

VALIDATION PLAN REPORT APACHE HD - APACHE 2014 IMPROVEMENTS

PRODUCT	DOCUMENT TYPE	PRODUCT CODE
APACHE HD , APACHE 2014	Validation plan report	

PRODUCT DESCRIPTION

Apache HD and Apache 2014 are an improved version of Apache injector (2013 version)

THE DESIGN GOALS:

Improve durability life
Improve the linearity performance by faster response time (only Apache HD)
Improve contamination tolerances
Quite operation ,Noise Reduction

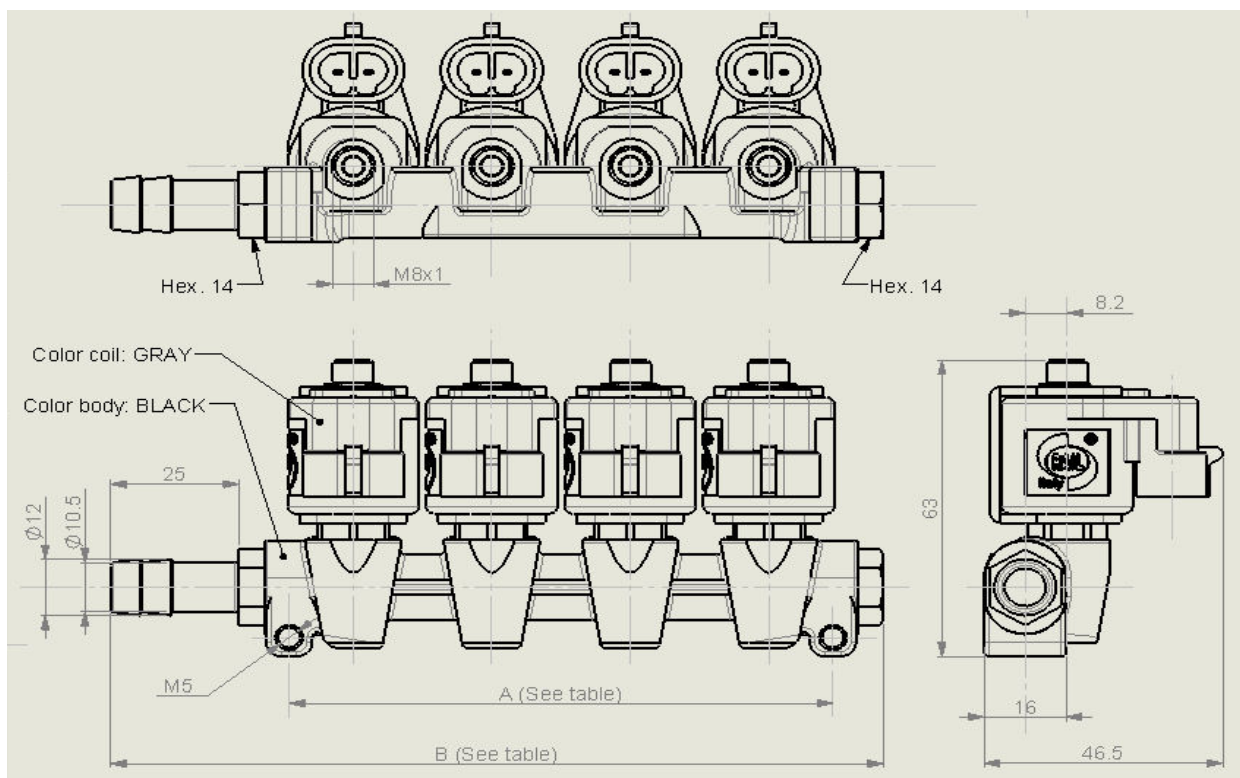
Test description

Verify improvements of Apache 2014 and Apache HD by comparison with Apache 2013



		Technical Data	
		Apache HD	Apache
Available models		2, 3, 4 cylinders	
Working pressure		da 0,5 a 2,0 bar da 7 a 29 psi	
Max Working Pressure		3,0 bar 43 psi	
Rated Voltage (at coil)		10,8 - 14,4 V	
Minimum copper wire section for coil connection		0,75 mmq	
COIL TYPE		A2	A3
Coil Resistance (±5%) at T=25°C		2,0 Ohm	3,0 Ohm
Suggested peak current time		3,5 ms	4,5 ms
Cold Starting Requirements		Increase up to 20% the "peak current time" for first cycles when gas temperature is <10°C	
Suggested holding current (±10%)		1 A	1 A
Tested on new injector without nozzle at 12	Opening time Closing time (±10%) (Total injection time 5 ms)	2,7 ms 2,0 ms	3,7 ms 2,8 ms
	Minimum injection pulse (±5%)	2,8 ms	3,3 ms
