330 mB (317 mB + 1013 mB) while a 'Gauge' pressure gauge will show a reading of 317 mB (see fig.
E17-4

001657

E17-4 Comparison between 'Absolute' and 'Gauge' pressures E17-4).

Boost pressure checks

By connecting a pressure gauge into the inlet manifold pressure supply to the dump valve switch, (see fig.
E17-5

001658

E17-5 Pressure gauge connected to check turbocharger boost pressure E17-5), the following functions of the turbo- charging boost control system can be checked:

Boost pressure.

Dump valve operation.

Dump valve switch and solenoid operation.

Exhaust wastegate operation.

Air pressure transducer checks

By connecting a compound pressure gauge and Mityvac pressure vacuum pump to the air pressure transducer, (see fig.
E17-6

001659

E17-6 Compound pressure gauge and Mityvac pump connected to the boost control system air pressure transducer E17-6), a controlled pressure signal can be applied to the boost control system air pressure transducer to check the boost control solenoid operation.

Electrical test meters

Tests of the electrical components of the boost control system will invariably measure one or more of the three basic electrical properties, namely current (amps), potential difference (volts) and resistance (ohms).

To carry out such tests effectively it is important to use a good quality test meter. A poor meter can affect the results you obtain and can damage electronic components.

The ammeter (see fig.

E17-7

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E17-7 Using an ammeter to measure current flowing though a circuit E17-7)

The ammeter measures the electrical current flowing through the circuit. In order for it to do this it must be connected in series in the part of the circuit you are testing so that all the current flowing through the circuit to be tested actually passes through the meter. As the meter is effectively becoming part of the circuit, it is important that the meter does not consume any current itself. Therefore, a good quality ammeter will have a very low internal resistance, the lower the resistance the better the sensitivity.

The voltmeter (see fig.

E17-8

001661

E17-8 Using a voltmeter to measure potential difference in a circuit E17-8)

The voltmeter measures the difference in voltage (potential difference) between two points in a circuit. In order to do this it is connected in parallel with the part of the circuit or component which is being tested. In order that it does not affect the circuit being tested, it must not provide an alternative easier path for the electrical current to flow through. Therefore a good quality voltmeter has a very high resistance, the higher the resistance, the better the sensitivity.

The ohmmeter (see fig.

E17-9

001662

E17-9 Using an ohmmeter to measure the resistance of a component E17-9)

The ohmmeter measures the resistance of a component or part of the circuit using its own internal power source. It is connected in series with the component or circuit being tested. It is important that the circuit does not contain any outside electrical power source.

Digital multimeters

Electronic technology has provided the means for incorporating all three basic electrical meters into a single unit, the multimeter. However like all tools, it is possible to purchase good quality meters and poor quality meters, which is generally reflected in the price of the unit. Since modern electrical and electronic circuitry is sensitive to the type of meters used to test it, it is important to use a good quality meter when testing electrical functions.

Make sure that the specifications of any meter you use show that the ammeter has a very low resistance and that the voltmeter has a very high resistance.

Exhaust extraction

When a car engine is running, the gases issued from the exhaust tail pipe contain gases such as Carbon Monoxide which are extremely harmful to human beings.

If it is necessary to run the engine in a workshop, then it is most important to make sure that the exhaust gases are directed to a suitable point outside the workshop.

This can be achieved by connecting a suitable pipe or pipes to the car's exhaust tailpipes.

Some workshops are fitted with vacuum operated exhaust extraction devices which suck the exhaust out of the tailpipe and pump it to atmosphere at a suitable point.

These vacuum operated exhaust extraction devices must not be used on turbocharged cars. If they are, the vacuum may draw the oil past the oil seal in the turbine. If this occurs, it may cause permanent damage to the turbocharger and ultimately to the engine.

However, it is possible to use vacuum exhaust extraction systems where provision is made for them to draw ambient air as well as the exhaust. These systems reduce the "pull" through the vehicle exhaust system to acceptable levels.

Carbon Monoxide

A car's exhuast emits three main noxious gases, Carbon Monoxide (CO), Oxides of Nitrogen (NOX) and unburnt Hydrocarbons (HC).

Warning:
Of these, Carbon Monoxide is poisonous to man when inhaled. It is colourless, odourless and tasteless.

If Carbon Monoxide is inhaled into the lungs during the respiration process, it combines with the haemoglobin in the blood preventing oxygen entering the blood. If inhaled in sufficiently large quantities, it effectively suffocates the person by preventing the blood absorbing sufficient oxygen to meet the body's requirements.

In low concentrations, it causes headaches and slows down the body's mental and physical activity.

In high concentrations, it can cause unconsciousness and death.

As soon as the body is returned to fresh air, it will purge itself of the Carbon Monoxide in the lungs.

Hot exhaust systems

Exhaust systems and their components can reach extremely high temperatures, particularly around a turbocharger and the catalytic converters. Always ensure that the exhaust system is not hot before commencing work on a car.

Take care to avoid contact with exhaust components on a car when carrying out tests with the engine running.

Emergency treatment

If a case of Carbon Monoxide poisoning is suspected:

- 1.) Move the patient into fresh air immediately.
- 2.) If the patient has stopped breathing administer artificial respiration.
- 3.) Call for an ambulance.
- 4.) Keep the patient at rest and warm. If necessary, cover the patient to maintain warmth.

Be prepared to administer artificial respiration if the patient loses consciousness.

- 5.) Send the patient to hospital. Make sure he/she is accompanied by a proficient first aid person if an ambulance is not used.

Burns

In the event of a skin burn, immediatley administer the following emergency treatment:

- 1.) Do not remove any clothing over the burn.
- 2.) Run cold, clean water over the affected area.
- 3.) Do not burst any blisters.
- 4.) Do not apply any cream or oily preparation to the burned area.
- 5.) Cover the burned area, including any clothing, with a dry, clean, sterile dressing.
- 6.) Consult a medical centre or doctor as soon as possible after administering the above

emergency treatment.

Information gathering for fault diagnosis of a turbocharging boost control system

Useful questions to ask an owner and explanations

Answers to the following questions may prove useful when diagnosing a boost control system related fault.

Has the car been serviced or repaired recently?

If it has, then there is the possibility that a service operation has been carried out incorrectly. Referral to the appropriate service record may provide a possible cause.

When did you first notice the problem?

The length of time the fault has been present will indicate the seriousness of the fault.

Did the fault develop suddenly or over a period of time?

A fault which has developed suddenly is more likely to be the result of a traumatic failure such as an electrical wire breaking.

A fault which has developed over a period of time is more likely to be caused by progressive wear of a component or abrasion of a pipe.

Is the fault permanent or intermittent?

An intermittent fault is more likely to be caused by a fault within a wiring system than a mechanical failure of a component.

Does the car perform in a similar fashion to a normally aspirated car?

If it does, then it is most likely that there is a fault in the boost control system.

Do you fill the car up at a particular petrol station? Have you recently filled up elsewhere?

The knock sensing function of the boost control system is extremely sensitive. Using poor quality fuel will cause detonation.

The boost control system senses this and inhibits boost. This results in poor performance.

Simply replacing the fuel in the tank with some known good quality fuel may well restore the car's performance.

Have you noticed any other faults?

The boost control system electronic control unit receives input signals from the brake lights and speed control system.

A malfunction in either system could cause the boost control system to inhibit boost when it should not.

Are there any problems with starting?

If starting problems are being experienced, then it is likely that there is a fault in the ignition or fuel system.

Is the engine misfiring?

Misfiring is normally caused by faults within the fuel and ignition systems and not the boost control system.

Is detonation occurring?

Detonation, caused by excessive mixture leanness or advanced ignition, will cause the boost control system to inhibit boost pressure.

When the symptom is lack of power, a fault could exist in the fuel or ignition system causing detonation. The boost control system, operating correctly would then reduce boost pressure by stages to base pressure to overcome the detonation.

Is the car running hotter than normal?

Overheating can be caused by numerous faults in systems other than the boost control system, such as ignition timing retarded to far, an excessively lean air fuel ratio, poor air flow through the radiator or a restriction in the coolant passages. Again this will increase the incidence of detonation as overall combustion temperatures will be higher.

Preliminary visual inspection

This stage involves the visual inspection of systems and their components which could be the cause of the problem.

In the case of the turbocharging boost control system, reported faults are likely to relate to power loss.

Similar faults could be caused by the fuel injection and ignition systems.

Therefore, it is important that your preliminary visual inspection should also include an examination of the fuel injection and ignition systems' components.

Begin by checking the K-Motronic ECU for stored fault codes. Do this before you switch the battery master switch to off as any stored fault codes will be erased when you switch the battery off to carry out later checks.

The existence of a stored fault code may define the fault causing the complaint. The K-Motronic ECU does not store fault codes relating to the boost control system.

