XBEE
ENZYME FUEL TECHNOLOGY

TESTS OFFICIELS CEC
Diesel & Essence

EN PARFAITE CONFORMITÉ AVEC LES MOTEURS
Le **CEC** pour le développement de tests de performance des carburants, des lubrifiants et autres fluides, est l'organisme européen de référence agréé par plus de cinquante constructeurs automobiles, pétroliers et fabricants d'huiles.

prodrive

CEC

1 · Moteurs Diesel
Concernant les moteurs Diesel, la procédure CEC F-23-A-01 doit évaluer l'état des dépôts de carbone dans un moteur à injection indirecte de référence (PSA Peugeot XUD9 – A/L 4 cylindres – 1.9 lt).

Ces deux tests successifs ont été menés par le laboratoire anglais **Prodrive** les 17 et 18 juillet 2005 sous l'œil attentif de Garry Polkinghorne.

Pour être reconnus par les associations de professionnels (ACEA, Atiel, ATC et Concawe) décrites en page 2 et 3, le niveau d'encrassement doit impérativement être compris entre 85% et 95% : la technologie de l'enzyme XBEE permet au carburant de se placer à 92% et 91% respectivement, et ce en seulement 10 heures.

2 · Moteurs Essence
En ce qui concerne les moteurs Essence, la procédure CEC F-05-A-93 doit évaluer l'état des dépôts de carbone sur les soupapes d'admission dans un moteur à injection de référence (Mercedes-Benz M102.982 – 4 cylindres – 4 temps – 2.3 lt), équipé d'une injection Bosch KE-Jetronic.

À l'instar du premier, ce test a été mené par le laboratoire anglais **Prodrive** le 22 juillet 2005 sous le contrôle du même ingénieur.

Pour être reconnus par les associations de professionnels pré-citées, le niveau d'encrassement doit impérativement être compris entre 4.5 (très encrassé) et 10 (propre) : la technologie de l'enzyme XBEE permet au carburant de se placer à 8.07 en seulement 60 heures, soit 287 mg en moyenne (avec un plus bas à 215 mg) contre 314.25 mg pour le même carburant dans le même moteur sans XBEE.

ACEA European Automobile Manufacturers Association

atiel DRIVING STANDARDS IN LUBRICANT TECHNOLOGY

ATC

Concawe Environmental Science for European Refining

XBEE
ENZYME FUEL TECHNOLOGY

TESTS OFFICIELS CEC
Diesel & Essence

MEMBRES DE L'ACEA AYANT VALIDÉ CES TESTS CEC

ACEA European Automobile Manufacturers Association

Search the site

NEWS | ABOUT THE AUTOMOBILE INDUSTRY | STATISTICS | INDUSTRY TOPICS | PUBLICATIONS | ABOUT ACEA

About ACEA ▸ Who We Are ▸ ACEA Members

ACEA's Members

BMW GROUP · CNH INDUSTRIAL · DAF · DAIMLER · Ferrari · FCA FIAT CHRYSLER AUTOMOBILES · Ford · HONDA The Power of Dreams · HYUNDAI · JAGUAR LAND ROVER · PSA GROUPE · GROUPE RENAULT · TOYOTA · VOLKSWAGEN · VOLVO · VOLVO VOLVO GROUP

Who We Are
- ACEA Members
- Associated Organisations
- Partners

What We Do

How We Are Organised
- ACEA President
- ACEA Director General
- Board of Directors
- Commercial Vehicle Board of Directors
- Secretariat

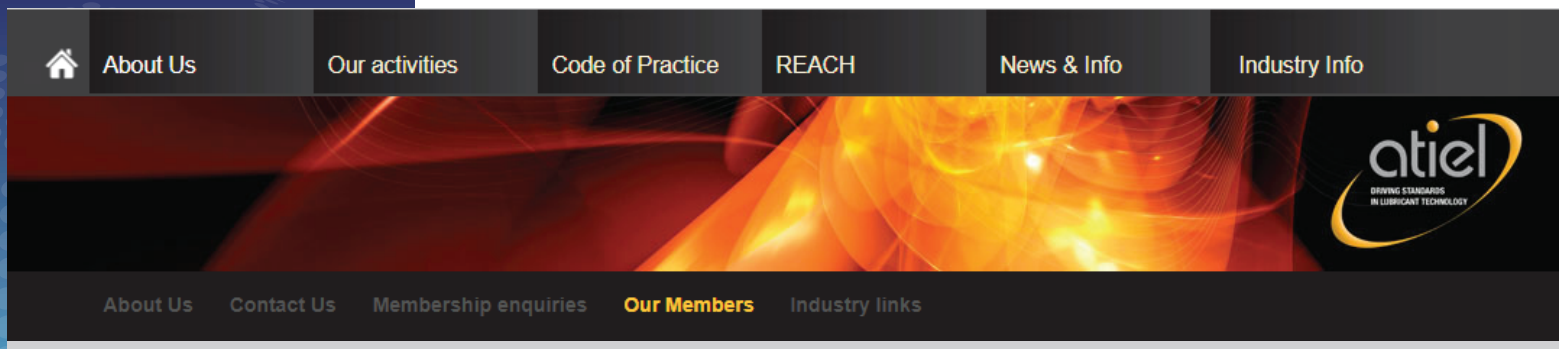
Transparency

Contact Us

XBEE
ENZYME FUEL TECHNOLOGY

TESTS OFFICIELS CEC
Diesel & Essence

MEMBRES DE L'ATIEL AYANT VALIDÉ CES TESTS CEC



Our Members

The ATIEL membership encompasses the majority of leading European oil companies plus international lubricant companies with an official European presence, representing extensive experience in the manufacture and marketing of engine oils. Click on the logos below to visit our members' websites.

