Bob F.

PEUGEOT XUD-9-AL NOZZLE COKING TEST
10 HOUR CYCLIC PROCEDURE

Ricardo Test No	:	11536-00
Procedure	:	F 23-T-00
Fuel Reference	:	BP, EN 590 Low sulphur Diesel
Additive Reference	:	N/A
Test Completed	:	02-Jun-00

Test Conducted For:

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THE EVALUATION OF INJECTOR NOZZLE COKING USING THE PEUGEOT XUD-9 ENGINE

1.0 INTRODUCTION

The Peugeot XUD-9 Nozzle Coking Test has been developed by the CEC PF-023 group. The test is designed to evaluate the capability of Diesel fuel additives to prevent injector nozzle coking in a modern indirect injection passenger car engine.

2.0 TEST ENGINE

Designation	-	Peugeot XUD-9-AL
No of cylinders	-	4
Swept volume	-	1.9 litre
Injector Nozzle	-	RDNOSDC 6850
Nozzle Opening Pressure	-	115 +/- 5 bar
Injection Pump	-	Roto Diesel Type 047
Dynamic Injection Timing	-	10° BTDC

3.0 TEST PROCEDURE

Stage	Time	Speed	Torque
1	30	1200±30	10±2
2	60	3000±30	50±2
3	60	1300±30	35±2
4	120	1850±30	50±2

Coolant out	95°C ± 2°C
Coolant delta	4°C (Stage 2)
Oil gallery	100°C ± 5
Air inlet	32°C ± 2°C
Fuel return pressure	-50 to +100 mbar
Fuel supply pressure	-100 to +100 mbar
Exhaust back pressure	50 ± 10 (Stage 2)

3.1 ENGINE PRE-TEST PREPERATION

The fuel system is flushed with the test fuel.
A clean set of slave injectors are fitted to the engine.
The engine is started and warmed up to procedure.
The fuel pump is flushed through to procedure with the test fuel.
The engine is then ramped up to 3000 r/m - 50 Nm and conditions are allowed to stabilise for ten minutes.
The engine is then set to the required set-up conditions and the data is logged.
Once all the set up conditions are correct the engine speed and load is reduced to 1000 r/m - 5 Nm for five minutes before stopping the engine.
New fuel filters are installed.
The slave injectors are removed from the engine.

3.2 ENGINE SET UP CONDITIONS

Speed (r/m)	3004
Load (Nm)	50
Fuel Temp, pump (deg C)	31
Inlet Air (deg C)	32
Exhaust (deg C)	333
Exhaust bp (mbar)	51
Coolant in (deg C)	90.9
Coolant out (deg C)	95.3
Coolant delta (deg C)	4
Oil temp (deg C)	100
Smoke (AVL)	1.1
Blow-by (lpm)	11
Fuel consumption (kg/hr)	4.8
Fuel pump pressure in (mb)	35
Fuel pump pressure out (mb)	4
Dynamic injection pump timing	10.0

3.3 TEST INJECTOR PREPARATION

New nozzles are flowed with air, using the nozzle flow testing rig to ISO 4010.

Measurements are taken at lift points 0.05, 0.1, 0.2, 0.3, 0.4 and 0.5 mm.

The nozzles are assembled, set to the correct opening pressure and then fitted to the engine.

3.4 TEST RUN

The engine is warmed up to test conditions and run for 10 hours without stops, using the fuel to which the test additive has been added.

3.5 END OF TEST

At the end of test the injectors are removed from the engine, dismantled, and the nozzles reflowed on the test rig.

3.6 REPORTING OF RESULTS

Results are expressed as the percentage residual airflow for each lift point.

3.7 FUEL BLENDING

Market place fuel, additive pre-blendid at distribution terminal.

3.8 ENGINE OPERATING CONDITIONS

The engine operating conditions are monitored and recorded every 5th cycle throughout the test.The minimum,maximum and average values are displayed below for all 4 stages.

	Stage 1			Stage 2		
	min	max	ave	min	max	ave
Speed (r/m)	1199	1205	1202	3002	3004	3002
Load (Nm)	10.4	10.9	10.7	50.0	50.8	50.4
Fuel Temp, pump (deg C)	31	32	31	31	32	31
Inlet Air (deg C)	32	33	32	32	33	32
Exhaust (deg C)	192	201	197	310	318	312
Exhaust bp (mbar)	12	15	14	49	50	49
Coolant in (deg C)	89	93	91	91	93	92
Coolant out (deg C)	94	96	96	95	96	96
Oil temp (deg C)	98	99	99	101	102	102
Smoke (AVL)	*	*	*	0.8	1.2	1.0
Fuel pump pressure in (mb)	19	42	32	16	37	28
Fuel pump pressure out (mb)	5	23	10	7	21	10
	Stage 3			Stage 4		
	min	max	ave	min	max	ave
Speed (r/m)	1299	1302	1300	1848	1851	1850
Load (Nm)	34.4	35.5	35.2	50.1	50.6	50.4
Fuel Temp, pump (deg C)	31	32	32	31	32	31
Inlet Air (deg C)	32	33	32	31	33	32
Exhaust (deg C)	210	213	211	251	254	252
Exhaust bp (mbar)	13	14	14	16	17	16
Coolant in (deg C)	91	92	91	90	93	91
Coolant out (deg C)	94	95	95	94	96	96
Oil temp (deg C)	99	100	100	99	99	99
Smoke (AVL)	*	*	*	0.8	1.5	1.1
Fuel pump pressure in (mb)	18	42	30	15	39	28
Fuel pump pressure out (mb)	8	22	11	8	22	11
Total fuel consumption for test (lts)	34.0					