Next switch the battery off and then carry out a careful visual examination of the components, mechanical and electrical.

Look for obvious problems, particularly loose connections and damaged pipes or cables.

Inspection of air intake, manifold, pressure hose and pipe connections

The turbocharging system achieves its effect by increasing the quantity of air delivered to the combustion chambers.

A leak in any of the system's hoses, pipes and their connections may allow 'boosted' intake air to escape to atmosphere before it reaches the combustion chambers.

Alternatively, a leak or restriction could cause the malfunction of one of the system's components which is actuated by pressure or vacuum.

The following hoses, pipes and their connections should be checked:

Inlet manifold to dump valve switch

Inlet manifold to dump valve solenoid

Dump valve solenoid to dump valve

Inlet manifold to boost control APT

Inlet manifold to K-Motronic APT

Turbocharger to boost control solenoid

Boost control solenoid to wastegate

Air intake filter to turbocharger compressor inlet

Turbocharger compressor outlet to intercooler

Intercooler to air intake elbow

Dump valve to turbocharger compressor inlet

Check that:

All hoses, pipes and connections are secure and correctly clipped.

All hoses and pipes are in good condition with no abrasions, evidence of leaks or restrictions.

All hoses and pipes are fitted in their correct positions.

Inspection of electrical connection points

Poor electrical connections account for a large percentage of faults.

The electrical wires and connections to the following components should be checked:

Air flow sensor potentiometer

Boost control air pressure transducer

Boost control ECU parameter code socket

Boost control ECU socket

Boost control solenoid

Boost control solenoid 2-way plug and socket

Dump valve solenoid

Dump valve solenoid 2-way plug and socket

Dump valve switch

Dump valve switch 4-way plug and socket

Electro-hydraulic actuator

Engine reference sensors

High tension leads

Ignition amplifiers

Ignition coils

Ignition distributor

K-Motronic air pressure transducer

K-Motronic ECU parameter code socket

K-Motronic ECU socket

Knock sensors

Left-hand valance 12-way plug and socket

Right-hand valance 7-way plug and socket

Spark plugs

Throttle position switch

Check that:

All the electrical connections are secure and in good condition.

All relevant electrical wiring connections are in their correct positions.

All relevant electrical wiring is in good condition.

Parameter code sockets are correctly configured.

Any new or substituted wiring is the correct size and length.

Any new or substituted wiring is connected correctly.

Basic ignition and fuel injection system checks

If no obvious faults are apparent, check

- *) that the engine is running on all eight cylinders, evenly
- *) the ignition timing (idle and part load map)
- *) the idle mixture CO concentration before commencing with the procedures listed in the boost control system fault diagnosis charts.

Cars fitted with catalytic converters

(refer to table: 4736e17e_0001)

Cars not fitted with catalytic converters

(refer to table: 4736e17e_0002)

Note:
On fuel injected cars, the mixture has a tendency to 'lean off' during the first 80 to 160 kms (50 - 100 miles) after the system has been disturbed, resulting in loss of performance. Refer to Product Support Information Sheet K16 (TSD 4736) which explains the cause and appropriate service action.

Boost pressure check

In the case of turbocharger boost control system, a boost pressure check is an important part of fault diagnosis as it shows exactly what is happening to the boost control system under actual running conditions and can provide evidence of malfunctions.

Warning:
Do not attempt to carry out this test with the car stationary as it will cause strain on the engine, transmission and brakes. When the system is operating correctly, boost build up is inhibited by the brake inhibit function responding to the illumination of the brake lights.

Warning:
Therefore, the check must be carried out during a road test.

Ideally a set of figures obtained from a car known to be operating to specification should be available for comparison.

It is beneficial if technicians have previous experience of boost pressure gauge reactions for cars operating to specification and operating at base pressure.

Equipment/tools required

A combination vacuum pressure gauge.

A 'T' piece (A windscreen washer 'T' piece is suitable).

A short connecting hose (Internal diameter 3mm, 0.125 in), (see fig.
E17-11

001664

E17-11 Boost pressure gauge connection E17-11, X).

A long connecting hose, long enough to reach the saloon from under the bonnet (Internal diameter 3mm, 0.125 in), (see fig., E17-11, Y).

Note:
The test requires simultaneous observation of needle reactions on the boost pressure gauge and tachometer. The task can be made easier by mounting a tachometer and the boost pressure gauge side by side on a small piece of board which can be held during the test by the observer.

Connection (see fig.
E17-11
001664
E17-11 Boost pressure gauge connection
E17-12
001665
E17-12 Boost pressure gauge hose routing E17-11 and E17-12)

- 1.) Disconnect the signal hose from the dump valve vacuum switch.
- 2.) Connect the signal hose to one arm of the 'T' piece.
- 3.) Connect the other arm of the 'T' piece to the dump valve vacuum switch using the short piece hose (see fig.
  E17-11

  001664

  E17-11 Boost pressure gauge connection E17-11, X).
- 4.) Connect the pressure gauge to the remaining arm of the 'T' piece using the long piece of hose (see fig.
  E17-11

  001664

  E17-11 Boost pressure gauge connection E17-11, Y).

- 5.) Make sure that all the connections are tight and leakproof.
- 6.) Carefully route the hose through the passenger side front window (see fig. *E17-12*

001665

E17-12 Boost pressure gauge hose routing E17-12).

- 7.) Cover the paintwork on the scuttle by the left-hand rear corner of the bonnet to prevent it being damaged by the hose.
- 8.) Making sure that the hose does not foul any engine components and is not unduly compressed, carefully close the bonnet.
- 9.) Carry out a road test.

Road test

The road test requires two people, one to drive the car, the other to observe the gauges and record the performance.

Warning:
For safety, do not attempt to carry out this test on your own.

Ideally, the test should be carried out on a private road or test track.

It is most important at all times, to observe all the applicable traffic legislation, particularly road speed limits. At the same time consideration must be given to other road users and every effort must be made to avoid causing incidents.

Tests, described on pages E17-7, E17-8, E17-9 and E17-11 enable the following functions of the boost control system to be checked:

Full Load Boost Pressure Characteristics

Braking System Inhibit Function

Try to emulate any fault described by the owner unless it is unsafe to do so.

By comparing your road test results with the figures of a known good car you will be able to assess the fault more accurately.

Full load boost pressure characteristic test

This test observes the reaction of the boost control system when it is operating at full load.

Select Intermediate and subject the car to a full throttle acceleration from rest while the observer watches the boost pressure gauge and tachometer and notes down his observations.

The action happens very rapidly. Therefore, it may be necessary to repeat the test two or more times to see what is happening.

Full load boost pressure characteristic graphs

Boost pressures recorded during a full load boost characteristic test should be seen to be similar to the characteristics shown in the graphs in figure
E17-13

001666

E17-13 Boost pressure graphs

A	Cars not fitted with catalytic converters
B	Cars fitted with catalytic converters
C	Base pressure curve
*	'Gauge' readings at atmospheric pressure 1013 mB, all other pressure readings are 'Absolute'

E17-13.

However, the transmission will shift up from Low to Intermediate during the test. During the upshift, the engine speed reduces as the higher gear is engaged and then begins to climb again. At the time of the upshift, the engine speed (approx. 4000 rev/min) is at a point where boost pressure is decreasing due to the wastegate opening. As the engine speed falls, the boost pressure will increase

again in line with the appropriate boost characteristic until the engine speed begins to increase again.
Figures
E17-14
001667
E17-14 Boost pressure graph - Full load characteristic - Car not fitted with catalytic converters
E17-15
001668
E17-15 Boost pressure graph - Full load characteristic - Car fitted with catalytic converters
E17-14 and E17-15, in which the actual events are plotted against time, show what will be seen on the gauge during the tests if the system is operating to specification.

The bottom axis of each graph is the actual elapsed time or 'time code' (in minutes and seconds). The vertical axis refers to the manifold depression/pressure which is measured in millibars (gauge) and the engine speed in rev/min.

Full load characteristic, car not fitted with catalytic converters (see fig. *E17-14*

001667

E17-14 Boost pressure graph - Full load characteristic - Car not fitted with catalytic converters E17-14)

Figure E17-14 shows the graph plotted from the results obtained in the full load test for a car not fitted with catalytic converters.

At the start of the test, (Time code - 9 min: 50 sec:), the engine is idling at 600 rev/min with a manifold depression of 620 mB (gauge).

Immediately the throttles are opened, (9:50), (A), the manifold depression falls away extremely rapidly. Approximately 1 second later (9:51), (B), the transition to boost occurs as the boost pressure gauge needle crosses the zero point on the scale. At this point the engine speed is 2000 rev/min.

Boost pressure and engine speed continue to increase rapidly until the wastegate begins to open (9:54), (C), when the engine speed is 3000 rev/min and boost pressure is 475 mB gauge.