Membership entitles a company or organisation to representation at the General Assembly and on the key ATIEL Committees and participation in its Special Task Forces. To enquire about membership see box top right.

aramco · bp · CEPSA · Chevron · eni · ExxonMobil
FUCHS · galp · GAZPROM NEFT · Gulf · idemitsu · Q8
LOTOS · LUKOIL · MOL · NESTE · ORLEN OIL · PETRONAS
REPSOL · Shell · SK lubricants · TATNEFT · TOTAL · UEIL
Valvoline

Membership enquiries

Membership of ATIEL is open to any lubricant manufacturer or marketer with an official presence in the European market.

To enquire about membership click here.

XUD-9 Nozzle Coking Test

Test procedure :	CEC F-23-A-01 Issue 13
Test Number :	XBXUD001
Client :	Xbee
Fuel Code :	RF93T095
Additive Code :	Xbee
Treat Rate :	4000:1 by volume
Test Complete Date :	17-Jul-05

Client Address :	Avenue de Bielefeld Senne 29900 Concarneau France
Client Distribution :	Ronan Pennec
Client Order Number :	300030168000020638668
Test Items Supplied By :	Xbee
Test Fuel Received Date :	22-Jun-04
Test Additive Received Date :	11-Jul-05
Test Lubricant :	RL223

Authorised by: G. Polkinghorne

Contents

1.0 Introduction

This test method is designed to evaluate the capability of a diesel fuel to control the formation of deposits on the injector nozzles of an Indirect Injection diesel engine. Results of tests run to this method are expressed in terms of the percentage airflow loss at various injector needle lift points. Airflow measurements are accomplished with an airflow rig complying with ISO 4010.

2.0 Test description

2.1 Test engine

The engine used for this test is a Peugeot XUD9AL unit supplied by PSA specifically for Nozzle Coking Testing, originally at the request of the CEC PF-023 Working Group.

Engine part number:	70100
Swept volume:	1.9 litre
Injection Pump:	Roto Diesel DCP R 84 43 B910A
Injector body:	Lucas LCR 67307
Injector nozzle:	Lucas RDNO SDC 6850 (unflatted)
Firing order:	1,3,4,2 (No. 1 at flywheel end)

2.2 Engine build and item preparation

The injector nozzles are cleaned and checked for airflow at 0.05, 0.1, 0.2, 0.3 and 0.4mm lift. Nozzles are discarded if the airflow is outside of the range 250ml/min to 320ml/min. The nozzles are assembled into the injector bodies and the opening pressures set to 115±5 bar.

2.3 Test procedure

A slave set of injectors is fitted to the engine. The previous test fuel is drained from the system. The engine is run for 25 minutes in order to flush through the fuel system. During this time all the spill-off fuel is discarded and not returned. The engine is then set to test speed and load and all specified parameters checked and adjusted to the test specification. The slave injectors are then replaced with the test units.

2.4 Engine warm-up

Engine Warm-up	
Duration (mins)	**Speed/load**
5	Idle speed / no load
10	2000 rev/min / 34Nm torque
10	3000 rev/min / 50 Nm torque

Immediately after the warm-up the following test cycle is run 134 times giving a total test time of 10 hours and 3 minutes.

Test Operating Conditions			
Stage	**Time (secs)**	**Speed (rev/min)**	**Torque (Nm)**
1	30	1200 ± 30	10 ± 2
2	60	3000 ± 30	50 ± 2
3	60	1300 ± 30	35 ± 2
4	120	1850 ± 30	50 ± 2

2.5 Other operating parameters

Run Parameters	
Coolant outlet temperature (°C)	95 ± 2
Coolant delta (°C)	4 ± 2
Oil gallery temperature (°C)	100 ± 5
Air inlet temperature (°C)	32 ± 2
Fuel temperature at pump (°C)	31 ± 2
Fuel pump inlet pressure - stage 2 (mbar)	-50 to +100
Fuel pump outlet pressure - stage 2 (mbar)	-100 to +100
Exhaust back pressure - stage 2 (mbar)	50 ± 10
Air Intake Pressure (mbar)	950 ± 10

Test Number : XBXUD001
Fuel Code : RF93T095
Additive Code : Xbee
Treat rate : 4000:1 by volume

3.0 Results

3.1 Pre-test

Reference (Nozzle 215)			
Lift (mm)	**Reading %**	**Obs. Flow (cc/min)**	**Corr. Flow (cc/min)**
0	0.1	1	1
0.1	47.6	238	258

Settings		
Test Hours	0	
Date	16-Jul-05	
Operator	AH	
Ambient press (mbar)	1009.9	*(= Pa)*
Ambient temp. (°K)	298.0	*(= Ta)*

