

600AirSuspension

'Dust in the Wind'

Sherlock Tests

Analyzing Leaks in the Mercedes Air Suspension of the W112, W109 and W100

I received many mails and calls about air suspension issues in these beloved Mercedes Benz cars and I decided to suggest a couple of test, which can be performed at home in order to find the problems. The trouble comes not only with an old system but also with newly renovated units going into the old system.

Car Down

With the car on the ground you scratch your head and wonder what this is.

Yes it is the Mercedes air suspension and the privilege of owning a classic Mercedes Benz. The good news is: As bad as it may seem (and believe me I know how it feels) -a leaking air suspension is repairable. But in order to repair efficiently it is best to have a proper analysis of what is going on and which parts are leaking. This is what the Sherlock Tests are all about.

Reasons for a low car

Two words: Old rubber.

The main reason for a leaking system is hardened or fossilized rubber. These are rubber seal rings inside the system that were exposed to chemicals, weather, heat and time. The dominant issue is typically time: It is just a matter of time when the suspension does start leaking.

The theoretical life expectancy of a rubber seal is roughly 10 -20 years. The wording already tells you there is a lot of variances in the timing of rubber break down and the life expectancy may vary a lot with the exposure to certain chemicals and temperatures. I also see often fossilized rings next to hardened but still usable seal rings in an old Bosch valve. This means even in the same environment some rings age faster than others. Mostly the custom Bosch rings had a limited life and started hardening earlier than others. This means the production and composition of the rubber seal is a factor. The one chemical the driver has influence on is the Ethanol in the antifreeze device. I see often the use of some sort of ethanol and the product label does not disclose the precise content of the product. Use only ethanol that is certified by analysis is 96% pure or higher that does not contain any paint removers, acetone or other aggressive substances.

With a car that drops on a regular basis to the point when the oil pan touches asphalt you are wondering if it is time to do something about it.

Cleanliness is Key

Without knowing the basics of the system and which unit and what inside the unit is bad you have a hard time to analyze for yourself and find the problem. That is why you keep reading about the Sherlock Tests.

Then there are others, probably the majority of passionate 109 and 112 and 600 drivers who know the subject and what I am talking about. You know the basis and love working on your car. Now the car is down [again!]. Even though you have replaced a unit or two - the car still leaks or semi leaks. Some rebuilders even claim that slight air leaks are normal in the air suspension. This is like saying: leaks in a car tire are normal.

But it seems that the statistics for the air suspension rather support the 'leaking normal'. The truth is that precision rebuilding and cleanliness during install can produce a very airtight system. That does not mean that there are not well-rebuilt units. However there are some rebuilt units that come with warranty and some without.

How bad is the Leak?

Mercedes defined the threshold for pressure drop in the support group:

-1 bar maximum pressure drop in 24 hours-

One interpretation is this: With 15 bar in the tank your car would stay up about 7 days until it would then drop below the 8 bar (15 bar -7bar =8 bar) which is considered the minimum for the air bags creating the pressure equilibrium for support group and work group. By the way it is actually not quite accurate to state that one pressure setting is the pressure in the 4 air bags. The front bags have higher pressures than rear normally, with an empty car the front is at 5.5 or 7 bar, the rear at 5-8 bars for the 300SEL, the 600 has different work pressures: 8-10bar in Front and 7- 9.5bar in the Rear.

For simplicity reasons let us go with 8 bar. This is also roughly the threshold for the pressure switch and the dash light comes on if the support pressure falls below 8 bar. However this minimum pressure is not to confuse with the 10-12 bar needed in the tank in order to operate and test the car properly. The 8 bar can keep the car barely up meaning with less than that in the air bag the car would sink.

Back to the calculation: If the car has an initial charge of 15bar in the tank and it does not drop for one week (7 days) before axles drop Mercedes considers that still acceptable. If it drops earlier than that, well.... then you are out of the Mercedes specs and the system needs rebuilding. Without a proper pressure gauge installed however

this it is hard to monitor pressures for this test. We will come back to the pressure gauge and its advantages for better analysis of the support group.

Please be very careful when you open up the semi-closed system of the air suspension. No dirt should enter the inner volumes of the air suspension or trouble is at hand. This is a warning in general. Many owners may not dare to open up the inner parts of the system themselves but have their mechanic do it who probably has not a good idea what he is doing either. Baseline is: The air suspension has to be treated and repaired under 'clean room' condition, imagine it is a Swiss watch.