At 9:57, (D), the transmission changes up from low to intermediate. Engine speed falls from 4275 rev/min to 3150 rev/min before beginning to climb again. At the same time boost pressure begins to rise again as the wastegate closes slightly before opening again at 10:02.

Between 10:04 and 10:06, (E), it can be seen that boost pressure does not conform to specification. This is due to the boost control system reacting to the occurrence of detonation which, in this case, was attributed to a combination of poor quality fuel and ambient conditions.

At 10:06, the throttles are released. The inlet manifold pressure changes rapidly from a boost pressure of +100 mB to a depression of -800 mB (10:06), (F), in fourteen twenty-fifths of a second. As this happens, the dump valve opens to recirculate boosted air delivered by the turbocharger compressor to the air intake. Engine speed then falls slowly as the car decelerates on overrun without braking.

Full load characteristic, car fitted with catalytic converters (see fig. *E17-15*

001668

E17-15 Boost pressure graph - Full load characteristic - Car fitted with catalytic converters E17-15)

Figure E17-15 shows the graph plotted from the results obtained in a similar full load test for a car which was fitted with catalytic converters.

The gauge reaction is similar to that shown in figure
E17-14

001667

E17-14 Boost pressure graph - Full load characteristic - Car not fitted with catalytic converters

E17-14 for a car not fitted with catalytic converters. Starting from idle (14:34), with a manifold depression of -625 mB at 600 rev/min, the throttles are opened and manifold depression falls away rapidly, (A). The transition to boost occurs about a second later (14:35), (B), when the engine speed is 2000 rev/min and the pressure continues to climb rapidly until the wastegate begins to open (14:39), (C), at a boost pressure of 400 mB (gauge) at 2900 rev/min.

The engine speed falls as the transmission shifts up (14:42), (D), when the wastegate closes again slightly. The test ends at 14:51 when the throttles are released and the inlet manifold pressure drops from a boost pressure of +100 mB to -800 mB in about a second, (F).

Again detonation occurred between 14:49 and 14:51, (E).

Fault condition - Base pressure

Base pressure characteristic, car fitted with catalytic converters (see fig.
E17-16

001669

E17-16 Boost pressure graph - Boost control system operating at base pressure E17-16)

Figure E17-16 shows the graph plotted from the results obtained in a test where the boost pressure system was operating at base pressure. This was achieved by disconnecting the boost control solenoid 2-way plug and socket. The wastegate is subjected to the full boost pressure signal throughout the engine's operation.

As with previous tests, the idling condition is 600 rev/ min, -600mB (15:23), (A). The initial reaction to throttle opening is similar to a turbocharged engine operating correctly with the transition to boost occurring about a second after the throttles are opened when the engine speed reaches 2000 rev/min.

However as the engine speed reaches 2400 rev/min the wastegate opens fully (15:25), (B), to limit boost pressure to 160 mB throughout the test until 15:41, (D), when the throttles are released. During the test, the transmission upshift occurred at 15:32, (C).

The graph for a car not fitted with catalytic converters would appear very similar, except that maximum boost would be achieved at a lower engine speed and earlier in the test.

Fault condition - Wastegate remains closed

Wastegate fully closed, car fitted with catalytic converters (see fig.
E17-17

001670

E17-17 Boost pressure graph - Wastegate remains closed E17-17)

Figure E17-17 shows the graph plotted from the results obtained in a test where the wastegate was stuck closed throughout the test. Starting with a depression of -450 mB at 1200 rev/min, (A), manifold pressure rose rapidly with engine speed going off the scale until it reached an estimated 700 mB at 3200 rev/min (07:45), (B). At this point the dump valve opened as a safety valve to recirculate the boosted air back to the turbocharger intake. The dump valve remained open for the remainder of the test.

Fault condition - Engine speed signal missing

Engine speed signal missing, car not fitted with catalytic converters (see fig.
E17-18

001671

E17-18 Boost pressure graph - Engine speed signal missing E17-18)

Figure E17-18 shows the results obtained during a test in which it was found that the boost control system electronic control unit was not receiving an engine speed signal from the K-Motronic electronic control unit due to an open circuit in the appropriate wire.

Starting with a depression of -500 mB at 1100 rev/min (17:34), (A), manifold depression falls away rapidly as engine speed increases. At 2000 rev/min (17:38), (B), the transition to boost occurs and boost pressure continues to rise with engine speed until the wastegate begins to open at 3100 rev/min, (17:40), (C). Boost pressure then falls suddenly to base pressure, (D), where it remains throughout the remainder of the test while the engine was under full load. As soon as the load was relieved, the system appeared to reset itself and the same results were observed when the test was repeated.

Braking system inhibit function test

This test checks that the boost control system electronic control unit is inhibiting the boost pressure to base pressure when the brakes are applied.

Procedure

To carry out this test, select Intermediate gear. Lightly feather the brakes so that the brake lights just illuminate and, at the same time, depress the accelerator, then release the brake pedal. Do not apply excessive brake pressure during the test as such action will impose unreasonable stresses on the brakes and transmission.

Boost pressure gauge reaction

If the braking inhibit function is operating correctly, the reaction of the needle on the boost pressure gauge for a car not fitted with catalytic converters should be similar to that shown in figure
E17-19

001672

E17-19 Boost pressure graph - Braking system inhibit function operating correctly

A	Brake pedal applied, accelerator pedal being depressed
B	Brake pedal released

E17-19.

During the time that the brake pedal is depressed (A), the boost pressure increases with engine speed up to the base pressure curve where it remains until the brakes are released.

Immediately the brake pedal is released (B), the boost pressure increases almost instantaneously to the full load characteristic curve.

Explanation

The gauge reaction illustrates the operation of the braking system inhibit function.

Boost pressure is not required whenever the car's brakes are applied.

When the brakes are applied, the circuit to the brake lights is closed, illuminating the brake lights.

At the same time a system's voltage signal is supplied by the brake light system to pin 20 of the boost control ECU.

This causes the ECU to remove the positive voltage signal to the boost control solenoid. Spring pressure closes the solenoid valve so that the full boost pressure signal is applied to the wastegate causing it to open according to the base pressure characteristic curve.

If for some reason, such as broken connection, the brake light signal was not present, the boost control ECU would not recognize when the brakes were applied.

In this instance boost pressure would increase in line with the full load curve and not as shown in figure
E17-19

001672

E17-19 Boost pressure graph - Braking system inhibit function operating correctly

A	Brake pedal applied, accelerator pedal being depressed
B	Brake pedal released

E17-19.

Should this action be experienced during a boost pressure test, then the test should be aborted immediately and the boost control and braking systems should be checked to determine the cause of the missing braking system signal.

Engine Fault Diagnosis Chart - Possible Causes of Fault

(refer to table: 4736e17e_0003) (refer to table: 4736e17e_0004)

Engine Fault Diagnosis Chart - Possible Causes of Fault, K-Motronic Engine Management System @ Emission Control Systems

(refer to table: 4736e17e_0005)

Engine fault diagnosis chart - Turbocharging boost control and K-Motronic engine management systems

This chart is designed to assist with the diagnosis of turbocharging boost control system and engine management system related faults which may occur on turbocharged engines.

It is assumed that the engine is mechanically correct, i.e all cylinder compressions are equal within specification.

The chart lists the faults which may be experienced and suggests possible causes of each fault.

When diagnosing a fault, the appropriate 'possible' causes should be considered in conjunction with other evidence of the fault together with the theoretical opera- tion of the turbocharging boost control and K-Motronic engine management systems.

The letter/digit code, e.g. A1, B4, C22, etc., refers to the lists appearing within the Engine fault diagnosis charts.

Preliminary checks - when shown

Although preliminary checks listed below may not necessarily be the prime cause of the fault, they should be checked first as they are the least disruptive operations.

Preliminary checks

A1, A2, A3, A12, A20, A22, A25, A30, A35, A39, A40, A42, A44, A46, A48, A49, A50, A51, A53, B3, B4, B5, B6, B15, B17, B19, B23, B27, B30, B33, B37, C1, C4, C21, C22, C32, C33, C54, C56, C58, C60, C62, C64, C66, C68, C70, C72, C74, C76, C79, C83, D1, D2, D4, D8, D10, D13, D26, D30, D33, D34, E6, E8, E17, E19.

Note:
Additional explanations regarding the effects of open/short circuits in the boost control electrical systems will be found on pages E17-28 to E17-34. Additional explanations regarding the effects of leaks/blockages in the boost control hose/pipe connections and malfunctions of the systems components will be found on pages E17-35 and E17-36.

A Full load boost pressure gaugue test

This part of the chart is designed to assist with turbo- charging system fault diagnosis where a full load boost pressure characteristic test is carried out.

The chart lists the abnormal "full load" gauge reactions and other conditions which may be observed during the test and suggests possible causes of each abnormal gauge reaction.

