Title of the Invention: A method and an apparatus for performing a leak test of a liquid gas fuel system of a motor vehicle

Abstract Title: A method and apparatus for performing a leak test of a liquid gas fuel system of a motor vehicle

A method is described for performing a leak test of a liquid gas fuel system of a motor vehicle, wherein the liquid gas fuel system comprises a first section between a filling opening and a tank, a second section between an outlet of the tank and an evaporator, and a third section between an output of the evaporator and a fuel injection system, wherein the method comprises the following:

- Leak test of the third section by filling the third section with compressed air and monitoring the variation in pressure in the third section by means of a pressure sensor arranged on the fuel injection system;
- Leak test of the second section by filling the second section with compressed air, venting the second section into the third section, and monitoring the variation in pressure in the third section by means of a pressure sensor arranged on the fuel injection system.
START

Screw adapter into gas filler, connect pressure testing unit (gauge) to adapter, connect air hose to testing unit, open ball valve of air supply, connect computer unit & start

Display computer unit "open ball valve testing system"

Open ball valve testing system =>
Pressure to supply tank => Confirm computer unit

Filling time of tank => 3-4 mins => Stopwatch computer unit

Display computer unit "System filled, close ball valve of testing system"

Close ball valve of testing system => Confirm computer unit

Stabilization time approx. 3-4 mins. => Stopwatch computer unit

Display computer unit "check of gauge, reading of initial value"

Reading of initial pressure / note value => Confirm computer unit

Measuring time of filler 2 mins. => Stopwatch computer unit

Open valve 1 and 2 and close after waiting time => Remainder of system is supplied with pressure

Reading of pressure/temp. (P/T) sensor => Initial value?

185> value < 194 kPa

No

Termination - serious leakage or wrong sensor

Yes

Measuring time low-press. side 6 mins. => Stopwatch computer unit

Reading P/T sensor => Final value value?

A

B
Leakage in the region of filler tank

Pressure drop > 5 mbar?

Yes

Pressure drop > 2Kpa

No

Cancellation, notification: Leakage in low-press. system

Yes

Triggering of injectors => Pressure relief low-press. side

Triggering of valve 2 (valve 1 remains closed)

Reading of press./temp. (P/T) sensor => value V1

(= Pressure value of feed system AFTER measuring time of low-press.)

Confirm => Start reference measurement of feed system

Triggering of injectors => Pressure relief low-press. side

Triggering of valve 1 (valve 2 remains closed) =>
Reference filling of feed system

Triggering of valve 2 (valve 1 remains closed)

Reading of press./temp. (P/T) sensor => value V2

(Reference value W/O leakage) measuring time low-press.)

Value V1 < V2

(DP > 2KPa)?

Yes

Confirmation => Pressure test end => Start relief

Display computer unit "Low-press. and feed system OK"

Cancellation, report: leakage in feed system

B

B
Description

A method and an apparatus for performing a leak test of a liquid gas fuel system of a motor vehicle

The invention relates to a method and an apparatus for performing a leak test of a liquid gas fuel system of a motor vehicle.

A method for checking the isolation state of a liquid gas tank provided at least partly underground is known from DE 10 2004 055 167 B3. Liquid gas tanks are also used in motor vehicles.

It is the object of embodiments of the invention to provide a method and an apparatus which allow the reliable and rapid performance of a leak test of a liquid gas fuel system of a motor vehicle, especially before first start-up.

In accordance with one aspect of the invention, a method is provided for performing a leak test of a liquid gas fuel system of a motor vehicle, wherein the liquid gas fuel system comprises a first section between a filling opening and tank, a second section between an output of the tank and an evaporator, and a third section between an output of the evaporator and a fuel injection system. The method comprises a leak test of the third section by filling the third section with compressed air and monitoring the variation of pressure in the third section by means of a pressure sensor arranged on the fuel injection system. It further comprises a leak test of the second section by filling the second section with compressed air, venting the second section into the third section, and monitoring the variation of pressure in the third section by means of the pressure sensor arranged on the fuel injection system.