Meter Specification			
Serial No.	**Max Flow (cc/min)**	**Pi**	**Ti**
98205460A	500	1013.25	273

Cylinder 1		Nozzle:	F17
Lift (mm)	**Reading (%)**	**Obs.Flow (cc/min)**	**Corr.Flow (cc/min)**
0	0.1	1	1
0.05	43.2	216	235
0.1	51.2	256	278
0.2	63.4	317	344
0.3	78.8	394	428
0.4	98.2	491	533

Cylinder 2		Nozzle:	F18
Lift (mm)	**Reading (%)**	**Obs.Flow (cc/min)**	**Corr.Flow (cc/min)**
0	0.1	1	1
0.05	40.7	204	221
0.1	50.5	253	274
0.2	65.9	330	358
0.3	81.5	408	443
0.4	96.1	481	522

Cylinder 3		Nozzle:	F19
Lift (mm)	**Reading (%)**	**Obs. Flow (cc/min)**	**Corr. Flow (cc/min)**
0	0.1	1	1
0.05	41.0	205	223
0.1	52.2	261	283
0.2	67.8	339	368
0.3	83.6	418	454
0.4	99.9	500	542

Cylinder 4		Nozzle:	F20
Lift (mm)	**Reading (%)**	**Obs. Flow (cc/min)**	**Corr. Flow (cc/min)**
0	0.1	1	1
0.05	40.6	203	220
0.1	51.7	259	281
0.2	66.6	333	362
0.3	82.2	411	446
0.4	97.7	489	530

$$\text{Corrected flow} = \text{Observed flow} * \frac{P_i}{P_a} * \frac{T_a}{T_i} * \sqrt{\frac{293}{T_a}}$$

where P_i = Calibration pressure of mass flowmeter in mbar

P_a = Ambient pressure in mbar

T_a = Ambient temperature in °K

T_i = Calibration temperature of mass flowmeter in °K

Test Number : XBXUD001
Fuel Code : RF93T095
Additive Code : Xbee
Treat rate : 4000:1 by volume

3.2 Post-test

Reference (Nozzle 215)			
Lift (mm)	**Reading %**	**Obs. Flow (cc/min)**	**Corr. Flow (cc/min)**
0	0.1	1	1
0.1	47.8	239	258

Settings		
Test Hours:	10	
Date:	17-Jul-05	
Operator:	AH	
Ambient press (mbar)	1009.8	*(= Pa)*
Ambient temp. (°K)	295.2	*(= Ta)*

Meter Specification			
Serial No.	**Max Flow (cc/min)**	**Pi**	**Ti**
98205460A	500	1013.25	273

Cylinder 1		Nozzle:	F17
Lift (mm)	**Reading (%)**	**Obs.Flow (cc/min)**	**Corr.Flow (cc/min)**
0	0.1	1	1
0.05	3.8	19	21
0.1	4.9	25	26
0.2	9.4	47	51
0.3	17.7	89	96
0.4	41.9	210	226

Cylinder 2		Nozzle:	F18
Lift (mm)	**Reading (%)**	**Obs.Flow (cc/min)**	**Corr.Flow (cc/min)**
0	0.1	1	1
0.05	2.1	11	11
0.1	2.7	14	15
0.2	5.0	25	27
0.3	12.5	63	68
0.4	35.4	177	191

Cylinder 3		Nozzle:	F19
Lift (mm)	**Reading (%)**	**Obs.Flow (cc/min)**	**Corr.Flow (cc/min)**
0	0.1	1	1
0.05	5.1	26	28
0.1	6.9	35	37
0.2	13.3	67	72
0.3	27.0	135	146
0.4	50.3	252	272

Cylinder 4		Nozzle:	F20
Lift (mm)	**Reading (%)**	**Obs.Flow (cc/min)**	**Corr.Flow (cc/min)**
0	0.1	1	1
0.05	3.4	17	18
0.1	4.4	22	24
0.2	7.0	35	38
0.3	12.4	62	67
0.4	30.3	152	164

$$\text{Corrected flow} = \text{Observed flow} * \frac{P_i}{P_a} * \frac{T_a}{T_i} * \sqrt{\frac{293}{T_a}}$$

where P_i = Calibration pressure of mass flowmeter in mbar

P_a = Ambient pressure in mbar

T_a = Ambient temperature in °K

T_i = Calibration temperature of mass flowmeter in °K

Test Number : XBXUD001
Fuel Code : RF93T095
Additive Code : Xbee
Treat rate : 4000:1 by volume

3.3 Flow loss calculations

Cylinder 1 (Flywheel end)				Nozzle : F17
Needle lift (mm)	Corrected airflow (cc/min)		Residual flow	Nozzle Fouling (%)
	Clean	Dirty		
0.05	235	21	9%	91%
0.1	278	26	10%	90%
0.2	344	51	15%	85%
0.3	428	96	22%	78%
0.4	533	226	42%	58%

Cylinder 2				Nozzle : F18
Needle lift (mm)	Corrected airflow (cc/min)		Residual flow	Nozzle Fouling (%)
	Clean	Dirty		
0.05	221	11	5%	95%
0.1	274	15	5%	95%
0.2	358	27	8%	92%
0.3	443	68	15%	85%
0.4	522	191	37%	63%