Full load boost pressure follows normal reaction but pressure is lower than normally expected, throughout test

A1, A2, A3, A4, A6, A7, A8, A10, A11, A32, A33, A34, A35, A41

Full load boost pressure follows normal reaction but pressure is higher than normally expected, throughout test

A26, A27, A29, A30, A31, A32, A33, A34, A36, A37, A38,

Full load boost pressure normal reaction for catalyst equipped car experienced on non-catalyst equipped car

A33, A34

Full load boost pressure normal reaction for non-catalyst equipped car experienced on catalyst equipped car

A33, A34

Full load boost pressure follows normal reaction but pressure varies between normal pressure and base pressure at high engine speeds

A34, A45, A46, A47, A52, A53, B1, C1, D1

Full load boost pressure conforms to base pressure curve

A32, A33, A35, A36, A37, A40, A45, A46, A47, A48, A50

Full load boost pressure build up poor, not exceeding base pressure until 4000 rev/min when boost pressure rises momentarily to about 500 mB

A33, A35

Full load boost pressure rises with engine speed to maximum off scale and remains there until engine load is relieved

A13, A26, A27, A29, A30, A31, A32, A33, A36, A37, A38, A39, A40, A41, A42, A43, A44

Full load boost pressure rises with engine speed to maximum 200 mB

A44

Full load boost pressure increases almost to normal maximum then quickly falls to base pressure and remains at base pressure until engine load relieved. The condition is repeated each time full load is applied.

A52, A53

Manifold depression only recorded

A2, A4, A5, A6, A8, A10

Part load boost pressure at lower than 'normally experienced'

A1, A2, A3, A4, A6, A7, A8, A10, A11, A12, A13, A15, A17, A25, A26, A28, A32, A33, A35, A36, A37, A40, A41, A44

Boost pressure not inhibited when brakes applied

A48, A49

Boost pressure not inhibited when speed control system engaged

A50, A51

001673

Preliminary checks and conditions - Fault diagnosis flow chart

Notes concerning "Preliminary checks and conditions" fault diagnosis chart

- 1.) The recommended fault diagnosis procedure has been developed to make a technician's diagnosis of a fault as easy and complete as possible, taking into account accessibility of components and ease of testing.
- 2.) Although designed to operate at voltages corresponding to partly charged batteries, electronic systems are susceptible to fluctuations in voltage supply. Ensuring that the battery is fully charged will make sure that the electronic control unit will operate correctly unless it is faulty.
- 3.) The voltage and current values measured in an electronic control system require an accurate meter.
- 4.) Breaking a connection of a wire which is live causes high voltage spikes which can cause damage to an electronic control unit.
- 5.) Normally, each test is carried out in isolation to the one preceding it or following it. If wires are left disconnected after a test, their continued disconnection may affect the results of the next test. As a general rule always return a circuit to normal immediately after each specific check unless specifically instructed not to.

- 6.) In many cases, faults are caused by loose or poor electrical connections. With the exception of the boost control electronic control unit most of the important connections in the boost control electrical circuits can be checked after opening the bonnet.
- 7.) Reconnect or repair any fault connections before proceeding with the other tests. This will ensure the integrity of all the electrical connections.
- 8.) When the engine is running, the boost control system electronic control unit regulates turbocharger boost pressure by supplying a variable 12Hz mark space (duty cycle) voltage signal to the boost control solenoid, which controls the boost signal delivered to the wastegate. This duty cycle signal can be recognized by a 'clicking' sound coming from the solenoid. It should not be present when the ignition is on with the engine stationary, or when the boost control unit is in one of the inhibit modes.

Switching the ignition on and listening for the clicking of the solenoid is a good initial check.

Presence of a clicking sound after 10 seconds indiactes the presence of a fault in the system.

- 9.) Switch off the ignition first. Insert the voltmeter positive probe into the back of the socket to measure the voltage at the pink green cable.

This test confirms that the electronic control unit is supplying the boost control solenoid with a voltage signal.

- 10. Switch the ignition off. Check the continuity (electrical integrity) of the cables in the boost control circuit:
- (a) pink green cable from the boost control unit pin 12 to the boost control solenoid 2-way plug and socket.
- (b) black cables (supply and earth return) from the boost control solenoid 2-way plug to the solenoid.
- (c) black cable (earth return) from the boost control solenoid 2-way plug to earth.

Check for continuity in the boost control solenoid and the boost control solenoid 2-way plug connections.

Replace any faulty wiring or connections.

- 11. There are two identical air pressure transducers which are mounted together. When the cars leave the factory:

The upper air pressure transducer is normally connected by a grey coloured plug, which has 4 cables, to the boost control electronic control unit to provide it with a boost pressure feedback signal.

The lower air pressure transducer is normally connected by a black coloured plug, which has 3 cables, to the K-Motronic electronic control unit to provide it with a boost pressure signal.

During service, however, it is possible for these connections to be reversed.

- 12. Make sure the ignition is switched off. Insert the voltmeter positive probe into the back of purple brown connection to air pressure transducer. Connect the voltmeter negative probe into the back of black connection. Switch the ignition on. The air pressure transducer is supplied with a constant input voltage between 4.95 and 5.05 Volts whenever the ignition is switched on.
- 13. Carry out the checks detailed on page E17-25.
- 14. Make sure the ignition is switched off. Insert the ohmmeter positive probe into back of black connection to air pressure transducer. Connect the ohmmeter negative probe to the earth point for the cable. Alternatively, insert a voltmeter positive probe into back of black connection to air pressure transducer. Connect the voltmeter negative probe to the earth point for the cable. Switch the ignition on. 0.05 Volts indicates cable continuity and acceptable voltage drop in cable. Switch the ignition off.
- 15. Carry out the checks detailed within the Preliminary checks and conditions fault diagnosis flow chart.

001674

Boost control system air pressure transducer (APT) - Fault diagnosis

flow chart

Notes concerning "Boost control system air pressure transducer (APT)" fault diagnosis chart

- 1.) There are two identical air pressure transducers which are mounted together. When the cars leave the factory:

The upper air pressure transducer is normally connected by a grey coloured plug, which has 4 cables , to the boost control electronic control unit to provide it with a boost pressure feedback signal.

The lower air pressure transducer is normally connected by a black coloured plug, which has 3 cables, to the K-Motronic electronic control unit to provide it with a boost pressure signal.

During service, however, it is possible for these connections to be reversed.

- 2.) Make sure the ignition is switched off. Insert the voltmeter positive probe into the back of the purple brown connection to air pressure transducer. Connect the voltmeter negative probe into the back of black connec- tion. Switch the ignition on. The air pressure transducer is supplied with a constant input voltage between 4.95 and 5.05 Volts whenever the ignition is switched on.
- 3.) When the boost control system ECU is operating correctly the voltage output at pin 9 should be 4.95 - 5.05 Volts. If the voltage is correct, there is a fault in the purple brown cable between the boost control system ECU and the air pressure transducer. If the voltage is not within specifications, there is a fault within the voltage supply circuit to the boost control system ECU.
- 4.-5. These checks ensure that the boost control system ECU is receiving a satisfactory systems voltage supply.
- 6.) A high resistance in this cable will result in a lower than specification voltage supply to the air pressure transducer.
- 7.) Make sure ignition is switched off. Insert the ohmmeter positive probe into back of black connection to air pressure transducer. Connect the ohmmeter negative probe to the earth point for the cable.
- 8.) Insert a voltmeter positive probe into back of black connection to air pressure transducer. Connect the voltmeter negative probe to the earth point for the cable. Switch the ignition on, 0.05 volts indicates cable continuity and acceptable voltage drop in cable. Switch the ignition off.
- 9.) Make sure the ignition is switched off. Insert the voltmeter positive probe into the back of green slate connection to air pressure transducer. Insert the voltmeter negative probe into the back of the black connection to air pressure transducer. Start the engine and let it idle (at normal operating temperature).

This test checks the output voltage from the air pressure transducer when the engine is in a no load condition.

0.6 - 1.0 Volts is the correct range for the output when the manifold depression is approximately 300 mB - 400 mB absolute. Switch the engine off after test.

- 10. The output voltage from the air pressure transducer is proportional to the absolute pressure applied to it. A blockage in the signal pipe will cause an incorrect signal.
- 11. Switch off ignition before connecting voltmeter. Insert positive probe into back of green/slate connection to air pressure transducer. Remove back of boost control system electronic control unit plug. Make sure that the boost control system electronic control unit plug is plugged into the control unit. Insert negative probe into back of connection to pin 10 (green/slate). Switch the ignition on. 0.05 Volts indicates cable continuity and acceptable voltage drop in the cable. Switch the ignition off again.
- 12. Make sure the ignition is switched off. Insert the voltmeter positive probe into back of green/slate connection to air pressure transducer. Connect the voltmeter negative probe to earth.