The method offers the advantage that it allows the leak test of a liquid gas fuel system, wherein it is not only possible to check the tank itself but also the second and the third section, which can only be accessed with difficulty by means of a sniffing test. It is advantageous in this respect that for the purpose of monitoring the varia-
tion of the pressure in the second and third section the pressure sensor can be used which is arranged in the region of the fuel injection system anyway. The leak test in the second section will then occur in such a way that the second section is vented after a specific waiting period into the third section and the pressure in the third section is determined. A reference measurement is performed subsequently, for which the second section is filled again and is vented into the third section without a waiting period, whereupon the pressure in the third section is determined again. The reference measurement therefore supplies a reference value as a result of the missing waiting time before the pressure measurement, with which the pressure determined after the waiting time can be compared.

The use of compressed air offers the advantage that it is easily available and is easy to handle. The leak test can occur before the first filling of the tank and prior to the start-up of the liquid gas fuel system. A leak can thus be diagnosed prior to the filling of the tank with liquid gas, so that only intact liquid gas fuel systems are filled. The liquid gas fuel system can be filled for this purpose with compressed air up to a later operating pressure, but the leak tests can also be performed at lower pressures.

The method allows a standardized procedure in the leak test of the liquid gas fuel system and is therefore especially reliable and independent from any individual evaluation by workers.

In one embodiment the leak test of the third section occurs before the leak test of the second section. This offers the advantage that the method can be performed in an especially economical and time-effective manner.

In this embodiment, the leak tests of the second and third section can comprise the following in particular:

- joint filling of the second and third section with compressed air;
- separation of the second section from the third section by closing a valve between the second section and the third section;
- leak test of the third section with the following steps:
  - determination of an initial value for the pressure in the third section by means of a pressure sensor arranged on the fuel injection system;
- determination of a final value for the pressure in the third section after the expiration of a waiting time;
- comparison of the initial value with the final value and determination of a leakage if the difference between initial value and final value exceeds a predetermined limit value;
- pressure relief of the third section;
- leak test of the second section with the following steps:
  - venting of the second section into the third section by opening the valve between the second section and the third section;
  - determination of a first pressure value for the pressure in the third section by means of the pressure sensor arranged in the fuel injection system;
  - pressure relief of the second and third section;
  - renewed filling of the second section with compressed air;
  - venting of the second section into the third section by opening the valve between the second section and the third section;
  - determination of a second pressure value for the pressure in the third section by means of the pressure sensor arranged on the fuel injection system;
  - comparison of the first pressure value with the second pressure value and determination of a leakage if the difference of the first pressure value and the second pressure value exceeds a predetermined limit value.

In this procedure, the second pressure value is used as the reference value because it indicates the pressure in the second section prior to the expiration of a waiting period during which a leakage would be noticeable.

This embodiment offers the advantage that the leak tests can be performed as rapidly as possible because waiting periods are minimized by the sequence of the test steps. By moving the test of the third section forward, the test of the second section can occur subsequently by means of the same pressure sensor which is arranged on the fuel injection system anyway. The time used for the leak test of third section can be used as a waiting time for the leak test of the second section.

In one embodiment, the renewed filling of the second section with compressed air occurs by opening the valve arranged between the first and second section when
the valve arranged between the second and third section is closed and when the first section is filled with compressed air. This procedure offers the advantage that compressed air which is present in the first section anyway can be used for filling the second section. It is possible to make use of the fact that the volume of the first section is very large in relation to the second section, so that variations in pressure in the first section by filling the second section are negligible.

In one embodiment, the pressure relief of the third section occurs by opening and subsequent closing of the injection valves. This leads to the advantage that the pressure relief can be performed in an especially simple and rapid manner by triggering the injection valves which are present anyway.

In one embodiment, a leak test of the first section occurs further by filling the first section with compressed air and monitoring the variation in pressure in the first section by means of a further pressure sensor arranged in the region of the filling opening.

An additional pressure sensor is provided in this embodiment in order to monitor the pressure in the first section. This pressure sensor can especially be attached in the region of the filling opening. This leads to the advantage that it is possible to check not only the tank per se, which is frequently already checked for leakproofness by the vendor, but also the remaining first section with the filling valve and the conduit between the filling valve and the tank. This enables a leak test of the entire, completely installed liquid gas fuel system.