Cylinder 3				Nozzle : F19
Needle lift (mm)	Corrected airflow (cc/min)		Residual flow	Nozzle Fouling (%)
	Clean	Dirty		
0.05	223	28	12%	88%
0.1	283	37	13%	87%
0.2	368	72	20%	80%
0.3	454	146	32%	68%
0.4	542	272	50%	50%

Cylinder 4				Nozzle : F20
Needle lift (mm)	Corrected airflow (cc/min)		Residual flow	Nozzle Fouling (%)
	Clean	Dirty		
0.05	220	18	8%	92%
0.1	281	24	8%	92%
0.2	362	38	10%	90%
0.3	446	67	15%	85%
0.4	530	164	31%	69%

Average Nozzle fouling at 0.1 mm lift **91%**

$$\text{Nozzle Fouling (\%)} = 100 \times \left(\frac{\text{clean - dirty}}{\text{clean}} \right)$$

Where test is valid according to procedure CEC F - 23 - A - 01

4.0 Unscheduled occurences

Unschedulded Issues			
Test	**Duration (hours)**	**Time off Test**	**Issue**

Unschedulded Shutdowns			
Test	**Duration (hours)**	**Time off Test**	**Reason for shutdown**

Deviations			
Test	**Duration (hours)**	**Max deviation**	**Name of "out of spec" parameter**

5.0 Referencing history

Two calibration fuels have been selected to enable the tuning of the XUD9A/L engine.

CEC reference fuel RF93-T-95 is used as the severe calibration product and the result from this test should provide a result of 90±5% average nozzle blockage at 0.1mm needle lift.

CEC Calibration fuel DF90 is used as an additised calibration product and currently the result from this test should provide a result of 75±3% as a rolling average of the last three tests.

Average % fouling @ 0.1mm lift				
Tests	**Test No.**	**Date**	**RF93T095 Fuel**	**DF90 Fuel**
35	PD-XUD9-154	18-Dec-04	91%	
51	PD-XUD9-163	09-Jan-05		68%
DF90 Batch 3 calibration fuel produces a 75% ± 3% average nozzle fouling				
61	PD-XUD9-176	13-Apr-05		75%
62	PD-XUD9-177	22-Apr-05		78%
63	PD-XUD9-178	23-Apr-05		74%
66	PD-XUD9-180	26-Apr-05	92%	
90	PD-XUD9-186	20-Jun-05		76%
111	PD-XUD9-187	08-Jul-05		77%

XUD-9 Nozzle Coking Test

Test procedure :	CEC F-23-A-01 Issue 13
Test Number :	XBXUD002
Client :	Xbee
Fuel Code :	RF93T095
Additive Code :	Xbee
Treat Rate :	4000:1 by volume
Test Complete Date :	18-Jul-05

Client Address :	Avenue de Bielefeld Senne 29900 Concarneau France
Client Distribution :	Ronan Pennec
Client Order Number :	300030168000020638668
Test Items Supplied By :	Xbee
Test Fuel Received Date :	22-Jun-04
Test Additive Received Date :	11-Jul-05
Test Lubricant :	RL223

Authorised by: G. Polkinghorne

Contents

1.0 Introduction

This test method is designed to evaluate the capability of a diesel fuel to control the formation of deposits on the injector nozzles of an Indirect Injection diesel engine. Results of tests run to this method are expressed in terms of the percentage airflow loss at various injector needle lift points. Airflow measurements are accomplished with an airflow rig complying with ISO 4010.

2.0 Test description

2.1 Test engine

The engine used for this test is a Peugeot XUD9AL unit supplied by PSA specifically for Nozzle Coking Testing, originally at the request of the CEC PF-023 Working Group.

Engine part number:	70100
Swept volume:	1.9 litre
Injection Pump:	Roto Diesel DCP R 84 43 B910A
Injector body:	Lucas LCR 67307
Injector nozzle:	Lucas RDNO SDC 6850 (unflatted)
Firing order:	1,3,4,2 (No. 1 at flywheel end)

2.2 Engine build and item preparation

The injector nozzles are cleaned and checked for airflow at 0.05, 0.1, 0.2, 0.3 and 0.4mm lift. Nozzles are discarded if the airflow is outside of the range 250ml/min to 320ml/min. The nozzles are assembled into the injector bodies and the opening pressures set to 115±5 bar.

2.3 Test procedure

A slave set of injectors is fitted to the engine. The previous test fuel is drained from the system. The engine is run for 25 minutes in order to flush through the fuel system. During this time all the spill-off fuel is discarded and not returned. The engine is then set to test speed and load and all specified parameters checked and adjusted to the test specification. The slave injectors are then replaced with the test units.

2.4 Engine warm-up

Engine Warm-up	
Duration (mins)	**Speed/load**
5	Idle speed / no load
10	2000 rev/min / 34Nm torque
10	3000 rev/min / 50 Nm torque

Immediately after the warm-up the following test cycle is run 134 times giving a total test time of 10 hours and 3 minutes.