Inlet gas fitting		Rubber hose: Ø 10 mm / Ø 12 mm / (Ø 14 mm) / (Ø 16 mm)	
Outlet gas fitting		Calibrated Nozzles M8x1 for rubber hose Ø 6 mm - (Ø 5 mm) - (Ø 4 mm)	
Calibrated hole range (for nozzles)		1,0 - 2,75 mm (0,25 mm step)	1,0 - 3,5 mm (0,25 mm step)
Gas Compatibility		CNG, GPL	
Power handling capability (more details on nozzle table)		GPL 1 bar up to 45 HP/cyl. CNG 2 bar up to 40 HP/cyl.	GPL 1 bar up to 50 HP/cyl. CNG 2 bar up to 45 HP/cyl.
Agreement and temperature range		67R-01 -20° C / +120° C	
		110R-00 -40°C / +120°C	

APACHE HD DRAWING



Leakage Test

Leakage must be less than 15 cc/h (Pressure from 0 to 11 bar) and (temperature from -40°C to +120 °C)

VT-12 Leakage Test		
Temperature :	Pressure From 0 to 11 bar	Result
- 40 °C	leakage less than 15cc/h	OK
- 20 °C	leakage less than 15cc/h	OK
+20 °C	leakage less than 15cc/h	OK
+ 120 °C	leakage less than 15cc/h	OK

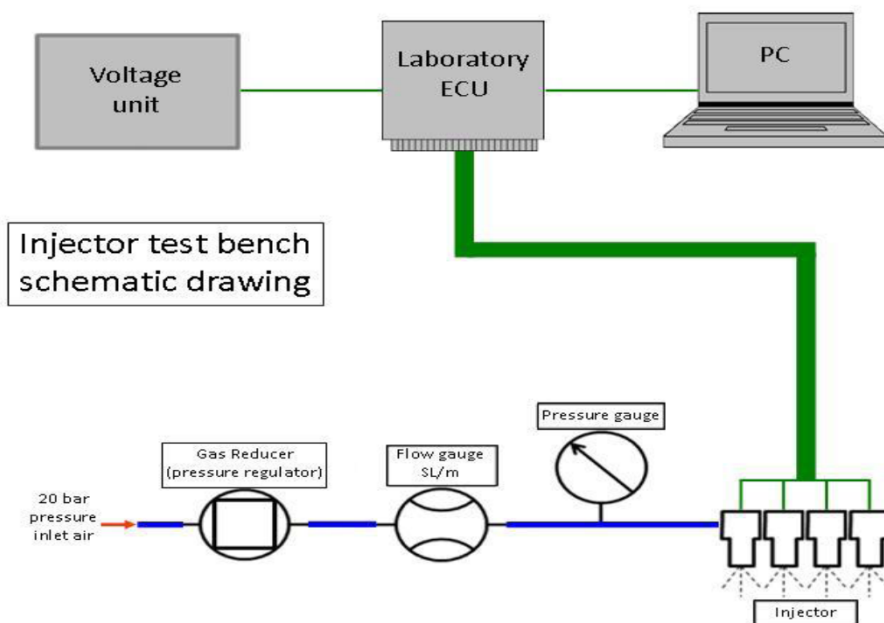
VT -18 Overpressur e 10 bar	Stroke Apache HD				Leakage
	1	2	3	4	
	0,46	0,46	0,46	0,46	ok
Δ Stroke after test	0,006	0,006	0,005	0,004	

Leakage is less than 15cc/h in every test conditions

Test Result:	Written:	Verified:	Approved:
Positive	Date: 20/06/2014	Date: 23/06/2014	Date: 03/09/2014
	Sign: F. Rossi	Sign: Castagnedoli	Sign: Stevani Luigi