In one embodiment, the leak test of the first section occurs at least partly simultaneously with the leak test of the second and/or third section. The first section is separated from the second and third section for example by the closure of a valve after the completed filling of all sections. Furthermore, the inflow into the region of the filling opening is closed. After a specific stabilization period, the monitoring of the variation in pressure occurs subsequently in the first section for the purpose of recognizing leakages. The monitoring typically occurs by recording an initial value and – after a fixed measuring period – an end value, and a subsequent comparison of initial value and end value, wherein a leakage is recognized when the initial value and the end value differ from each other by more than a predetermined amount.
Since the first section was separated from the second and third, and separate pressure sensors are provided for the leak tests, the leak tests can occur in the second and third section while the variation of pressure is monitored in the first section. This leads to the advantage that the time required for the leak test of the liquid gas fuel system is kept as short as possible.

In one embodiment, a variation of temperature in the region of the filling opening and/or in the region of the fuel injection system is monitored in addition to the variation of pressure. This leads to the advantage that the variation in the temperature of the injected compressed air can be monitored in addition, so that the influence of the variations in temperature of the injected compressed air on the monitored variation of pressure can be corrected. This allows for a high precision of the method. It can optionally be omitted in practice however because the increased precision is not required and the occurring variations in temperature are not strong enough to have a profound influence on the method.

In accordance with a further aspect of the invention, a computer program product is indicated, which – when it is executed on a computer unit – instructs the computer unit to perform the described method, especially a method for performing a leak test of a liquid gas fuel system of a motor vehicle, wherein the liquid gas fuel system comprises a first section between a filling opening and a tank, a second section between an output of the tank and an evaporator, and a third section between an output of the evaporator and a fuel injection system, wherein the method comprises the following:

- leak test of the third section by filling the third section with compressed air and monitoring the variation in pressure in the third section by means of a pressure sensor arranged on the fuel injection system;
- leak test of the second section by filling the second section with compressed air, venting the second section into the third section, and monitoring the variation in pressure in the third section by means of pressure sensor arranged on the fuel injection system.

In accordance with a further aspect of the invention, a computer-readable medium is provided on which such a computer program product is stored.

In accordance with a further aspect of the invention, an apparatus for performing a leak test of a liquid gas fuel system of a motor vehicle is provided, wherein the liq-
uid gas fuel system comprises a first section between a filling opening and tank, a
second section between an output of the tank and an evaporator, and a third sec-
tion between an output of the evaporator and a fuel injection system, wherein the
apparatus comprises the following:

- means for the leak test of the third section by filling the third section with
  compressed air and monitoring the variation in pressure in the third section
  by means of a pressure sensor arranged on the fuel injection system;
- means for the leak test of the second section by filling the second section
  with compressed air, venting the second section into the third section, and
  monitoring the variation in pressure in the third section by means of pres-
sure sensor arranged on the fuel injection system.

The apparatus allows a leak test of the liquid gas fuel system prior to the first start-
up of the motor vehicle and prior to the first filling of the tank. It offers the ad-

tantage that for the leak test of the second and third section, which can be ac-
cessed from the outside only with difficulty, a pressure sensor can be used which
is arranged on the fuel injection system anyway.

In accordance with one embodiment of the invention, the apparatus further com-
prises at least one further pressure sensor in the region of the filling opening. No
pressure sensor is typically provided in this region and the motor vehicle; it is
therefore only arranged there for the leak test and subsequently removed again.
The filling opening is easily accessible from the outside for this purpose.

In one embodiment, the apparatus further comprises at least one temperature
sensor in the region of the filling opening and/or in the region of the fuel injection
system. A temperature sensor is often provided anyway in the region of the fuel in-
jection system. The temperature of the injected compressed air can thus be moni-
tored in addition, so that corrections can be made on the influence of the variations
in temperature of the injected compressed air on the monitored variations of pres-
sure if the precision of the method is to be increased.

Embodiments of the invention will now be explained in greater detail by reference
to the enclosed drawings, wherein:
Fig. 1 schematically shows a liquid gas fuel system with a test apparatus for performing a leak test according to an embodiment of the invention;

Fig. 2 schematically shows steps of a method for performing a leak test according to an embodiment of the invention, and

Fig. 3 shows details of the method according to Fig. 2 by way of example.