This test checks the output voltage from the air pressure transducer at atmospheric conditions.

2.2 - 2.8 Volts is the correct range for the output when the ambient pressure is approximately 950 mB - 1200 mB. Switch the ignition off after test.

- 13. Previous tests have shown the APT to be operating satisfactorily. However the manifold vacuum pressure signal received by the air pressure transducer may be outside specifications as a result of a blockage, restriction or leak in the hose and pipe connecting the air pressure transducer to the inlet manifold.

001675

Boost control solenoid valve - Fault diagnosis chart

"Boost control solenoid valve" fault diagnosis chart

Additional notes

- 1.) The boost control solenoid valve has three ports:

The inlet connected to the turbocharger compressor (see Page E17-21, A-1).

the outlet connected to the wastegate (see Page E17-21, A-2).

the vent port (see Page E17-21, A-3).

A solenoid controlled valve inside the assembly opens or closes the vent port. The solenoid is spring loaded towards the closed position.

- 2.) When no voltage is applied to boost control solenoid valve which is operating correctly, the valve inside the assembly closes the vent port, leaving the other two ports connected.
- 3.) When systems voltage is applied to a boost control solenoid valve which is operating correctly, the valve inside the assembly opens the vent port. All three ports are connected together.
- 4.) If the plug is disconnected from the air pressure transducer, the circuit from pin 9 in the boost control system ECU becomes an open circuit. The boost control system ECU recognizing this 'malfunction' automatically issues a set duty cycle causing the boost control solenoid to click as the valve opens and closes.
- 5.) 3.6 Volts is representative of the safety duty cycle issued by the boost control system electronic control unit when a fault exists in the connections to the boost control system air pressure transducer.
- 6.) This test eliminates an open circuit in the harness between the boost control system air pressure transducer and the boost control system electronic control unit.
- 7.) The electrical resistance of a component increases as temperature increases. Anticipate higher readings if you are testing a hot car.

001676

Wastegate and Dump valve - Fault diagnosis flow chart

"Wastegate and Dump valve" fault diagnosis chart

Additional notes

- 1.) The wastegate is held closed by a spring and opened by a boost pressure signal applied to the diaphragm inside the wastegate. The magnitude of the signal is regulated by the boost control solenoid under the control of the Boost control system ECU. Any restriction or blockage in the pipes carrying this signal to the wastegate will reduce the signal causing the wastegate to remain closed when it should be open.
- 2.) The wastegate opens fully when the air pressure applied to its diaphragm is greater than 0.41 bar. If this pressure is applied suddenly and released suddenly, the valve should be heard to open and close.
- 3.) This test checks the operation of the dump valve circuit using a controlled vacuum signal in place of the manifold depression to operate the dump valve switch.
- 4.) When atmospheric pressure is applied to the dump valve switch, it remains open, de-energising the dump valve solenoid. The dump valve solenoid is spring loaded to the closed position. When the solenoid is de- energised, it connects the outlet and therefore the dump valve to atmospheric pressure and the dump valve remains closed.
- 5.) When operating correctly, the dump valve switch closes between 0.4 bar and 0.47 bar (12 -

14 in Hg.), energising the dump valve solenoid. This connects the dump valve to the manifold depression, opening the dump valve.

- 6.) When operating correctly, the dump valve switch opens between 0.4 bar and 0.42 bar (12 - 12.5 in Hg.), de-energising the dump valve solenoid. This connects the dump valve to the atmosphere, closing the dump valve.

001677

Brake lamps, Cruise control and Knock sensors - Fault diagnosis chart

"Brake lamps, Cruise control and Knock sensors" fault diagnosis chart

Additional notes

- 1.) The boost control system is designed to improve engine performance during engine load conditions. Full boost pressure is not required if the brakes are applied or if the cruise control system is activated. To ensure that boost is inhibited in these conditions, the boost control system ECU receives systems voltage signals from each of the systems when the systems are operational.
- 2.) The boost control system ECU uses a systems voltage signal from the brake lamps to indicate that the brakes are applied. If a short circuit occurs in the brake lamps circuit which causes the lamps to illuminate even though the brakes are released, the boost control system ECU will interpret the signal from the incorrectly illuminated brake lamps as a 'brakes applied' signal and inhibit boost pressure to base pressure causing poor performance.
- 3.) This test ensures that the boost control system ECU is receiving the correct signal from the brake lamps circuit.
- 4.) The boost control system ECU uses a systems voltage signal from the cruise control system to indicate that the cruise control is activated. If a short circuit occurs in the cruise control circuit which causes signal to be present even if the cruise control is switched out, the boost control system ECU will interpret the signal as a 'cruise control activated' signal and inhibit boost pressure to base pressure causing poor performance.

Disconnecting the cable through which the system voltage signal is delivered to the boost control system ECU prevents the boost control system ECU from receiving a 'cruise control activated' signal either false or correct. If normal performance is restored during this test, then there is fault in the cruise control system.

- 5.) At this point we have eliminated all the components and systems which could cause the boost control system to malfunction except the knock sensing system.

Turbocharging boost control system operation

An electronically controlled system, comprising an electronic control unit, sensors and a boost control solenoid, controls the output of the turbocharger by regulating the action of the exhaust gas wastegate.

The system can be effectively considered as a closed loop control system, the operation of which can be modified in response to particular circumstances.

The primary closed loop consists of the engine's exhaust, the exhaust wastegate, the turbocharger and the boost control solenoid.

The exhaust drives the turbocharger turbine generat- ing boost pressure in the compressor. A boost pressure signal is fed via the boost control solenoid to the exhaust wastegate which in turn controls the amount of exhaust flowing through the turbocharger.

A secondary loop comprising the air pressure transducer and electronic control unit controls the operation of the boost control solenoid.

While the engine is idling the turbocharger compres- sor delivers a boost pressure signal to the boost control solenoid.

At the same time a boost pressure signal is supplied to the electronic control unit via the air pressure transducer. The electronic control unit issues a duty cycle signal to the boost control solenoid causing it to vent most of its compressor signal to atmosphere. The boost signal delivered to the wastegate is not sufficient to open it.

As the engine speed increases, more exhaust gas is generated, which increases the speed and output of the turbocharger. The boost signal through the boost control solenoid to the wastegate increases, causing it to open progressively in line with the increase in engine power output to a predetermined level.

The electronic control unit operates on a digital basis and receives signals from the following sensors:

K-Motronic ECU	- Engine speed
Air pressure transducer	- Instantaneous boost pressure
Engine knock sensors (2)	- Detonation
Brakes	- Brakes applied
Speed Control	- Speed control engaged

The electronic control unit compares the signals it receives from the sensors with data programmed into its memory in the form of a boost control map which relates engine speed and load to boost pressure.

As an output, the electronic control unit issues a duty cycle signal to the boost control solenoid valve. This adjusts the boost pressure signal to the exhaust gas wastegate by bleeding a proportion of the signal to atmosphere, thereby causing the wastegate to open or close to achieve the required boost pressure.

A knock sensing system continually checks for detonation, which can be caused by low humidity, high ambient temperatures and the use of low grade fuel. If this occurs, the electronic control unit reduces boost pressure until the detonation ceases. This system operates on the basis that the knock sensors supply the electronic control unit with a continuous signal indicating all the engine noise. The control unit is programmed with engine noise data which it uses to filter basic engine noise out of the incoming signal. Any spikes caused by detonation are then easily recognized by the control unit.

Boost is limited to a predetermined maximum even if detonation does not occur. This is important especially with a cold engine as enormous amounts of boost could be processed by the engine without detonation. The resultant extremely high combustion pressures could cause serious damage to the engine.

Additional functions prevent the build up of normal boost when either the brakes are applied or when the cruise control system is activated.

Boost pressure is governed by the quality of the fuel available. In general, the higher the octane rating the higher the boost pressure can be allowed to go.

Boost pressure is also governed by the ambient temperature as this is directly proportional to the inlet temperature, which in turn affects the overall combustion temperature.

Boost pressure can be adjusted by the boost electronic control unit in line with engine speed and load by using a pre-programmed map. The characteristics of this map are designed to keep boost pressure just low enough to prevent detonation occurring under normal operating conditions.

Cable	**From**	**Cable Colour**	**To**
A	Fuse supply fuse B3 Fuseboard 1, 15A	Pink/White	Dump valve solenoid
B	Dump valve solenoid	White/Light Green (Changes to Brown at plug and socket connection)	Dump valve vacuum switch
C	Dump valve vacuum switch	Black	Earth (Ground)
D	Boost control solenoid	Black	Earth (Ground)
E	LH valance 12-way plug	White/Light Green	Dump valve vacuum

	and socket		switch
F	LH valance 12-way plug and socket	White/Light Green (Changes to Black/ Yellow at diode)	Purge cut-off solenoid
G	Air pressure transducer (pin 3)	Black	Earth (Ground)

Boost control system electrical connections to the electronic control unit

Effect of faulty circuit

Additional notes

- 1.) Electrical cables connected to electronic control units can act as aerials, picking up spurious signals emitted by other sources. The shield layer in the cables connected between the knock sensors and control unit is connected to an internal earth (ground) in the ECU. This ensures that any such signals picked up by the shield, providing that they are not overwhelming will be dissipated to earth, so that they do not interfere with the signal from the knock sensor signal.
- 2.) All turbocharged motor cars from VIN 24513 to VIN 31004 are fitted with the same boost pressure control electronic control unit, which is programmed with two sets of boost pressure characteristics.

