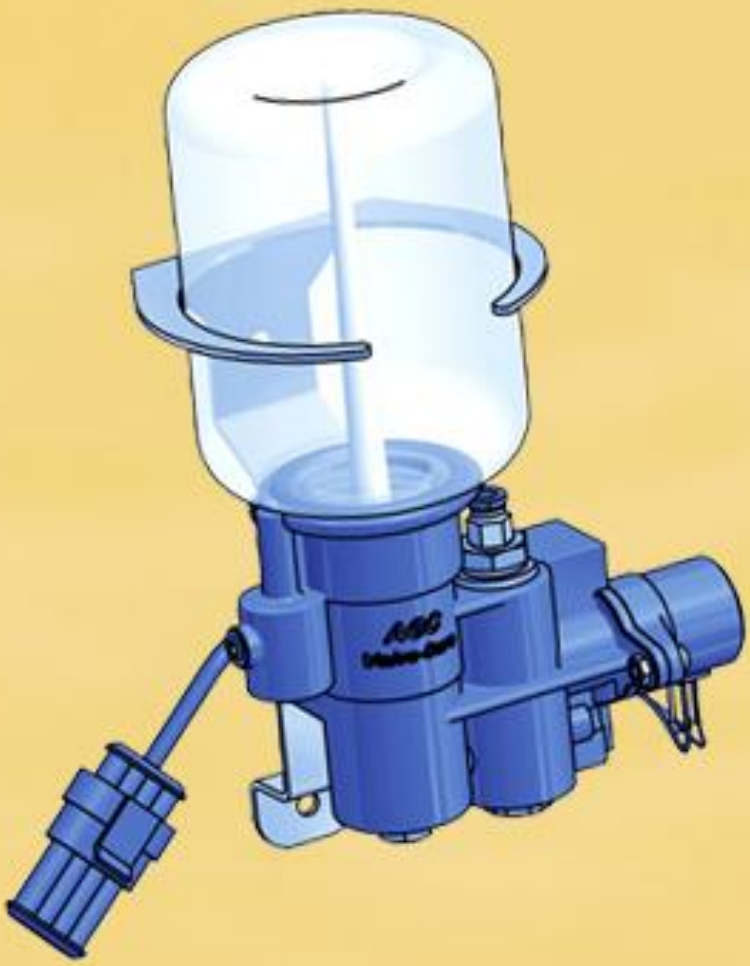
valve care



ENGINE TEST REPORT

This test is carried out by Jan Speed commissioned by Prins Autogassystemen B.V.

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Table of contents

Foreword

In order to confirm that the ValveCare system works properly, engine tests were carried out.

An initial test was done with the ValveCare system during its prototype phase in 2008. This test concluded that the chemicals in the ValveCare additive protected the inlet valves of the engine very well, but the outlet valves were not fully protected. Furthermore the dosing of the ValveCare fluid was not 100% spread equally over all cylinders of the engine.

The outcome of this test led to further developments and improvements in respect of the dosing unit and the chemicals used in the additive.

In this report you will find the results and key findings of the 2nd ValveCare test (2009) with the improved dosing unit and additive. This test was carried out by JanSpeed (UK) and commissioned by Prins Autogassystemen B.V. The test involves a 100 hour durability cycle test.

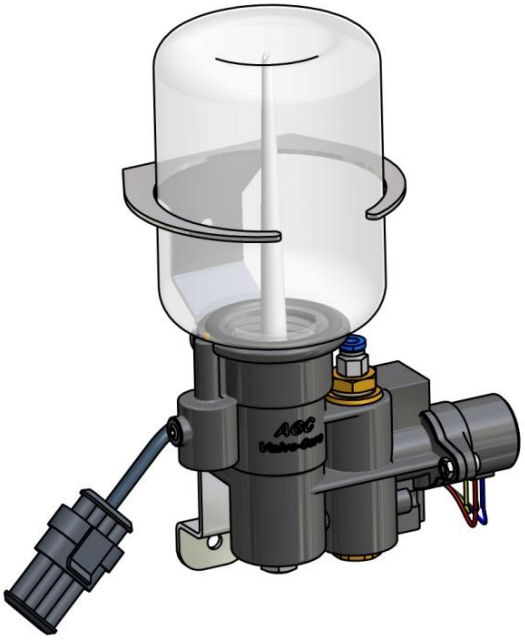
General operation ValveCare

The ValveCare dosing system consists of an additive dosing pump and a dosing unit. As soon as the car switches over to driving on LPG/CNG, the dosing pump will be switched on and the ValveCare fluid is injected under pressure into the dosing unit.