3.9 REPORT OF OPERATION OUTSIDE SPECIFICATION LIMITS

None.

4.0 FLOW RATES AND % RESIDUAL FLOW TABLES

Customer Fuel Code	BP, EN 590 Low sulphur Diesel	RTS Number	N/A
Additive	N/A	RTS Number	N/A
Fuel volume	60 lts		
Dose Rate	N/A	Engine Number	2
Rater SOT	MIH	Rater EOT	MCT

Cylinder 1

Nozzle 01

Lift (mm)	Flow Before test LPM	Flow After test LPM	Residual Flow (%)
0	0.0	0.0	0
0.05	0.206	0.027	13
0.1	0.296	0.050	17
0.2	0.387	0.059	15
0.3	0.475	0.098	21
0.4	0.566	0.161	28
0.5	0.673	0.371	55

Cylinder 2

Nozzle 02

Lift (mm)	Flow Before test LPM	Flow After test LPM	Residual Flow (%)
0	0.0	0.0	0
0.05	0.219	0.043	19
0.1	0.269	0.054	20
0.2	0.341	0.079	23
0.3	0.422	0.118	28
0.4	0.522	0.217	42
0.5	0.642	0.401	63

Cylinder 3

Nozzle 03

Lift (mm)	Flow Before test LPM	Flow After test LPM	Residual Flow (%)
0	0.0	0.0	0
0.05	0.194	0.044	23
0.1	0.282	0.065	23
0.2	0.371	0.125	34
0.3	0.457	0.219	48
0.4	0.550	0.332	60
0.5	0.663	0.487	73

Cylinder 4

Nozzle 04

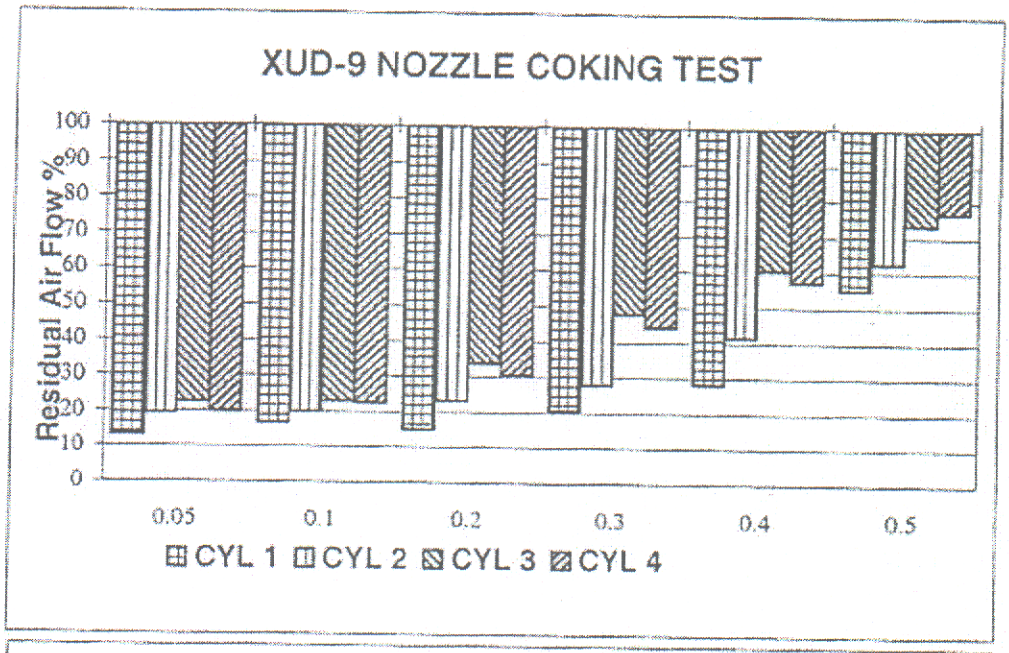
Lift (mm)	Flow Before test LPM	Flow After test LPM	Residual Flow (%)
0	0.0	0.0	0
0.05	0.200	0.040	20
0.1	0.259	0.059	23
0.2	0.351	0.107	30
0.3	0.446	0.197	44
0.4	0.547	0.313	57
0.5	0.674	0.518	77