One set is used for cars not fitted with catalytic converters, where peak boost pressure at full load at 2750 rev/min is 1440 mB (Absolute), 380 - 480 mB (Gauge) depending on ambient conditions.

The other set is used for cars fitted with catalytic converters, where peak boost pressure at full load at 2750 rev/min is 1330 mB (Absolute), 270 - 370 mB (Gauge) depending on ambient conditions.

The appropriate programme in the electronic control is selected during production be either fitting or not fitting a link into the parameter code socket which is connected between pins 5 and 6 of the control unit.

On cars fitted with catalytic converters, the link is fitted to the parameter code socket to complete the electrical circuit between pins 5 and 6. This action connects pin 6 of the control unit to earth via the earth cable connected to pin 5.

On cars not fitted with catalytic converters, the link is not fitted to the parameter code socket. The absence of a link creates an open circuit at pin 6 of the ECU.

- 3.) A short circuit of this cable to earth is the equivalent of having a link fitted to parameter code socket. The electronic control unit will use the characteristics programmed for cars fitted with catalytic converters, i.e. peak boost pressure at full load at 2750 rev/min will be 1330 mB (Absolute), 270 - 370 mB (Gauge) depending on ambient conditions. The car's full load acceleration would be poorer than normally expected.
- 4.) An open circuit in this cable is the same as removing the link fitted to parameter code socket.

The electronic control unit will use the characteristics programmed for cars not fitted with catalytic converters, i.e. peak boost pressure at full load at 2750 rev/min will be 1440 mB (Absolute), 380 - 480 mB (Gauge) depend- ing on ambient conditions.

If a car fitted with catalytic converters is driven with the boost control system operating as for a non-catalyst equipped car, the boost pressure will be greater than normal specification. However, the ignition map for catalyst equipped cars has a greater degree of advance when compared with the non-catalyst car. This will cause detonation. The knock sensing circuit will sense this and will cause the boost to fluctuate and generally reduce overall performance.

- 5.) The air pressure transducer converts the manifold pressure/depression into an electrical signal, which enables the boost control ECU to monitor changes made to the boost pressure by the control system. The air pressure transducer operates like a potentiometer. It is supplied with a constant voltage by the boost control electronic control unit which is used to produce an output signal back to the control unit. The manifold pressure/ depression acting on a diaphragm inside the transducer causes a change in the output signal which is propor- tional to the 'absolute' pressure.

- 6.) The boost control ECU registers an output voltage to the air pressure transducer and a zero volts signal from the air pressure transducer. The ECU interprets this signal as a high manifold depression even though positive pressure would exist during boost conditions. Therefore it allows boost to continue to increase throughout the entire engine speed range.
- 7.) Any of these conditions if left unchecked, could cause engine damage as the knock sensing system is rendered inoperable.
- 8.) The boost control unit controls the boost pressure by regulating a duty cycle voltage signal it supplies to the boost control solenoid which in turn adjusts the pressure signal to the wastegate. The boost control solenoid is spring loaded towards the closed position. If no voltage is present at the boost control solenoid, it will remain closed causing the full pressure signal to be applied to the wastegate. The wastegate will open in accordance with the base pressure characteristic curve.

Boost control system electrical connections to the electronic control unit - Effect of faulty circuit

(refer to table: 4736e17e_0008)

Boost control system electrical connections to the electronic control unit -

Effect of faulty circuit

- 1.) When the engine is running, the knock sensor supplies an AC millivolt signal to the ECU corresponding to all engine noise. The ECU recognizes a complete absence of signal as a fault condition. It automatically removes the duty cycle signal it supplies through pin 12 to the boost control solenoid causing the wastegate to inhibit boost to the base pressure curve.
- 2.) If a knock sensor wire is open circuited and the sensor lead passes very close to an ignition high tension lead, it will pick up a signal like a radio aerial. This signal may mislead the ECU into believing that the knock sensing system is operating correctly as it is receiving a signal similar to normal engine noise. This will be recognized by the presence of audible low engine speed detonation when the engine is under high load. Any such detonation must be investigated and its cause corrected.
- 3.) To enable the boost control ECU to inhibit boost pressure to the base pressure characteristic, it receives a system's voltage signal from the stop lamps circuit when the brakes are applied. If, for some reason, the stop lamps remain stuck on then this inhibit function will be activated and car's performance will be restricted.
- 4.) The boost control system ECU uses the engine speed signal to desensitize the knock sensing system in line with the increase in engine noise at full load as engine speed increases. An open or short circuit causes premature boost reduction as the ECU interprets the signals it receives as detonation at low engine speeds.

Boost control system electrical connections to the electronic control unit - Effect of faulty circuit

(refer to table: 4736e17e_0009)

Boost control system electrical connections other than electronic control unit (ECU) connections - Effect of faulty circuit

- 1.) The dump valve will be connected to the manifold depression/pressure signal throughout the engine speed range. The action of the wastegate will be progressive instead of the normal sudden closure when the engine inlet vacuum falls below 318 mm (12.5 in) Hg. A slight delay will occur in the development of boost pressure.
- 2.) Instead of closing at low manifold depression and during boost conditions, the purge control solenoid will remain open all the time. The purge line to the evaporative loss control canister will be subjected to the prevailing manifold depression or pressure.
- 3.) The dump valve will not open at low engine loads causing boost pressure to exist in the inlet manifold when the engine would normally run as a naturally aspirated unit.

- 4.) The purge control solenoid will remain closed all the time, prevent purging occurring.
- 5.) The boost control unit controls the boost pressure by regulating a duty cycle voltage signal it supplies to the boost control solenoid which in turn adjusts the pressure signal to the wastegate. The boost control solenoid is spring loaded towards the closed position. If no voltage is present at the boost control solenoid, it will remain closed causing the full pressure signal to be applied to the wastegate. The wastegate will open in accordance with the base pressure characteristic curve.
- 6.) Only if the short circuit is in the white/light green cable. If the short circuit is in the black/yellow cable, the diode will stop the backfeed occurring and the dump valve will behave as normal.
- 7.) The boost control system ECU 'senses' the absence of the earth.

Boost control system electrical connections other than ECU connections

	Cable From	Cable Colour	To	Signal/Voltage	Effect If Cable Becomes Open Circuit	Effect If Cable is Short Circuited to Earth
	Letter**					
	All cars					
A	Fused supply fuse B3, Fuseboard1, 15A	Pink/White	Dump valve solenoid	Systems voltage with ignition on.	Dump valve solenoid will be permanently de-energised, linking the dump valve to the inlet manifold. [1]	Fuse B3 on Fuseboard F1 will blow. This is the main ignition fuse. The engine will fail to crank.
B	Dump valve solenoid	White/Light Green (Changes to Brown at plug and socket connection)	Dump valve vacuum switch	Earth (Ground) with ignition on, engine off. Open circuit with engine at idle.	Dump valve solenoid will be permanently de-energised, linking the dump valve to the inlet manifold. [1] The evaporative loss control canister (if fitted) will be subject to boost pressure. [2]	Dump valve solenoid will be energised whenever the ignition is on. [3] Purging of the evaporative loss control canister (if fitted) will be inhibited. [4]
C	Dump valve vacuum switch	Black	Earth (Ground)	Earth (Ground) at all times.	Dump valve solenoid will be permanently de-energised, linking the dump valve to the inlet manifold. [1]	Dump valve solenoid operates normally as it should be earthed (ground).
D	Boost control solenoid	Black	Earth (Ground)	Earth (Ground) at all times.	Boost control solenoid will be permanently de-energised.	Boost control solenoid operates normally as it

					Wastegate restricts boost to base pressure (150 - 180 mB). [5]	should be earthed (ground).
E	LH valance 12-way plug and socket	White/Light Green	Dump valve vacuum switch	Earth (Ground) with ignition on, engine off. Open circuit with engine at idle. Earth (Ground) under boost pressure.	Dump valve solenoid will be permanently de-energised, linking the dump valve to the inlet manifold. [1]	Dump valve solenoid will be energised whenever the ignition is switched on. [3] Purging of the evaporative loss control canister (if fitted) will be inhibited. [4]
F	LH valance 12-way plug and socket	White/Light Green (Changes to Black/ Yellow at diode)	Purge cut-off solenoid	Earth (Ground) with ignition on, engine off. Open circuit with engine at idle Earth (Ground) under boost pressure.	The evaporative loss control canister (if fitted) will be subject to boost pressure. [2]	Purging of the evaporative loss control canister (if fitted) will be inhibited. [4] Dump valve solenoid will be energised whenever the ignition is switched on. [3] [6]
G	Air pressure transducer (pin 3)	Black	Earth (Ground)	Earth (Ground) at all times.	Boost pressure will increase to a maximum 200mB. Performance will be restricted. [7]	Air pressure transducer operates normally as it should be earthed (ground).
	Cable letter ** The letter code for the cables refers to the letters used in figure E17-22 on Page E17-28.					