Test Operating Conditions			
Stage	**Time (secs)**	**Speed (rev/min)**	**Torque (Nm)**
1	30	1200 ± 30	10 ± 2
2	60	3000 ± 30	50 ± 2
3	60	1300 ± 30	35 ± 2
4	120	1850 ± 30	50 ± 2

2.5 Other operating parameters

Run Parameters	
Coolant outlet temperature (°C)	95 ± 2
Coolant delta (°C)	4 ± 2
Oil gallery temperature (°C)	100 ± 5
Air inlet temperature (°C)	32 ± 2
Fuel temperature at pump (°C)	31 ± 2
Fuel pump inlet pressure - stage 2 (mbar)	-50 to +100
Fuel pump outlet pressure - stage 2 (mbar)	-100 to +100
Exhaust back pressure - stage 2 (mbar)	50 ± 10
Air Intake Pressure (mbar)	950 ± 10

Test Number : XBXUD002
Fuel Code : RF93T095
Additive Code : Xbee
Treat rate : 4000:1 by volume

3.0 Results

3.1 Pre-test

Reference (Nozzle 215)			
Lift (mm)	**Reading %**	**Obs. Flow (cc/min)**	**Corr. Flow (cc/min)**
0	0.1	1	1
0.1	47.3	237	258

Settings		
Test Hours	0	
Date	17-Jul-05	
Operator	AH	
Ambient press (mbar)	1007.9	*(= Pa)*
Ambient temp. (°K)	298.6	*(= Ta)*

Meter Specification			
Serial No.	**Max Flow (cc/min)**	**Pi**	**Ti**
98205460A	500	1013.25	273

Cylinder 1		Nozzle:	F17
Lift (mm)	**Reading (%)**	**Obs.Flow (cc/min)**	**Corr.Flow (cc/min)**
0	0.1	1	1
0.05	44.6	223	243
0.1	51.8	259	282
0.2	64.8	324	353
0.3	80.8	404	440
0.4	100.8	504	549

Cylinder 2		Nozzle:	F18
Lift (mm)	**Reading (%)**	**Obs.Flow (cc/min)**	**Corr.Flow (cc/min)**
0	0.1	1	1
0.05	40.9	205	223
0.1	51.1	256	278
0.2	66.0	330	359
0.3	81.6	408	444
0.4	96.3	482	524

Cylinder 3		Nozzle:	F19
Lift (mm)	**Reading (%)**	**Obs. Flow (cc/min)**	**Corr. Flow (cc/min)**
0	0.1	1	1
0.05	40.4	202	220
0.1	52.2	261	284
0.2	68.0	340	370
0.3	84.1	421	458
0.4	100.9	505	549

Cylinder 4		Nozzle:	F20
Lift (mm)	**Reading (%)**	**Obs. Flow (cc/min)**	**Corr. Flow (cc/min)**
0	0.1	1	1
0.05	39.9	200	217
0.1	51.7	259	282
0.2	66.9	335	364
0.3	82.8	414	451
0.4	98.5	493	536

$$\text{Corrected flow} = \text{Observed flow} * \frac{P_i}{P_a} * \frac{T_a}{T_i} * \sqrt{\frac{293}{T_a}}$$

where P_i = Calibration pressure of mass flowmeter in mbar

P_a = Ambient pressure in mbar

T_a = Ambient temperature in °K

T_i = Calibration temperature of mass flowmeter in °K

Test Number : XBXUD002
Fuel Code : RF93T095
Additive Code : Xbee
Treat rate : 4000:1 by volume

3.2 Post-test

Reference (Nozzle 215)			
Lift (mm)	**Reading %**	**Obs. Flow (cc/min)**	**Corr. Flow (cc/min)**
0	0.1	1	1
0.1	46.9	235	257

Settings		
Test Hours:	10	
Date:	18-Jul-05	
Operator:	GP	
Ambient press (mbar)	1000.44	*(= Pa)*
Ambient temp. (°K)	298.0	*(= Ta)*

Meter Specification			
Serial No.	**Max Flow (cc/min)**	**Pi**	**Ti**
98205460A	500	1013.25	273

Cylinder 1		Nozzle:	F17
Lift (mm)	**Reading (%)**	**Obs.Flow (cc/min)**	**Corr.Flow (cc/min)**
0	0.1	1	1
0.05	2.8	14	15
0.1	3.6	18	20
0.2	6.8	34	37
0.3	15.2	76	83
0.4	41.5	208	227

Cylinder 2		Nozzle:	F18
Lift (mm)	**Reading (%)**	**Obs.Flow (cc/min)**	**Corr.Flow (cc/min)**
0	0.1	1	1
0.05	2.8	14	15
0.1	3.5	18	19
0.2	5.8	29	32
0.3	11.8	59	65
0.4	32.6	163	179

Cylinder 3		Nozzle:	F19
Lift (mm)	**Reading (%)**	**Obs.Flow (cc/min)**	**Corr.Flow (cc/min)**
0	0.1	1	1
0.05	3.2	16	18
0.1	4.1	21	22
0.2	7.4	37	41
0.3	17.9	90	98
0.4	47.9	240	263