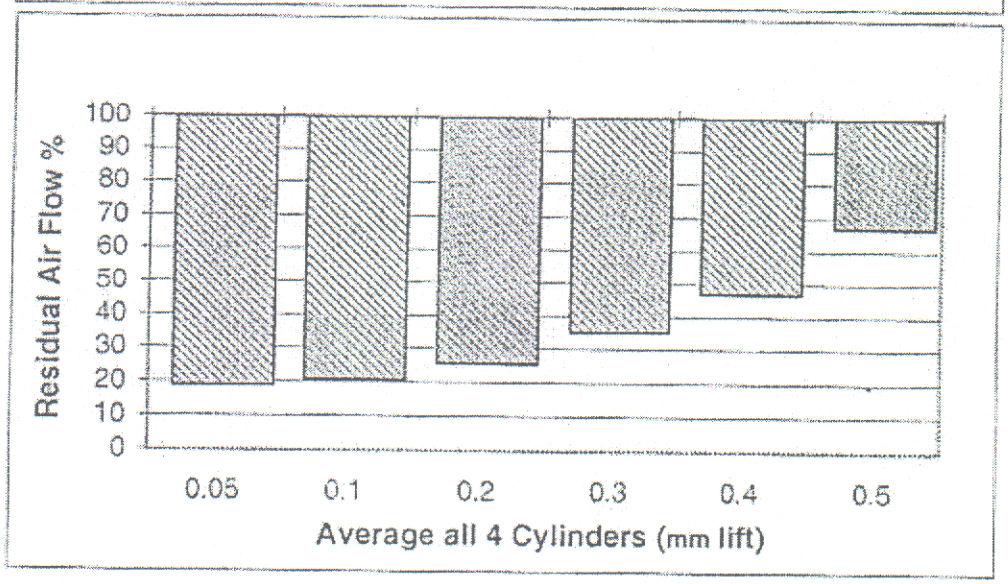
Average of all 4 nozzles

Lift (mm)	0	0.05	0.1	0.2	0.3	0.4	0.5
Residual flow %	0	19	21	26	35	47	67

All results are corrected to standard conditions, 293 K / 980 mbar.

4.1 RESIDUAL AIR FLOW GRAPHS





5.0 REFERENCE BASE FUEL, RESULTS SUMMARY

Test Number	11529-00	Procedure	F 23-T-00
Test Date	23-May-00	Test Stand	4:1
Fuel Code	RF 93-T-95	RTS Number	N/A
Additive	None	RTS Number	N/A
Dose Rate	N/A		

Cylinder 1
Nozzle JK 963

Lift (mm)	Flow Before test LPM	Flow After test LPM	Residual Flow (%)
0	0.0	0.0	0
0.05	0.217	0.028	13
0.1	0.274	0.042	15
0.2	0.370	0.084	23
0.3	0.465	0.156	34
0.4	0.563	0.302	54
0.5	0.685	0.488	71

Cylinder 2
Nozzle JK 964

Lift (mm)	Flow Before test LPM	Flow After test LPM	Residual Flow (%)
0	0.0	0.0	0
0.05	0.227	0.030	13
0.1	0.284	0.039	14
0.2	0.373	0.070	19
0.3	0.461	0.138	30
0.4	0.543	0.226	42
0.5	0.664	0.346	52

Cylinder 3
Nozzle JK 965

Lift (mm)	Flow Before test LPM	Flow After test LPM	Residual Flow (%)
0	0.0	0.0	0
0.05	0.199	0.026	13
0.1	0.246	0.036	15
0.2	0.321	0.104	32
0.3	0.405	0.208	51
0.4	0.499	0.332	66
0.5	0.616	0.432	70

Cylinder 4
Nozzle JK 966

Lift (mm)	Flow Before test LPM	Flow After test LPM	Residual Flow (%)
0	0.0	0.0	0
0.05	0.214	0.019	9
0.1	0.269	0.021	8
0.2	0.360	0.029	8
0.3	0.453	0.045	10
0.4	0.549	0.105	19
0.5	0.670	0.400	60

Average of all 4 nozzles

Lift (mm)	0	0.05	0.1	0.2	0.3	0.4	0.5
Residual flow %	0	12	13	20	31	45	63

All results are corrected to standard conditions, 293 K / 980 mbar.