There is probably the old and untouched system then there are probably a few or new parts. And you have possibly no clear idea about the history of what was repaired and when and what not. And then you replace some components with new or renovated parts. And then during the process there is a good chance of contamination to the inner of the system as lines and ports are open. Dirt can enter the otherwise 'closed' system and there is more: old debris that once settled inside has the chance to brake loose while you are working on the components and may make the sensitive inner new valves leak, at least temporarily.

In case you are not lucky and still find some slight leakage after you installed a renovated and tested unit there are only two ways. You drive a lot and pray that the contaminants are flushed out while the air is moving through the system (which might happen). But if nothing cures the leak you need to take the axle valve out again for inspection. If you decide to drive please fill the alcohol bottle with specified pure ethanol (min 96% ethanol) or Wabcothyl, the only product I'd recommend but unfortunately not available in the US.

Support Group and Work Group

If you follow my air suspension articles you might have noticed that I am referring to the support group and the work group as 2 inner air volumes that are separate from each other most of the time but join each other during certain axle valve activities. With some basic knowledge and understanding about these 2 groups and the series of Tests described here you can accurately analyze your system.

The two groups within the air suspension are physically separated if the car is parked and the suspension is not moving. A separated group means that the inner air volume of the support group (the air molecules in the tank, main valve, air lines from check valve to the axle valves) is separated from the 3 work groups (air molecules in the 2 front and 2 rear air springs separated by the 3 axle valves).

This separation is normal and has to happen when the car is in the neutral position, for instance when the car is parked but also when the car is moving but the suspension is

not operating outside the neutral zone which is seldom the case. The neutral position defines a certain car height with some tolerance of probably +/- 2mm. If the car is moving up and down beyond the neutral zone or probably, say +/-2mm, this separation is voided and the air volumes merge. During normal driving the suspension goes well beyond the neutral zone in both directions but the throttle within the intake and exhaust valves (inside the axle valves) is making sure there are no big air movements happening during normal driving with the car suspension. If the car is low and the intake valve opens (to bring the car to normal height) the support group and the work group are joining for that time to allow for equalizing pressure (and pump the air spring up). If the exhaust valve opens to lower the car the work group and exhaust line (return through main valve) join.

If the air is separated and the 4 groups (one support group, three work groups) and all groups are air tight-then the car is not dropping. A drop in height is happening when certain work groups and/or support group are leaking.

Sherlock Tests

When you are performing the series of Sherlock Tests you can determine if your axle valves or support group units are tight. If one or more units are leaking you also can find out which axle valve is leaking and what part of the axle valve is leaking.

The general rule for a car dropping in height is: The axle valve/ air spring is in question at the respective side of the car drop. Please note that each single side drop, for instance Front Left, affects the other axles. It affects typically the Rear Left side most. A faulty Front Left axle valve had the Front Left side dropped and it appears that the Rear Left also dropped. The dropped Front Left will also pull down the Front Right due to the strong torsion bar especially if the support pressure is gone and the Front Right cannot recover. Things are not always as they seem. You need to analyze very carefully and measure! However the side with the failing axle valve will drop the most in height measured in inches as height differential from ground to wheel well. Be a scientist and analyze with empiric measurements.

It is a good practice in general to have the support group air tight for all tests and of course this is the best for the operation of the car because that is the way the system is designed. In case the support group is not tight this clearly needs repair. The issues are potentially leaks in the main valve, the check valve and sometimes the drain valve. The Schrader valve in the tank and top plug screw are very rarely leaking. Air lines have proven to be a rare problem too. Sometimes the metal lines suffer from corrosion or wear through rubbing against another hose.

Sherlock Tests are introduced mainly to separate out certain areas of the system and find leaks in the various parts of the axle valves but also for testing the support group without specialized tools and pressure gauges. Pressure gauges are however

recommended in addition to verify pressure drops if you have a chance. Pressure readings are always a good thing for analysis.

Leaks of the Axle Valve

The axle valve can potentially leak in many different areas. In order to categorize: there are 4 potential leak locations

- a) The Intake Valve (E- Port)
- b) The Intake Check Valve (E- Check Valve)
- c) The Toggle called STK
- d) The Exhaust Valve (A-Port)

With the series of tests, proper protocol and write-up every hobbyist can find most of the leaks mentioned. These leaks are primarily inner leaks, which will finally show themselves as external leak but in a different location. This means there is hardly a way to find external leaks at the location of the internal leak.