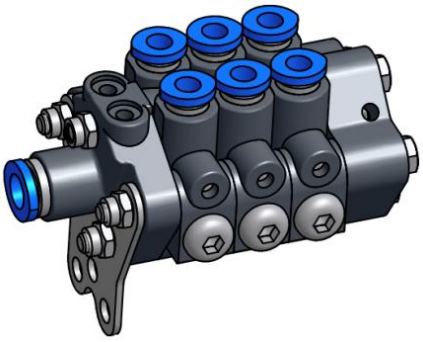
This ValveCare dosing unit makes a 100% equal spread of the ValveCare fluid possible over all cylinders (up to 10 cylinders).

ValveCare communicates directly with the Prins VSI system and will warn you in case of malfunctions by using beep signals from the VSI switch. In case of very critical errors, driving on LPG/CNG will no longer be possible.

ValveCare is unique, because the fluid dosage is calculated based on engine load and the spreading of the fluid is 100% equal over all cylinders. Consequently, the engine is always protected by the right amount of additives, even in case of turbocharged engines.



Dosing pump



Dosing unit

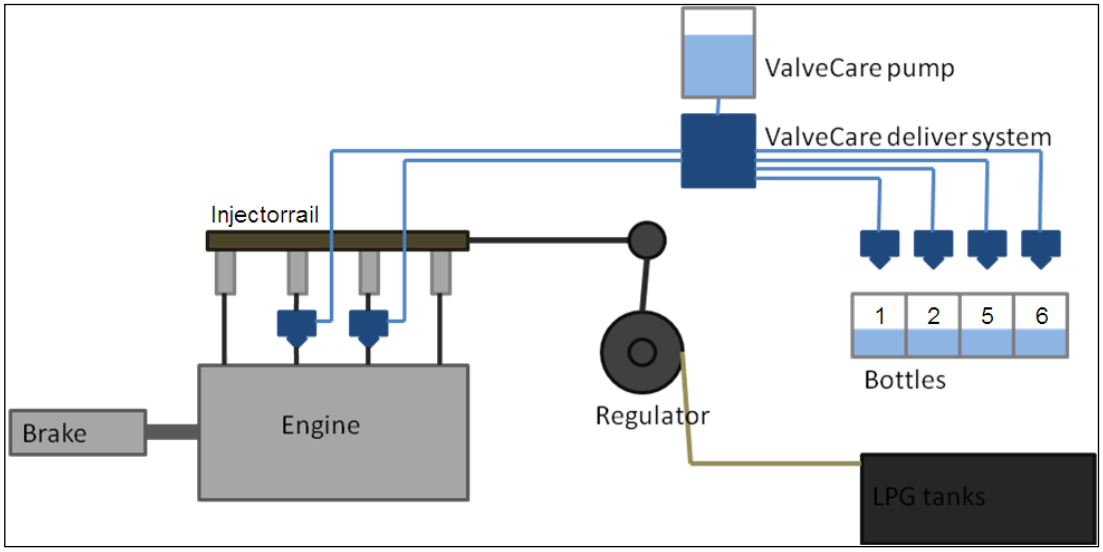
Test report

Purpose

The purpose is to test the new chemicals in the ValveCare additive and the working of the ValveCare dosing unit for making a 100% equal spreading of the ValveCare additive over all cylinders.

Test

The 100 hour durability engine test is done by JanSpeed in England. Photos of the test facilities of JanSpeed can be found in attachment 1. A graphical diagram of the test setup is found in the picture below.



Test situation

The engine test cycle is controlled by the engine brake. The test is done according to a standardized 100 hour durability cycle, in which the engine is very heavily loaded. The test scheme can be found in Attachment 2.