5.1 REFERENCE ADDITISED FUEL, RESULTS SUMMARY

Test Number	11530-00	Procedure	F 23-T-00
Test Date	24-May-00	Test Stand	4:1
Fuel Code	RTS 4342	RTS Number	RTS 4342
Additive	Pre blended	RTS Number	N/A
Dose Rate	N/A		

Cylinder 1
Nozzle JK 967

Lift (mm)	Flow Before test LPM	Flow After test LPM	Residual Flow (%)
0	0.0	0.0	0
0.05	0.232	0.098	42
0.1	0.285	0.128	45
0.2	0.365	0.218	60
0.3	0.448	0.310	69
0.4	0.543	0.419	77
0.5	0.666	0.598	90

Cylinder 2
Nozzle JK 968

Lift (mm)	Flow Before test LPM	Flow After test LPM	Residual Flow (%)
0	0.0	0.0	0
0.05	0.230	0.077	34
0.1	0.291	0.108	37
0.2	0.376	0.194	52
0.3	0.460	0.304	66
0.4	0.552	0.438	79
0.5	0.671	0.621	93

Cylinder 3
Nozzle JK 969

Lift (mm)	Flow Before test LPM	Flow After test LPM	Residual Flow (%)
0	0.0	0.0	0
0.05	0.207	0.093	45
0.1	0.264	0.121	46
0.2	0.342	0.190	56
0.3	0.419	0.272	65
0.4	0.497	0.385	77
0.5	0.632	0.552	87

Cylinder 4
Nozzle JK 970

Lift (mm)	Flow Before test LPM	Flow After test LPM	Residual Flow (%)
0	0.0	0.0	0
0.05	0.228	0.097	42
0.1	0.286	0.133	46
0.2	0.371	0.244	66
0.3	0.454	0.358	79
0.4	0.545	0.512	94
0.5	0.661	0.641	97

Average of all 4 nozzles

Lift (mm)	0	0.05	0.1	0.2	0.3	0.4	0.5
Residual flow %	0	41	44	58	70	82	92

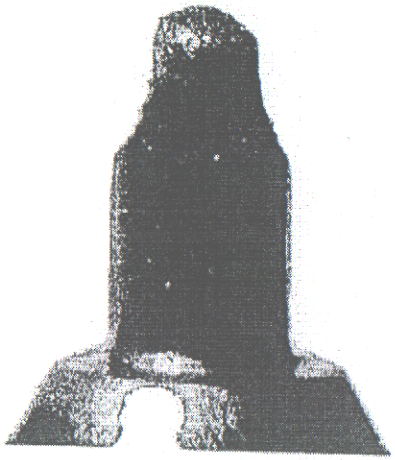
All results are corrected to standard conditions, 293 K / 980 mbar.

6.0 PHOTOGRAPHS OF TEST PARTS

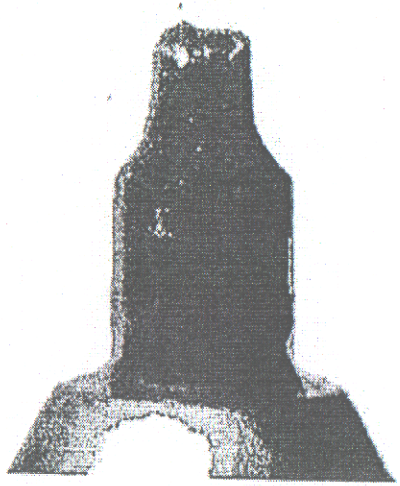
1 Pintle cylinder 1
2 Pintle cylinder 2
3 Pintle cylinder 3
4 Pintle cylinder 4

1536-00

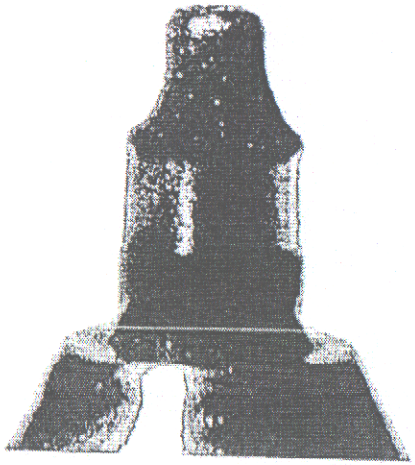
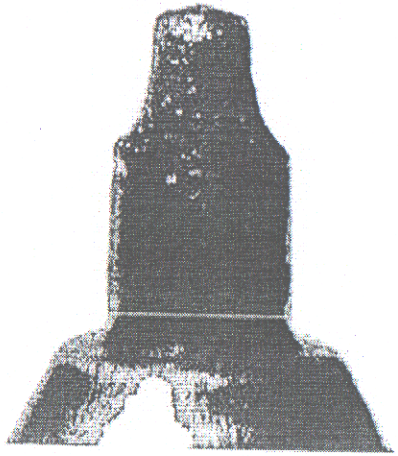
Nozzle 1



Nozzle 2



Nozzle 3



Nozzle 4