Boost control system hose connections - Effect of restrictions, blockages or leaks

- 1.) The boost pressure signal delivered to the wastegate would be less than specification. In extreme cases there would be no boost pressure signal at all. The wastegate would open later than during normal operation causing boost pressure to exceed specification.

- 2.) The output signal from the air pressure transducer will remain constant at a value which depends on the pressure in the transducer.
- 3.) Dependent on the severity of the leak, the pressure applied to the transducer will be less than the actual boost pressure. Therefore, its output signal to the boost control ECU will be less than specifications throughout the full engine speed range.
- 4.) The boost control ECU will interpret the signal as a lower than normal boost pressure and will change the duty cycle signal to the boost control solenoid causing it to delay the action of the wastegate. Boost pressure will increase causing an excessive boost condition.
- 5.) The dump valve will not open at low engine loads causing boost pressure to exist in the inlet manifold under high load when the engine would normally run as a naturally aspirated unit.
- 6.) When the engine inlet vacuum is less than 318 mm (12.5 in) Hg., the back of the dump valve diaphragm is exposed to ambient air pressure which allows spring force to close the valve. Any leak in the pipes would not affect this part of the operation. However in conditions where the vacuum would normally exceed 318 mm (12.5 in) Hg. which would open the valve, the presence of a leak would reduce the depression applied to the diaphragm allowing the valve to close causing boost pressure to exist in the inlet manifold when the engine would normally run as a naturally aspirated unit.
- 7.) This is the same as the system being in the boost inhibit mode.
- 8.) The wastegate will be open all the time allowing exhaust to bypass the turbine, even at speed when it would be closed if operating according to the base pressure curve.
- 9.) The dump valve will be connected to the manifold depression/pressure signal throughout the engine speed range. The action of the wastegate will be progressive instead of the normal sudden closure when the engine inlet vacuum falls below 318 mm (12.5 in) Hg.

Boost control system hose connections - Effect of restrictions, blockages or leaks

Pipe**	From	To	Signal	If Restricted or Blocked	If Leaking
	All cars				
A	Compressor turbine	Boost control solenoid	Boost pressure	Wastegate will not open according to specifications. Boost pressure exceeds specifications until dump valve opens as safety valve at 600 mB (8.5 lbf/in&1]	Wastegate will not open according to specifications. Boost pressure exceeds specifications until dump valve opens as safety valve at 600 mB (8.5 lbf/in&1]
B	Boost control solenoid	Wastegate	Boost pressure	Wastegate will not open according to specifications. Boost pressure exceeds specifications until dump valve opens as safety valve at 600 mB (8.5 lbf/in&1]	Wastegate will not open according to specifications. Boost pressure exceeds specifications until dump valve opens as safety valve at

					600 mB (8.5 lbf/in&1]
C	Inlet manifold	Air pressure transducer	Manifold depression/pressure	No change in manifold depression/pressure will be registered and boost pressure will exceed pre-set limits until: A - Detonation takes place and boost is reduced until detonation stops B - The dump valves opens at 600 mB. [2][4]	Depending on the severity of the leak, a similar situation will be exhibited as if the pipe was blocked. [3][4]
D	Inlet manifold	Dump valve solenoid	Manifold depression/pressure	Dump valve will remain closed except when boost pressure exceeds 600 mB (8.5 lbf/in&ngine will operate continually under boost conditions. [5]	Dump valve will not open and close according to specifications. Recirculation of boost air may not occur during low load conditions. [6]
E	Inlet manifold	Dump valve switch	Manifold depression/pressure	Dump valve will remain closed except when boost pressure exceeds 600 mB (8.5 lbf/in&ngine will operate continually under boost conditions. [5]	Dump valve will not open and close according to specifications. Recirculation of boost air may not occur during low load conditions. [6]
F	Dump valve solenoid	Dump valve	Manifold depression	Dump valve will remain closed except when boost pressure exceeds 600 mB (8.5 lbf/in&ngine will operate continually under boost conditions. [5]	Dump valve will not open and close according to specifications. Recirculation of boost air may not occur during low load conditions. [6]
	Pipe ** The letter code for the pipes refers to the letters used in figure E17-23 on Page E17-35.				

Boost control system components - Effect of malfunctions

Component	Function	If Stuck Open	If Stuck Closed
Boost control solenoid	Regulates boost pressure signal to the wastegate to control boost pressure according to engine operating characteristics.	Wastegate will not open according to specifications. Boost pressure exceeds specifications until dump valve opens as safety valve at 600 mB (8.5 lbf/in&1]	Boost pressure will increase according to base pressure curve causing poor engine performance. [7]
Wastegate	Regulates flow of exhaust gas through turbocharger turbine to control turbocharger output.	Boost pressure will increase according to base pressure curve causing poor engine performance. [8]	Wastegate will not open according to specifications. Boost Pressure exceeds specifications until dump valve opens as safety valve at 600 mB (8.5 lbf/in&
Dump valve switch	Controls operation of dump valve solenoid.	Dump valve will be open. Recirculation of boost air will occur during part load conditions. [9]	Dump valve will remain closed except when boost pressure exceeds 600 mB (8.5 lbf/in&oost will occur when idling. [5]
Dump valve solenoid	Controls operation of dump valve.	Dump valve will not open and close according to specifications. Recirculation of boost air may occur during part load conditions. As pressure builds up in the manifold, the dump valve will not operate as a pressure relief valve during overboost conditions. [9]	Dump valve will remain closed except when boost pressure exceeds 600 mB (8.5 lbf/in&5]
Dump Valve	Opens air by-pass to provide naturally aspirated	Boosted intake air will be recirculated to the inlet side of the condition. compressor causing poor engine performance. Note: Some boost will be present at high loads.	Dump valve will remain closed and would not be noticeable under normal operating conditions. Turbo 'hang on' may be noticeable during deceleration at very high road speeds. The dump valve will not operate as a pressure relief valve during overboost conditions.

Air pressure transducer (APT) pressure/voltage characteristics

The air pressure transducers fitted to the boost control and K-Motronic engine management systems of turbocharged motor cars from VIN 24513 to VIN 31004 are constructed to convert 'Absolute' pressure into an output voltage signal which is based on an input voltage signal.

The following formula defines the output voltage in terms of input voltage supply to the air pressure transducer and absolute pressure applied to the transducer.

V° = V- x ((0.005 x P) - 0.04)

Where:

V- = Voltage supply to the air pressure transducer. The normal value for this is 5.0 V ± 50 mV (4.95 V - 5.05V)

Boost control system air pressure transducer

This is measured between the purple/brown (PN) cable from pin 9 of the boost control system electronic control unit to pin 3 of the air pressure transducer and the black (B) cable from pin 1 of the air pressure transducer to earth (ground).

K-Motronic engine management system air pressure transducer

This is measured between the purple/brown (PN) cable from pin 21 of the K-Motronic engine management system electronic control unit to pin 3 of the air pressure transducer and the black (B) cable from pin 1 of the air pressure transducer to earth (ground).

V° = Voltage output from the air pressure transducer

Boost control system air pressure transducer

This is measured between the green/slate (GS) cable from pin 2 of the air pressure transducer to pin 10 of the boost control system electronic control unit and the black cable (B) from pin 1 of the air pressure transducer to earth (ground).

K-Motronic engine management system air pressure transducer

This is measured between the green/slate (GS) cable from pin 2 of the air pressure transducer to pin 23 of the K-Motronic engine management system electronic control unit and the black cable (B) from pin 1 of the air pressure transducer to earth (ground).

P = Absolute pressure in kPa (1 kPa = 10 mB)

Example

VsV, P = 1000 mB = 100 kPa, V°	
V°sups; x ((0.005 x P) - 0.04)	
V°x ((0.005 x 100) - 0.04)	
V°x (0.50 - 0.04)	
V°x (0.46)	
V°3 V	

The same formula can be rewritten to express the 'Absolute' pressure (P) in terms of the supply voltage (V-) and the measured output voltage (V°).