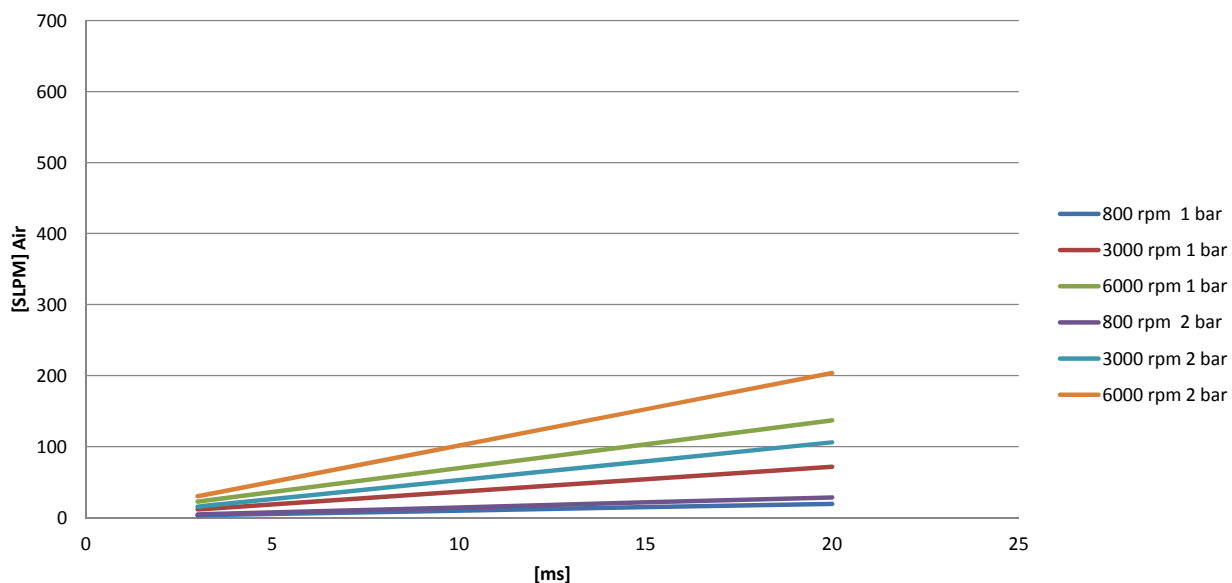
Apache HD Flow rate Test

Flow curve on different driving condition :
linearity performance comaparison: Apache HD-Apache 3 ohm (version 2013 and 2014)

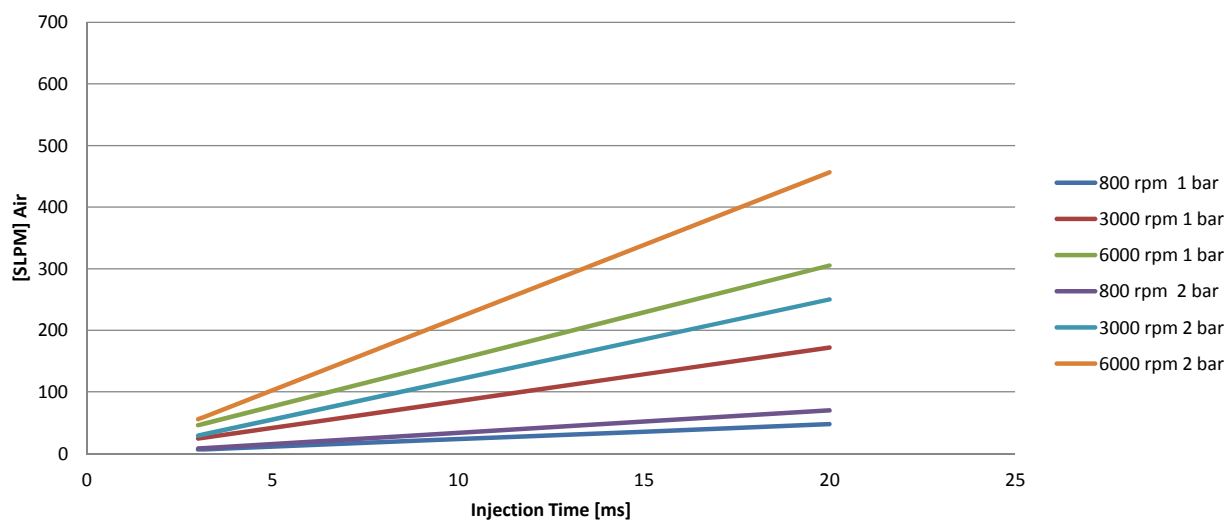


Flow rate Test parameter	RPM	Inj. T. (ms)	Pressure (bar)	Nozzle Φ (mm)
From	800	4	1	1,5
To	6000	20	2	2,5