Cylinder 4		Nozzle:	F20
Lift (mm)	**Reading (%)**	**Obs.Flow (cc/min)**	**Corr.Flow (cc/min)**
0	0.1	1	1
0.05	4.2	21	23
0.1	5.4	27	30
0.2	8.6	43	47
0.3	16.4	82	90
0.4	44.4	222	243

$$\text{Corrected flow} = \text{Observed flow} * \frac{P_i}{P_a} * \frac{T_a}{T_i} * \sqrt{\frac{293}{T_a}}$$

where P_i = Calibration pressure of mass flowmeter in mbar

P_a = Ambient pressure in mbar

T_a = Ambient temperature in °K

T_i = Calibration temperature of mass flowmeter in °K

Test Number : XBXUD002
Fuel Code : RF93T095
Additive Code : Xbee
Treat rate : 4000:1 by volume

3.3 Flow loss calculations

Cylinder 1 (Flywheel end)				Nozzle : F17
Needle lift (mm)	Corrected airflow (cc/min)		Residual flow	Nozzle Fouling (%)
	Clean	Dirty		
0.05	243	15	6%	94%
0.1	282	20	7%	93%
0.2	353	37	11%	89%
0.3	440	83	19%	81%
0.4	549	227	41%	59%

Cylinder 2				Nozzle : F18
Needle lift (mm)	Corrected airflow (cc/min)		Residual flow	Nozzle Fouling (%)
	Clean	Dirty		
0.05	223	15	7%	93%
0.1	278	19	7%	93%
0.2	359	32	9%	91%
0.3	444	65	15%	85%
0.4	524	179	34%	66%

Cylinder 3				Nozzle : F19
Needle lift (mm)	Corrected airflow (cc/min)		Residual flow	Nozzle Fouling (%)
	Clean	Dirty		
0.05	220	18	8%	92%
0.1	284	22	8%	92%
0.2	370	41	11%	89%
0.3	458	98	21%	79%
0.4	549	263	48%	52%

Cylinder 4				Nozzle : F20
Needle lift (mm)	Corrected airflow (cc/min)		Residual flow	Nozzle Fouling (%)
	Clean	Dirty		
0.05	217	23	11%	89%
0.1	282	30	11%	89%
0.2	364	47	13%	87%
0.3	451	90	20%	80%
0.4	536	243	45%	55%

Average Nozzle fouling at 0.1 mm lift **92%**

$$\text{Nozzle Fouling (\%)} = 100 \times \left(\frac{\text{clean - dirty}}{\text{clean}} \right)$$

Where test is valid according to procedure CEC F - 23 - A - 01

4.0 Unscheduled occurences

Unschedulded Issues			
Test	**Duration (hours)**	**Time off Test**	**Issue**

Unschedulded Shutdowns			
Test	**Duration (hours)**	**Time off Test**	**Reason for shutdown**

Deviations			
Test	**Duration (hours)**	**Max deviation**	**Name of "out of spec" parameter**

5.0 Referencing history

Two calibration fuels have been selected to enable the tuning of the XUD9A/L engine.

CEC reference fuel RF93-T-95 is used as the severe calibration product and the result from this test should provide a result of 90±5% average nozzle blockage at 0.1mm needle lift.

CEC Calibration fuel DF90 is used as an additised calibration product and currently the result from this test should provide a result of 75±3% as a rolling average of the last three tests.

Average % fouling @ 0.1mm lift				
Tests	**Test No.**	**Date**	**RF93T095 Fuel**	**DF90 Fuel**
35	PD-XUD9-154	18-Dec-04	91%	
51	PD-XUD9-163	09-Jan-05		68%
DF90 Batch 3 calibration fuel produces a 75% ± 3% average nozzle fouling				
61	PD-XUD9-176	13-Apr-05		75%
62	PD-XUD9-177	22-Apr-05		78%
63	PD-XUD9-178	23-Apr-05		74%
66	PD-XUD9-180	26-Apr-05	92%	
90	PD-XUD9-186	20-Jun-05		76%
111	PD-XUD9-187	08-Jul-05		77%

M-102-E Intake Valve Deposit Test

Test procedure :	**CEC F-05-A-93**
Test Number :	**XB102001**
Client :	**Xbee**
Client Address :	**Avenue de Bielefeld Senne** **29900 Concarneau** **France**
Client Distribution :	**Ronan Pennec**
Client Order Number :	**30003016800020600000**
Fuel Code :	**DF12 batch 5**
Test Fuel Received Date :	**14-Jul-05**
Additive Code :	**Xbee**
Treat Rate :	**4000:1**
Test Additive Received Date :	**11-Jul-05**
Test Oil :	**RL223**
Test Complete Date :	**22-Jul-05**
Project Engineer :	**G.Polkinghorne**

Contents

Test description

This test method is designed to evaluate the propensity of gasoline or gasoline additive formulations to prevent inlet valve deposits in fuel injected engines. Results of tests run under this method are presented as the weight of the inlet valve deposit and as a merit rating based on a scale from 4.5 (extremely heavy inlet valve deposits) to 10 (clean inlet valve). Gasolines giving satisfactory performance in this test will possibly give enhanced protection against the formation of inlet valve deposits when utilised in four stroke gasoline fuelled engines.