The engine is running on LPG. Cylinder 1 and 4 are running on LPG only and cylinder 2 and 3 on LPG and ValveCare. The ValveCare dosing unit for six cylinders is used, where two of the outputs are connected to the engine and four are connected to reference bottles. The equal dosing of the dosing unit is checked via these bottles.

Measurements

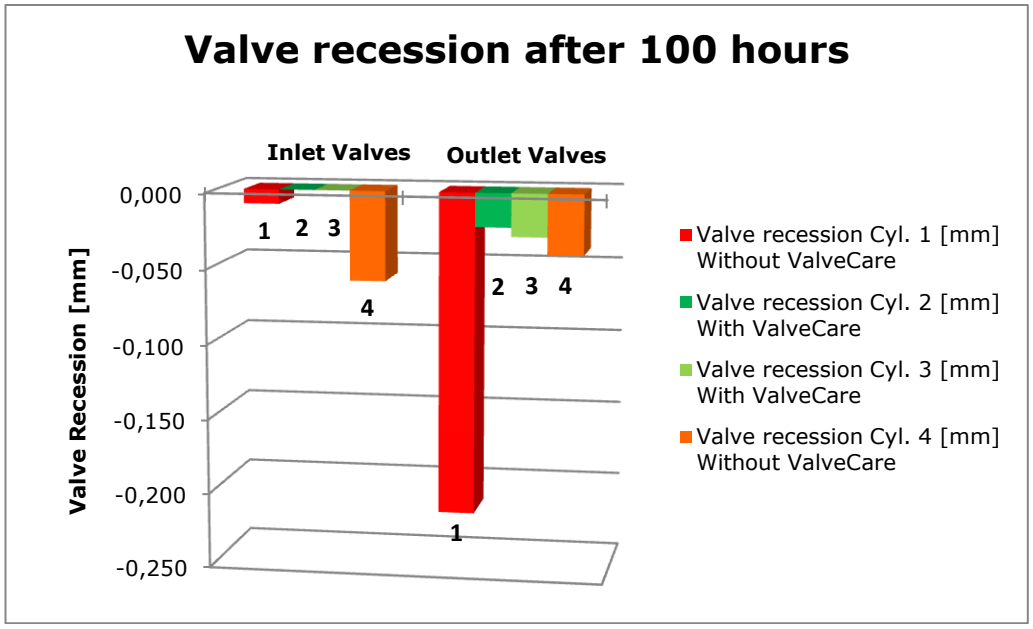
The results of the test are shown in the table below. The most important values are the valve recession and the amount of ValveCare additive in the four reference bottles.

Cycles [hours]	Valves	Valve recession Cyl. 1 [mm]	Valve recession Cyl. 2 [mm]	Valve recession Cyl. 3 [mm]	Valve recession Cyl. 4 [mm]		ValveCare in bottle 1 [gram]	ValveCare in bottle 2 [gram]	ValveCare in bottle 5 [gram]	ValveCare in bottle 6 [gram]
0	@0 In1	0,000	0,000	0,000	0,000		0	0	0	0
	@0 In2	0,000	0,000	0,000	0,000					
	@0 Out1	0,000	0,000	0,000	0,000					
	@0 Out2	0,000	0,000	0,000	0,000					
100	@100 In1	**-0,008**	**0,000**	**0,000**	**-0,093**					
	@100 In2	**-0,011**	**0,000**	**0,000**	**-0,026**					
	@100 Out1	**-0,233**	**-0,032**	**-0,033**	**-0,010**					
	@100 Out2	**-0,195**	**-0,013**	**-0,024**	**-0,070**		**234**	**230**	**231**	**233**

Results

Valve recession

To illustrate the valve recession the test results after 100 hours are implemented into a graph.



As you can see in the graph, the valve recession on the inlet valves is significantly less when ValveCare is added to the LPG (cylinder 2 and 3). The inlet valves of these cylinders do not show any wear. Even after the complete 100 hours cycle the valve recession is still 0 mm. The inlet valves without ValveCare (cylinder 1 and 4) both show a certain valve recession already, after 100 hours.

The thermal load on the outlet valves is higher than on the inlet valves, which means higher wear of the outlet valves. The outlet valves of cylinder 2 and 3 are protected with ValveCare and show significantly less wear than the valves of the other two cylinders (cylinder 1 and 4) without ValveCare.