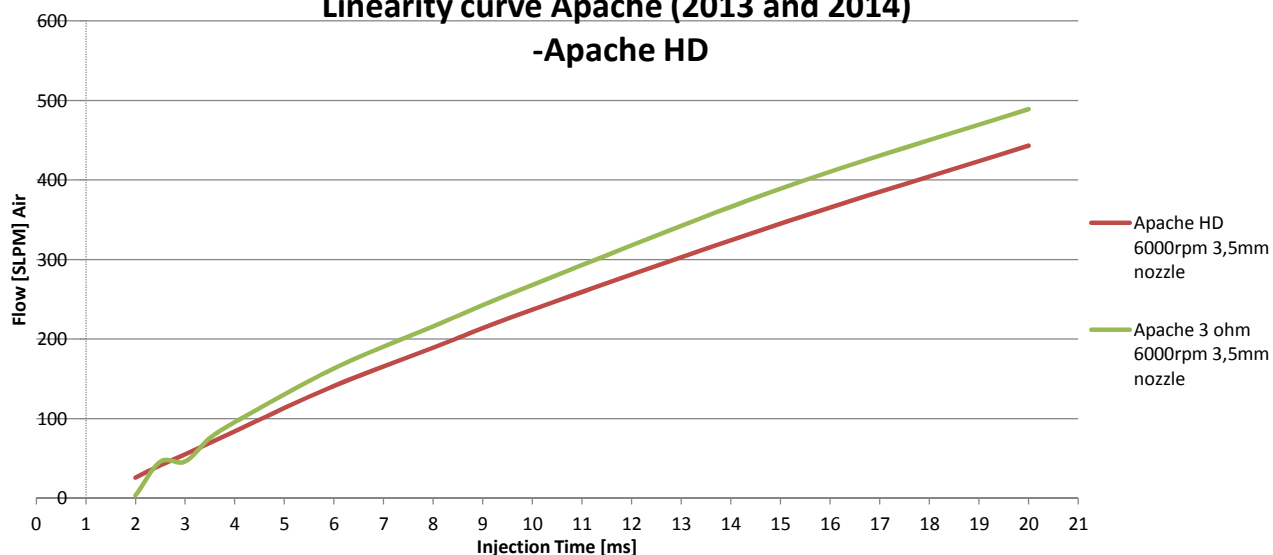
IG1 Apache HD 1,5 mm nozzle



IG1 Apache HD 2,5 mm nozzle



Linearity curve Apache (2013 and 2014) -Apache HD



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Durability Test

Below there is a table to compare the laboratory durability in the same test conditions of three version of Apache and Apache HD

Laboratory Endurance Test				
Test condition:				
Filtered dried air inlet @ 1 bar				
50°C closed box temperature				
6000 RPM frequency – 3.5 ms Injection time				
ECU RAIL piloting parameters @ 14 Volt				
Step N°	N° cycle	Apache 2013	Apache 2014	Apache HD
0	0			
1	25M			
2	50M			
3	75M			
4	100M			
5	125M			
6	150M			
7	175M			
8	200M			
9	225M			
10	250M			
11	275M			
12	300M			
13	325M			
14	350M			
15	375M			
16	400M			
17	425M			
18	450M			
19	475M			
20	500M			
Tolerances:				
Values % changing from starting to after test:				
Stroke: < 7 %				
Dynamic Flow: < 5 %				
Static Flow: < 5 %				
Opening,Closing Time: < 10 %				

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Contamination Tolerances

Verify the rubber characteristics with laboratory test and on the Car

Seal disc and V-ring material characteristics

	Apache 2013	Apache HD , Apache 2014	
Rubber compound:	Brown FKM (Apache)	New Black (Apache HD)	
Characteristics Comparison:			Test Method
Tensile strength:			ASTM D 412/C
Elongation:			ASTM D 412/C
Compression Set:			ASTM D 395/B
Characteristics changes after ageing with CNG and LPG:			ASTM D 471
	Good characteristics	Very good characteristics	

Endurance Test on the field (Apache HD -Apache 2014)