Some tests are to determine leaking axle valves (work group which include the axle valves), other Tests are for a leaking support group. In order to test the single groups it is wise to separate the two groups.

If your car drops (or rises!) at any of the tests the work group at the dropping axle is leaking and 95% of the time the problem is the Axle Valve.

Test 1

Preparation/precondition

- 1) Main Valve in N (lever all the way in for Normal Driving) , Main Valve working to spec
- 2) Support group is airtight (if your support is not air tight perform Test 5 and find the leaks...fix... then come back)
- 3) Work groups not leaking: Air springs [3] and air lines [3] from axle valve port B to spring are air tight
- 4) Support pressure verified (10 – 15 bar in the air tank)
- 5) Note the car height per wheel measured from level ground to wheel well and measure again after 1 hour / 2 hours/3 hours / 6 hours/12 hours/ 24 hours

The drop of your car is probably the reason you are reading this anyway. Before you go any further maybe make sure -as good as you can- and check the air tightness of the support group. Try to verify if it is air tight or leaking. If you suspect a leaking support group it will be most possibly a leaking check valve, a leaking main valve and /or a leaking drain valve. Please read Test 6 instruction to tighten the support group as much as possible because a tight support group will make your car and the testing better. After you did your best to tighten the support group Test 1 is the simplest of all tests and also the least specific one in order to identify the detail problem. But Test 1 is a good starting point and you need to start somewhere.

After Test 1 you have a sheet of paper filled out with a pen showing data of car height per wheel and time. Sheet of paper shows 4 columns labeled car height in inches for Front Left, Front Right, Rear Left, Rear Right and lines show the time sequence after 1 hour /2 hours/3 hours / 6 hours / 12 hours 24 hours, etc. (I have a sheet as an example attached). The drop is measured with car parking on level ground and you measure each wheel from ground to wheel well when you start

If the car does not drop further after a first initial drop of roughly ½” within the first 1 or 2 hours after engine shut down there is no external and no internal leak in the work group and you are done. Car is behaving, as it should in terms of drop.

A small amount of drop after shut down can happen and is normal if it is in the 1 cm range (1/2” range). This drop includes the pressure adjustment of the valve if driving indicated a higher riding height.

If an axle drops more than that and keeps dropping after the first hours there is an internal or /and external leak that needs attention. This leak will most possibly be located in the axle valve if the air spring is not leaking.

If the axle valve is the problem without reading the pressure in the support tank and without testing the exhaust it is not possible to locate the exact leaking part of the axle valve. If Test one is positive please move on to Test 2 in order to narrow down the leaking parts.

Test 2

The difference between Test 1 and Test 2 is the setting of the main valve

Preparation/precondition

- 1) Main Valve in S (Lock), Main Valve working to spec
- 2) Support group is airtight (if your support is not air tight perform Test 5 and find the leaks...fix... then come back)
- 3) Work groups not leaking: Air springs [3]and air lines [3] from axle valve port B to spring are air tight

4) Support pressure verified (10 – 15 bar in the air tank)

5) Note the car height per wheel measured from level ground to wheel well and measure again after 1 hour /2 hours/3 hours / 6 hours/12 hours/ 24 hours

If the car does not drop (or rise) over a long period of time there is no big external and no internal leak in the work group under the given condition. Note that the exhaust valve of the axle valve is 'hiding' with main valve in lock.

If an axle drops with an otherwise tight support group (meaning support pressure 10 bar) then there must be an internal leak in STK. Note that a leaking exhaust valve cannot show itself in 'S'.

If an axle rises there must be an internal leak in E (E-valve, Not E-check valve).

It is difficult to 'see' a rise of 2 to 3 mm (null zone) in the air suspension with the main valve in N. It won't go any higher than 3mm in 'N'. However with the main valve in 'S' and a leaking E-valve the axle rises continuously until support pressure = spring pressure. If the support has an additional small leak then the axle first rises then stops...or the axle falls in case the E check valve is not working.

With the main valve in 'N' and a leaking E valve the axle will rise a bit above the null point (null zone is 2 -3mm: the car height difference between closing E and opening A) anything above that axle starts exhausting air. This means with main valve in N and a leaking intake valve the car goes up 2-3mm for instance until the exhaust valve (A-Valve) is activated and releases air and the car sinks a couple of mm. This rise and fall cycle repeats itself until all support pressure is exhausted.