The liquid gas fuel system 1 according to Fig. 1 comprises a first section 2, which extends from a filling opening 4 for liquid gas, which comprises a filling valve 3, up to a tank 5 for liquid gas. The tank 5 comprises devices not designated in closer detail for monitoring the content, especially also safety valves, and a pressure sensor designated in this case as a reference pressure gauge 24 monitoring the pressure in the tank 5.

A first valve 7, which can be triggered electromagnetically, is arranged at the output 6 of the tank 5. The first valve 7 separates the first section 2 from the second section 8, which extends from the first valve 7 to a second valve 10 in the region of an evaporator 9, which second valve 10 can also be triggered electromagnetically. The evaporator 9 further comprises a coolant loop 11 and a pressure regulator 12, and is provided for converting the liquid fuel into the gaseous state.

The second valve 10 separates the second section 8 from the third section 13, which extends from the second valve 10 to a fuel injection system 14. The fuel injection system 14 comprises a number of injection valves 15 and a pressure and temperature sensor 16.

A test apparatus 17 can be arranged in the region of the filling opening 4 for performing a leak test of the liquid gas fuel system 1. The test apparatus 17 comprises a ball valve 18, via which a compressed air supply is controllable, and a further pressure and temperature sensor 19.

The performance of the leak test of the liquid gas fuel system 1 is described by reference to Figs. 2 and 3.
Fig. 2 schematically shows steps of a method for carrying out a leak test according to an embodiment of the invention. The filling of the fuel injection system shown in Fig. 1 with compressed air occurs at first. A pressure of approximately 3 bars is desirable. It is also possible to work with higher or lower pressures. The values shown in the drawings merely represent examples.

The leak test of the first section occurs separate from, but simultaneously with, the leak tests of the second and third section. The leak test of the third section occurs before the leak test of the second section in order to use the time for performing the leak test of the third section as the waiting time for the leak test of the second section.

Fig. 3 shows exemplary details of the method according to Fig. 2. After the technical preparation, the filling of the tank 5 is performed. The leak tests of the first section 2 or the second section 8 and the third section 13 are then carried out separate from each other, but at least partly in parallel with respect to timing. The second section 8 is also designated in this case as the feed flow and the third section 13 as the low-pressure side.

If a leakage is detected during one of the leak tests, a repair process occurs as indicated on the third page of Fig. 3, and subsequently a repetition of the leak test.

Although at least one exemplary embodiment was shown in the description above, various changes and modifications can be made. The aforementioned embodiments are merely examples and are not provided to limit the scope of validity, the applicability or the configuration in any way. Instead, the description above provides a person skilled in the art with a plan to implement at least one exemplary embodiment, wherein numerous changes in the function and the arrangement of elements described in an exemplary embodiment can be made without departing from the scope of protection of the attached claims and their legal equivalents.
List of reference numerals

1 Liquid gas fuel system
2 First section
3 Filling valve
4 Filling opening
5 Tank
6 Output
7 First valve
8 Second section
9 Evaporator
10 Second valve
11 Coolant loop
12 Pressure regulator
13 Third section
14 Fuel injection system
15 Injection valve
16 Pressure and temperature sensor
17 Test apparatus
18 Ball valve
19 Further pressure and temperature sensor
20 Reference pressure gauge
CLAIMS:

1. A method for performing a leak test of a liquid gas fuel system (1) of a motor vehicle, wherein the liquid gas fuel system (1) comprises a first section (2) between a filling opening (4) and a tank (5), a second section (8) between an output (6) of the tank (5) and an evaporator (9), and a third section (13) between an output of the evaporator (9) and a fuel injection system (14), wherein the method comprises the following:
   - leak test of the third section (13) by filling the third section (13) with compressed air and monitoring the variation in pressure in the third section (13) by means of a pressure sensor (16) arranged on the fuel injection system (14);
   - leak test of the second section (8) by filling the second section (8) with compressed air, venting the second section (8) into the third section (13), and monitoring the variation in pressure in the third section (13) by means of pressure sensor (16) arranged on the fuel injection system (14).

2. A method according to claim 1,
   wherein the leak test of the third section (13) occurs before the leak test of the second section (8).