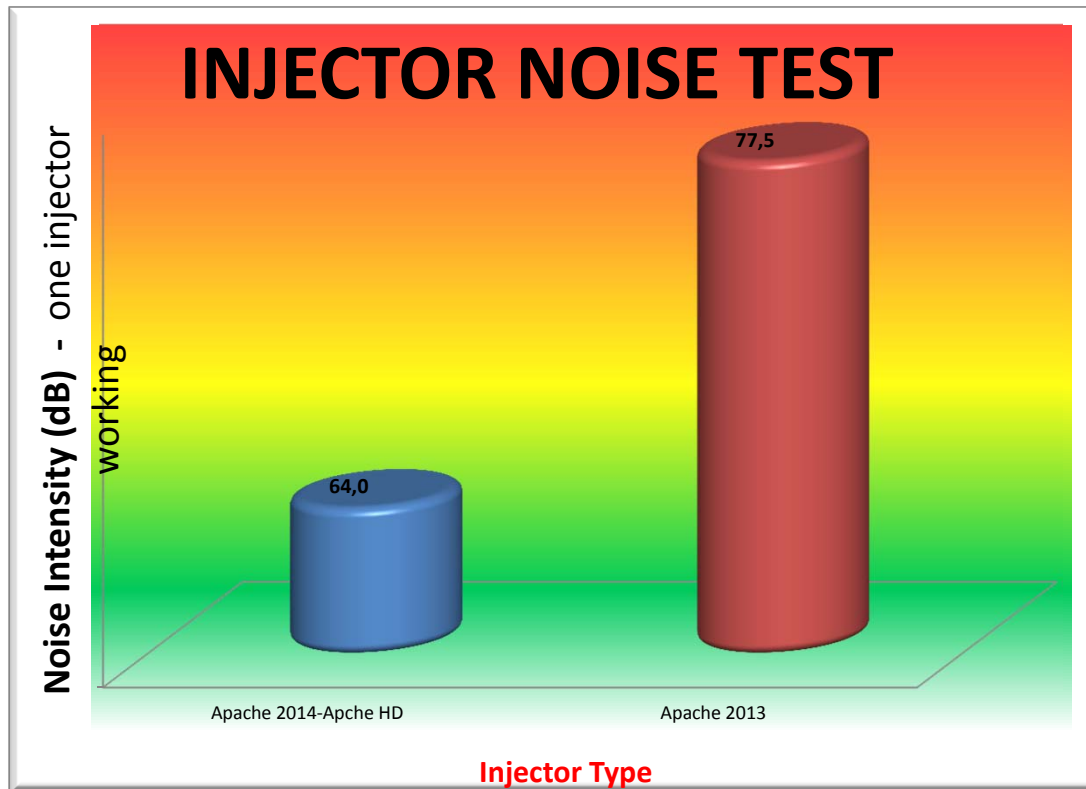
Samples N°	1	2	3	4	5	6	7	8
Instal. Date	January 2013	January 2013	January 2013	January 2013	Febr 2013	January 2013	Febr 2013	Febr 2013
Verify Date	June 2014	June 2014	June 2014	June 2014	June 2014	June 2014	June 2014	June 2014
Result	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
Samples N°	10	11	12	13	14	15	16	17
Instal. Date	January 2014	January 2013	Febr 2013	Febr 2013	Febr 2013	January 2013	Febr 2013	January 2013
Verify Date	June 2014	June 2014	June 2014	June 2014	June 2014	June 2014	June 2014	June 2014
Result	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
Test criteria :	The samples have to run without fault and without maintenance activity							

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Noise Test

Noise comparison Apache - Apache HD

Used instruments and test description:
 Laboratory ECU set at 6000 rpm and 5 ms injection time
 Stabilized power supply @ 14V
 Noise meter Extech HD600 - Maximum value measured



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Conclusion

These tests were performed in order to validate the improvements on Apache 2014 and Apache HD
 All the improvements Goals are verified and validated

Validation Results		
Design Goals:	Apache 2014	Apache HD
Durability Life	increased up to 100%	increased of 1000%
Linearity performance	no design change	improvement at low injection time
Contamination tolerances	Improved Rubber characteristics	Improved Rubber characteristics
Noise reduction	18 % noise reduction	18 % noise reduction
Improvement		
no improvement		

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