The metal wear of the valves will cause a red dust between the valves and the valve seats. This red dust acts as sand or sand paper and will grind out the valves and valve seats. This causes an exponential increase in the wear on the outlet valves of cylinder 1.

Operation 100% dosing unit

As you can see in the table the spreading of the ValveCare additive over the cylinders is equal. Even after the 100 hour durability test the difference in grams of additive added per cylinder is minimal.

The deviation between the bottles is less than 0.8%. This is a great result and underlines the excellent performance of the dosing unit.

Parts observations

The wear of the valves is much more on cylinder 1 and 4 as seen on the picture below. The red dust is a kind of metal wear, this dust acts as sand or sand paper and will grind out the valves and valve seats.

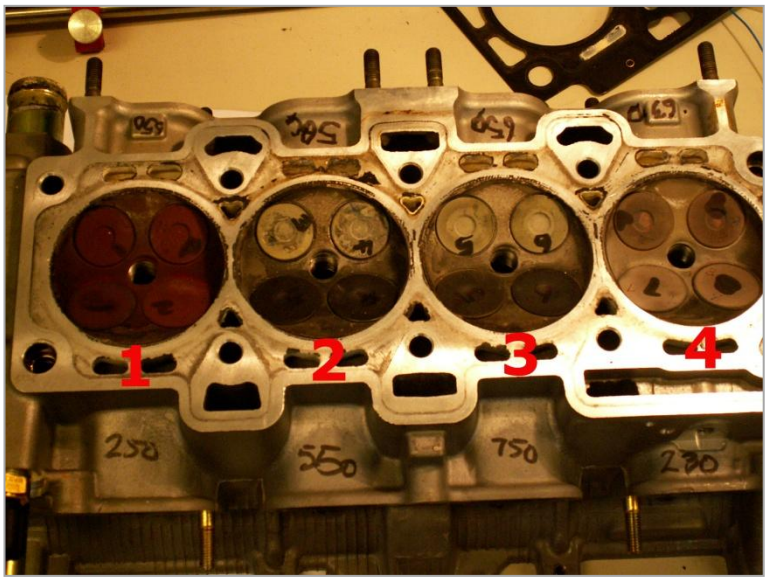
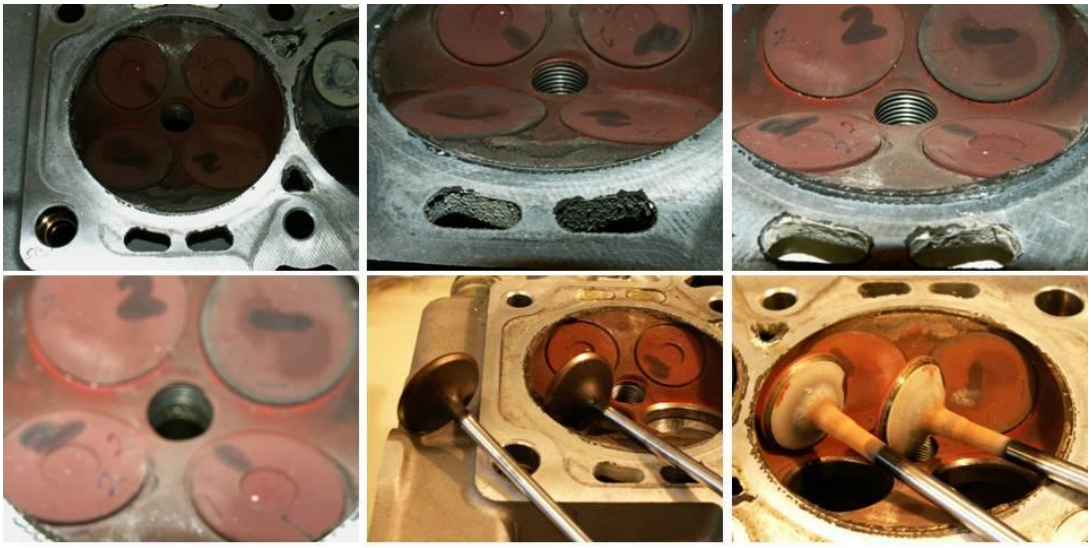


Photo cylinder head

The pictures below are close up photos of the valves in the cylinders. As you can see there is red dust (metal wear) in the cylinder without ValveCare.