The engine

The procedure utilises a Mercedes-Benz M102.982 four cylinder, four stroke 2.3 litre gasoline engine. The engine is equipped with Bosch KE-Jetronic fuel injection equipment and has the following specification :-

Bore/Stroke	-	95.50 / 80.25 mm
Swept Volume	-	2299 cc
Compression Ratio	-	9.0 : 1
Maximum Power	-	100kW @ 5100 rev/min

Engine preparation

The test engine is fitted with a cleaned cylinder head, which in turn has been fitted with new inlet valves. The inlet valves are pegged to prevent rotation. Fresh oil and a new oil filter are used for each test.

Test procedure

The engine is mounted on a test stand and operated for 800 cycles, totalling 60 hours. The cycle consists of four stages and is designed to represent urban driving conditions. Ignition advance and exhaust CO content are set prior to the start of the test.

Test procedure continued

Stage	Time (secs)	Speed (rev/min)	Torque (Nm)
1	30	800 ± 30	<5.0
2	60	1300 ± 30	29.4
3	120	1850 ± 30	32.5
4	60	3000 ± 30	35

Operating parameters

Parameter	Temperature (°C)
Coolant outlet	85 to 95
Oil gallery	90 to 105
Air inlet	25 to 35

End of test assessment

At the end of the test the cylinder head is dismounted from the engine and the valves carefully removed. The weight of deposit on the back of each valve is determined. The valves are then subjected to a visual rating against a photographic reference scale.

Pre-test checks

The following pre-test check run was completed during which ignition timing was checked and reset as necessary. Once the test was on cycle exhaust back pressure was set at stage 4 and blow-by was measured.

Engine Warm-up		
Duration (mins)	**Speed rpm**	**Torque Nm**
4	1500	0
6	3000	0

CO content at idle checked and reset to:	0.87	(0.5 to 1.0 %)
EBP at Stage 4 checked and reset to:	22	(10 to 25 mbar)
Ignition timing	13	(15 ± 3 ° BTDC)
Blow-by @ 3000 rev/min (Stage 4)	7	<20l/min

Compressions				
Cylinder number	**1**	**2**	**3**	**4**
Speed (rev/min)	195	190	180	185
Pressure (bar)	12.0	12.5	12.0	12.0

Specification : > 12 bar with a differential of < 1 bar between cylinder at 170 rev min.

Test number : XB102001
Fuel code : DF12 batch 5
Additive code : Xbee
Treat rate : 4000:1

Results summary

Engine number : TK-M102E-02-02
Total engine hours : 540
Test stand number : 7
Total test fuel consumption : 215 Litres
Total test oil consumption : 57 gm

Inlet valve deposit weights

Deposits					
Valve number	**1**	**2**	**3**	**4**	**Average**
Deposit weight	**249**	**215**	**432**	**252**	**287**

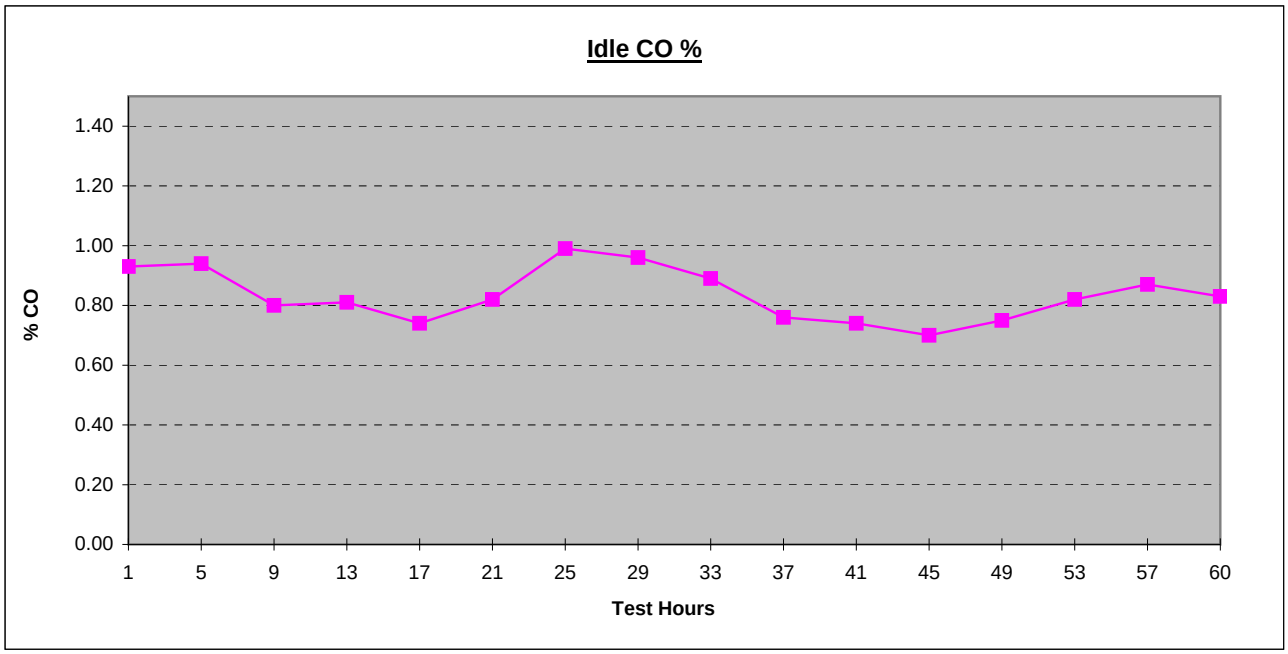
Inlet valve merit ratings

Merit rating					
Valve number	**1**	**2**	**3**	**4**	**Average**
Merit Rating	**8.31**	**8.31**	**7.61**	**8.04**	**8.07**