3. A method according to claim 2,
   wherein the leak tests of the second section (8) and the third section (13) comprise the following:
   - joint filling of the second section (8) and third section (13) with compressed air;
   - separation of the second section (8) from the third section (13) by closing a valve (10) between the second section (8) and the third section (13);
   - leak test of the third section (13) with the following steps:
     - determination of an initial value for the pressure in the third section (13) by means of a pressure sensor (16) arranged on the fuel injection system (14);
     - determination of a final value for the pressure in the third section (13) after the expiration of a waiting time;
- comparison of the initial value with the final value and determination of a leakage if the difference of the initial value and final value exceeds a predetermined limit value;

- pressure relief of the third section (13);

- leak test of the second section (8) with the following steps:
  - venting of the second section (8) into the third section (13) by opening the valve (10) between the second section (8) and the third section (13);
  - determination of a first pressure value for the pressure in the third section (13) by means of the pressure sensor (16) arranged on the fuel injection system (14);
  - pressure relief of the second section (8) and third section (13);
  - renewed filling of the second section (8) with compressed air;
  - venting of the second section (8) into the third section (13) by opening the valve (10) between the second section (8) and the third section (13);
  - determination of a second pressure value for the pressure in the third section (13) by means of the pressure sensor (16) arranged on the fuel injection system (14);
  - comparison of the first pressure value with the second pressure value and determination of a leakage if the difference between the first pressure value and the second pressure value exceeds a predetermined limit value.

4. A method according to claim 3, wherein the renewed filling of the second section (8) with compressed air occurs by opening the valve (7) arranged between the first section (2) and the second section (8) when the valve (10) arranged between the second section (8) and third section (13) is closed and when the first section (2) is filled with compressed air.

5. A method according to claim 3 or 4, wherein the pressure relief of the third section (13) occurs by opening and subsequent closing of the injection valves (15).

6. A method according to one of the claims 1 to 5,
wherein further a leak test of the first section (2) occurs by filling the first section (2) with compressed air and monitoring the variation in pressure in the first section (2) by means of a further pressure sensor (19) arranged in the region of the filling opening (4).

7. A method according to claim 6, wherein the leak test of the first section (2) occurs at least partly simultaneously with the leak test of the second section (8) and/or the third section (13).

8. A method according to one of the claims 1 to 7, wherein a variation of temperature in the region of the filling opening (4) and/or in the region of the fuel injection system (14) is monitored in addition to the variation of pressure.

9. An apparatus for performing a leak test of a liquid gas fuel system (1) of a motor vehicle, wherein the liquid gas fuel system (1) comprises a first section (2) between a filling opening (4) and a tank (5), a second section (8) between an output (6) of the tank (5) and an evaporator (9), and a third section (13) between an output of the evaporator (9) and a fuel injection system (14), wherein the apparatus comprises the following:
   - means for the leak test of the third section (13) by filling the third section (13) with compressed air and monitoring the variation in pressure in the third section (13) by means of at least one pressure sensor (16) arranged on the fuel injection system (14);
   - means for the leak test of the second section (8) by filling the second section (8) with compressed air, venting the second section (8) into the third section (13), and monitoring the variation in pressure in the third section (13) by means of pressure sensor (16) arranged on the fuel injection system (14).

10. An apparatus according to claim 9, wherein the apparatus further comprises at least one further pressure sensor (19) in the region of the filling opening (4).

11. An apparatus according to claim 9 or 10,
wherein the apparatus further comprises at least one temperature sensor
(16) in the region of the filling opening (4) and/or in the region of the fuel in-
jection system (14).

12. A computer program product, which when executed on a computer unit in-
structs said computer unit to perform a method according to one of the
claims 1 to 8.

13. A computer-readable medium, on which a computer program product ac-
cording to claim 12 is stored.
Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

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<tr>
<th>Category</th>
<th>Relevant to claims</th>
<th>Identity of document and passage or figure of particular relevance</th>
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<td>US2013/0000380 A1 (ZHOU) see abstract</td>
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<td>9</td>
<td>US2007/0169543 A1 (FAZEKAS) see abstract, paragraphs [0029] to [0034]</td>
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<td>Member of the same patent family</td>
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A Document indicating technological background and/or state of the art.
P Document published on or after the declared priority date but before the filing date of this invention.
E Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC:

Worldwide search of patent documents classified in the following areas of the IPC:

G01M

The following online and other databases have been used in the preparation of this search report:

EPODOC, WPI

International Classification:

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