P = V°ps; + 0.04/0.005	
Example	
Vs, V°175, P = ?	
P = 3.175/5.0 + 0.04/0.005	
P = 0.635 + 0.04/0.005	
P = 0.675/0.005 = 135 kPa	

The feature of the air pressure transducer is extremely useful as it provides a means to establish ambient atmospheric pressure for compensating gauge pressure readings when an 'Absolute' pressure gauge is not available.

Procedure

- 1.) Ensure that the environment under the bonnet is the same as the ambient surroundings, i.e. the engine is cold, and that the battery is fully charged.
- 2.) Disconnect the pipe to the air pressure transducer.
- 3.) Switch the ignition on.
- 4.) Measure the supply voltage (V-) between the purple/ brown (PN) cable (pin 3) and the black (B) cable (pin 1).
- 5.) Measure the output voltage (V°) between the green/ slate (GS) cable (pin 2) and the black (B) cable (pin 1).
- 6.) Locate the output voltage point on the graph (see fig. *E17-24*

001682

E17-24 Voltage - Pressure characteristic for air pressure transducer (APT) E17-24) for the measured supply voltage and read off the pressure (P).

Changes to the boost control system

Introduced on 1990 model year motor cars from VIN 31004

The following changes to the boost control system were introduced on turbocharged motor cars from VIN 31004.

Air pressure transducers

Two new identical air pressure transducers (Part No. UE 73180) have been introduced. They are located underneath the right-hand front wing panel. As with earlier turbocharged motor cars, one air pressure transducer provides a boost pressure feed back signal to the boost control electronic control unit, the other pro- vides a boost pressure signal to the K-Motronic engine management system electronic control unit.

The new air pressure transducers are not inter- changeable with the air pressure transducers fitted to motor cars prior to VIN 31004.

Boost control system electronic control unit

A new boost control system electronic control unit, part number UD 71736 has been introduced. The new electronic control unit is not interchangeable with the electronic control unit fitted to motor cars prior to VIN 31004.

Dump valve solenoid and dump valve switch

The dump valve solenoid and dump valve switch have been deleted.

Dump valve operation

The underneath of the dump valve diaphragm is connected directly to the inlet manifold and is subjected to the depression or pressure in the inlet according to the prevailing engine condition.

At low engine load, manifold depression holds the valve open against the action of the spring. Air delivered to the inlet manifold by the turbocharger is recirculated to the inlet side of the turbocharger.

As engine speed increases, and the depression falls away, the spring closes the dump valve allowing boost pressure to build up in the inlet manifold.

Full load enrichment current drawn by the EHA

Power loss at full load can be caused by loss of full load enrichment. It this is suspected, it must be checked during actual vehicle operation.

Equipment/tools required

A milliammeter

Adapter RH 9893

Extension leads for milliammeter

Connection

- 1.) Fit a milliammeter such that the meter reading can be observed by a front seat passenger.
- 2.) Using extension leads and adapter RH 9893 connect the meter in series with the EHA.

Full load enrichment (without boost correction)

- 3.) Disconnect the K-Motronic air pressure transducer (APT).
- 4.) Complete a full throttle standing start acceleration and record the current drawn by the EHA (mA), along with the engine speed indicated by the tachometer.

Full load enrichment (with boost correction)

- 5.) Re-connect the pipe to the K-Motronic air pressure transducer (APT).
- 6.) Complete a full throttle standing start acceleration and record the current drawn by the EHA (mA), along with the engine speed indicated by the tachometer.
- 7.) Compare the results of the test against the appropriate full load enrichment current supply maps (see figs.
  E17-28

001686

E17-28 Full load enrichment (without boost correction)
E17-29

001687

E17-29 Full load enrichment (with boost control) E17-28 and E17-29). If recorded results are outside specifications, refer to page B4-31 of Engine Management Systems Manual TSD 4737.

Note:
The current (mA) values on the graphs are nominal and should only be used as a guide-line for transient measurements.

The graphs are valid for ambient temperatures up to 26°C (77°F).

______ Cars fitted with catalytic converters

- - - Cars not fitted with catalytic converters.

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see Fig. E17-10

001663

E17-10 Effect of vacuum operated exhaust extraction device on the turbocharger turbine seal

see Fig. E17-20

001678

E17-20 Turbocharging system

1	Engine knock sensors
2	Exhaust gas wastegate
3	Warm-up catalytic converter
4	Intercooler
5	Dump valve
6	Manifold pressure transducer
7	Dump valve solenoid valve
8	Dump valve vacuum switch
9	Intake air cleaner
10	Boost control solenoid valve
11	Boost control electronic control unit (ECU)
12	K-Motronic input signal (engine speed)
13	Brakes input signal

14	Cruise control system input signal

see Fig. E17-21

001679

E17-21 Turbocharging boost control system wiring diagram

1	'A' bank knock sensor
2	'B' bank knock sensor
3	Braking system input signal
4	Left-hand valance 12-way plug and socket
5	Left-hand valance signal connection
6	Cruise control system input signal
7	Boost control solenoid 2-way plug and socket
8	Boost control solenoid valve
9	Right-hand valance 7-way plug and socket
10	Dump valve solenoid 2-way plug and socket
11	Dump valve solenoid
12	Left-hand valance 12-way plug and socket
13	Dump valve vacuum switch 4-way plug and socket
14	Dump valve vacuum switch
15	Air pressure transducer
16	Boost control electronic control unit (ECU)
17	K-Motronic input signal (engine speed)
18	Parameter code socket (link required on cars fitted with catalytic converters)

see Fig. E17-22

001680

E17-22 Turbocharging boost control system wiring diagram

1	'A' bank knock sensor
2	'B' bank knock sensor
3	Braking system input signal
4	Left-hand valance 12-way plug and socket
5	Left-hand valance signal connection
6	Cruise control system input signal
7	Boost control solenoid 2-way plug and socket
8	Boost control solenoid valve
9	Right-hand valance 7-way plug and socket
10	Dump valve solenoid 2-way plug and socket
11	Dump valve solenoid
12	Left-hand valance 12-way plug and socket
13	Dump valve vacuum switch 4-way plug and socket
14	Dump valve vacuum switch
15	Air pressure transducer
16	Boost control electronic control unit (ECU)
17	K-Motronic input signal (engine speed)
18	Parameter code socket (link required on cars fitted with catalytic converters)

see Fig. E17-23

001681

E17-23 Turbocharging system hose/pipe connections

A	Turbocharger compressor turbine to boost control solenoid valve
B	Boost control solenoid valve to exhaust gas wastegate
C	Inlet manifold to air pressure transducer
D	Inlet manifold to dump valve solenoid valve
E	Inlet manifold to dump valve vacuum switch
F	Dump valve solenoid valve to dump valve
1	Engine knock sensors
2	Exhaust gas wastegate
3	Warm-up catalytic converter
4	Intercooler
5	Dump valve
6	Manifold pressure transducer
7	Dump valve solenoid valve
8	Dump valve vacuum switch
9	Intake air cleaner
10	Boost control solenoid valve
11	Boost control electronic control unit (ECU)
12	K-Motronic input signal (engine speed)
13	Brakes input signal
14	Cruise control system input signal

see Fig. E17-25

001683

E17-25 Air pressure transducer - turbocharged cars from VIN 31004

see Fig. E17-26

001684

E17-26 Turbocharging boost control system, cars from VIN 31004

1	Engine knock sensors
2	Exhaust gas wastegate
3	Warm-up catalytic converter
4	Intercooler
5	Dump valve
6	Air pressure transducer
7	Transmission modulator with restrictor
8	One way relief valve
9	Intake air cleaner
10	Boost control solenoid valve
11	Boost control electronic control unit (ECU)
12	K-Motronic input signal (engine speed)
13	Brakes input signal
14	Cruise control system input signal

see Fig. E17-27

001685

E17-27 Turbocharging boost control system wiring diagram, cars from VIN 31004

1	'A' bank knock sensor

2	'A' bank knock sensor 2-way plug
3	'B' bank knock sensor
4	'B' bank knock sensor 2-way plug
5	Valance to brake switch plug and socket 5-way
6	Left-hand engine to valance plug and socket 12-way
7	Brake lamp switch input signal
8	Cruise control system input signal
9	Right-hand main to right-hand valance plug and socket 9-way
10	Left-hand engine to valance plug and socket 18-way
11	Air pressure transducer plug and socket 6-way
12	Air pressure transducer
13	Air pressure transducer 2-way plug
14	Boost control solenoid plug and socket 2-way
15	Boost control solenoid valve
16	Right-hand valance earth point
17	K-Motronic input signal (engine speed)
18	To fuse B4 (20 amp) on fuseboard 1
19	Boost control solenoid to engine plug and socket 7-way
20	Engine earth point
21	Boost control solenoid to engine plug and socket 7-way
22	Parameter code socket (link required on cars fitted with catalytic converters)
23	Boost control electronic control unit (ECU)