Valves | Inlet Valves | Outlet Valves

Cylinder 1 – Without ValveCare

Valves Inlet Valves Outlet Valves

Cylinder 2 – With ValveCare

Valves Inlet Valves Outlet Valves

Cylinder 3 – With ValveCare

Valves | Inlet Valves | Outlet Valves

Cylinder 4 – Without ValveCare

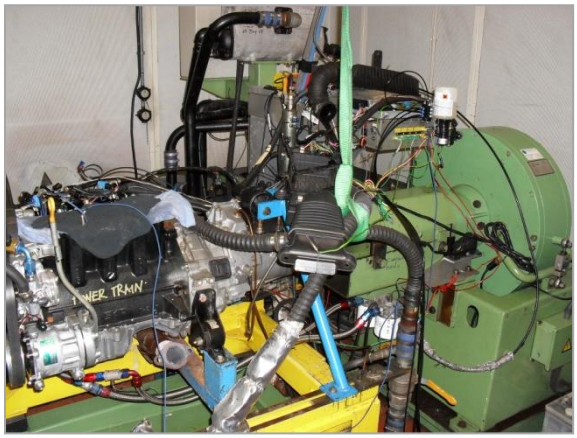
Conclusion

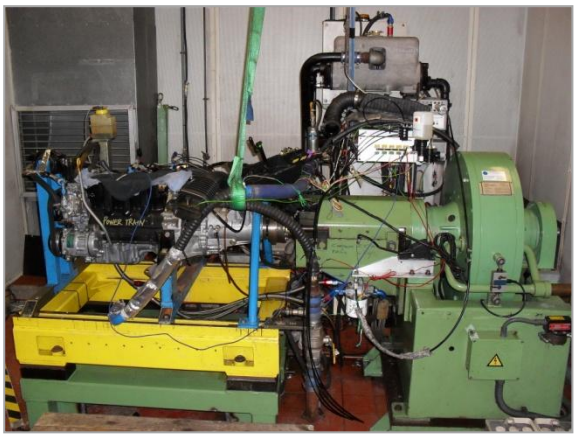
In conclusion we can state that the new ValveCare system with the dosing unit and the new additive performs very well. The valve and valve seat wear can be reduced significantly and the dosing of the ValveCare additive is equal over all cylinders.

The test results show that the new additive protects as well the inlet as outlet valves, even under the most extreme conditions. The valve recession on the inlet valves is equal to 0 at the valves were ValveCare is used. The outlet valves show a very little recession compared to the outlet valves without ValveCare.

With the dosing unit an equal additive dosing is guaranteed, so all cylinders get the correct dosage of ValveCare additive. The deviation in dosing measured over the complete durability test is only 0.8%.

Attachment 1 - Test facilities JanSpeed





Attachment 2 - Durability Cycle

STAGE	R.P.M.	Throttle	Minutes	
1	900	0	0.5	Idle
2	1700	100	3.0	Resonance 1
3	3000	100	6.0	
4	4000	100	12.0	peak torque
5	5300	70	6.0	
6	4800	100	6.0	Resonance 2
7	6600	100	3.0	Peak power rpm +10%
8	6000	100	6.0	peak power
9	6900	100	1.0	rpm max
10	5000	20	5.0	to promote ring flutter
11	900	0	1.0	Idle
12	4000	100	2.0	Peak torque
13	6000	100	1.0	Ramp to Peak power
14	6000	100	2.0	Peak power
15	4000	100	0.5	Ramp to Peak torque
16	6900	100	0.5	Ramp to peak speed
17	4000	100	0.5	Ramp to peak torque
18	6900	100	0.5	Ramp to peak speed
19	4000	100	0.5	Ramp to peak torque
20	6900	100	0.5	Ramp to peak speed
21	4000	100	0.5	Ramp to peak torque
22	4000	100	0.5	Peak torque
23	4000	50	1.5	Part load
24	900	0	0.5	idle