In Test 2 however the exhaust is locked and there is no exhaust leaving the system meaning if the axle rises high up... there is an E-valve leak and you clearly 'see' it by a substantial rise, more than 3mm.

A Test 2 'leak' can in theory also mean a valve timing overlap (E and A open at the same time, the car's rise is then limited to the valve overlap translated in axle height) but this is rather theory and might not be the case. I have not seen this so far.

If your car falls during Test 2 you know that either STK is leaking or E intake valve is leaking (car rises) or both.

Test 3

Preparation/precondition

1) Main Valve in S ('Lock'), Main Valve working to spec.

2) Release Support Pressure (Please drain the air tank via drain valve)

If the car does not drop then there is no external leak in the work group (Work group =pressurized air volume from axle valve to air spring) and there is no internal 'back leak ' (E-check valve is tight and working).

If an axle drops there must be a leak in the E-check valve or/and the air line B to spring and/or the springs itself is leaking.

Note that in 'S' the exhaust valve (A-valve) is hiding and must be tested in combination with Test 4 for instance.

Test 4

Preparation

1) Main valve in 'N', main valve working to spec.

2) Drain Support Pressure (Drain the air tank via drain valve)

If the car does not drop Stk, E- Check Valve and A- Valve of the axle valves are airtight.

Again a dropping axle indicates a work group leak and this means most possibly the axle valve (STK leak, E-Check Valve leak or A- valve leak). But could also be the leaking air spring or leaking airline from axle vale to spring or leak in connecting line between rear springs.

If Test 3 was positive (no drop) but Test 4 was negative.... Then the A- valve is the problem of the respective axle valve.

Test 5 and 6

For the following tests you need 2 additional Schrader valves, the same type you have installed at your air tank.

The reason for Tests 5/6 is the separation between support group and the work group.

Preparation for (both) Tests 5 and 6

1) Main valve in 'Normal' ('N')

2) Release Support Pressure : Drain air tank entirely

3) Remove airlines #2 and #3 at the main valve with a 12mm wrench
#2 (number stamped at main valve port) is the pressure line to the front valve (10 bar in the 109 and 112, 13bar for the 600 during operation)
#3 (number stamped at main valve port) is the pressure line to the rear valve (full support pressure for all cars for rear valve during operation).

Test 5

Preparation

- 1) Remove the 2 air fittings (14mm wrench) at the main valve at metal lines you already disconnected
- 2) Install Schrader valve at each port (#2 and #3).

The support lines are disconnected and the axle valves are not 'online' any more. That means they don't receive pressure input from the tank and have to live entirely with the air molecules enclosed in the work group. The car cannot be lifted any further, only lowered if the exhaust valve (A- valve) gets activated.

We pretend in this scenario that the axle valves are airtight and the car will not drop with disconnected support pressure (Test 4). If any of the axles drop the respective axle valve is leaking. It is simple. This is Test 4.

Test 3 and 4 involved measuring the axle height at all 4 wheels and taking records of the various heights every hour/day. If there occurs an initial little drop (like 1/8-1/4 inch after engine shut down) over the first hours but dropping stops after that then I'd say the axle valve is probably fine. Only if the drop is continuous (dropping does not stop) the axle valve needs to be repaired. Please note that Test 4 does not reveal a leaking E-valve.

Now there is a combined test that tells you if the axle valves are 100% air tight and working to specs.

In order to test the intake valve (E- valve) you are performing Test 4 or 5 plus Test 2 .
If Test4 (or 5) and Test 2 were positive (no drop, no rise) then the axle valve tested very positive.

Test 6

- 1) Main valve in 'N'
- 2) Schrader valves installed in ports #2 and #3 at main valve
- 3) Install pressure gauge at # 3

With this test the Support Group's air tightness can be tested and leaks tackled.

It is best to use a tire gauge (150-200psi) and use shop air to fill the tank with 150 psi or 10 bar. Please record the pressure drop over time. If you see a pressure drop there must be one or several leak points. This can be main valve, check valve, drain valve, tank, or any air line or air line connection. These leaks can be found with a soap spray or you can even hear a bigger leak.

For some enthusiasts the Tests and the inner workings of the system might seem complicated but if you study and understand the system better the tests will be simple and logical.

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