Test number : XB102001
Fuel code : DF12 batch 5
Additive code : Xbee
Treat rate : 4000:1

Emissions summary

Test Hours	% CO at Idle
1	0.93
5	0.94
9	0.80
13	0.81
17	0.74
21	0.82
25	0.99
29	0.96
33	0.89
37	0.76
41	0.74
45	0.70
49	0.75
53	0.82
57	0.87
60	0.83



Test number : XB102001
Fuel code : DF12 batch 5
Additive code : Xbee
Treat rate : 4000:1

Averaged operational data for each stage of the test cycle

Stage 1

	Engine speed rev/min	Engine load Nm	Fuel cons. kg/hr	Water out °C	Oil sump °C	Air inlet °C	Inlet depn. mbar	Exhaust temperatures Cyl. 1 °C	Cyl. 2 °C	Cyl 3 °C	Cyl 4 °C
Min	754	1.1	0.70	86	96	27	700	450	505	465	485
Max	842	1.4	1.06	95	100	31	728	545	611	569	584
Average	833	1.3	0.81	93	99	29	716	530	582	557	560

Stage 2

	Engine speed rev/min	Engine load Nm	Fuel cons. kg/hr	Water out °C	Oil sump °C	Air inlet °C	Inlet depn. mbar	Exhaust temperatures Cyl 1 °C	Cyl 2 °C	Cyl 3 °C	Cyl 4 °C
Min	1304	28.9	1.53	86	94	27	619	552	571	566	580
Max	1306	29.9	1.91	95	101	31	628	584	600	591	609
Average	1305	29.3	1.72	91	99	29	623	574	587	582	594

Stage 3

	Engine speed rev/min	Engine load Nm	Fuel cons. kg/hr	Water out °C	Oil sump °C	Air inlet °C	Inlet depn. mbar	Exhaust temperatures Cyl 1 °C	Cyl 2 °C	Cyl 3 °C	Cyl 4 °C
Min	1849	32.2	2.58	88	90	27	612	625	625	626	625
Max	1852	33.0	2.81	95	97	31	622	646	656	651	655
Average	1850	32.5	2.72	91	95	29	617	636	639	642	636

Stage 4

	Engine speed rev/min	Engine load Nm	Fuel cons. kg/hr	Water out °C	Oil sump °C	Air inlet °C	Inlet depn. mbar	Exhaust temperatures Cyl 1 °C	Cyl 2 °C	Cyl 3 °C	Cyl 4 °C
Min	2994	34.9	4.50	91	90	27	596	721	728	756	721
Max	2998	35.3	4.76	95	96	31	606	750	777	779	767
Average	2996	35.1	4.62	93	94	29	601	738	751	768	736

According to procedure CEC F-05-A-93 this test is deemed to be valid.

Test number : XB102001
Fuel code : DF12 batch 5
Additive code : Xbee
Treat rate : 4000:1

Inlet valve merit ratings

Valve 1

		4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	
	1								8				2	
S	2								7	1			2	
E	3								6	2	1	1		
G	4							3	5			1	1	
M	5							3	2		2	1	2	
E	6						2	1	5	1		1		
N	7								7	2	1			
T	8								7	2	1			
S	9								7	2			1	
	10								7	1			2	
Total		**0**	**0**	**0**	**0**	**0**	**2**	**7**	**61**	**11**	**5**	**4**	**10**	
Merit		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.14**	**0.53**	**4.88**	**0.94**	**0.45**	**0.38**	**1.00**	**8.31**

Deposit weight Before : 87.675 g
After : 87.924 g (flame face carbon removed)
Total : **249** mg

Valve 2

		4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	
	1							3	5				2	
S	2							2	6				2	
E	3							3	6				1	
G	4							2	7				1	
M	5							1	3	5			1	
E	6							1	5	2			2	
N	7							3	4	2	1			
T	8							4	3	1	1	1		
S	9								2	2	4	2		
	10								3	3	3	1		
Total		**0**	**0**	**0**	**0**	**0**	**0**	**19**	**44**	**15**	**9**	**4**	**9**	
Merit		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1.43**	**3.52**	**1.28**	**0.81**	**0.38**	**0.90**	**8.31**

Deposit Weight Before : 87.930 g
After : 88.145 g (flame face carbon removed)
Total : **215** mg

Test number : XB102001
Fuel code : DF12 batch 5
Additive code : Xbee
Treat rate : 4000:1

Inlet valve merit ratings continued

Valve 3

		4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	
	1				3	2			3	2				
S	2					3		1	6					
E	3							2	7	1				
G	4					2		1	6	1				
M	5					3	1		6					
E	6					4	1		5					
N	7							1	4	1	2	2		
T	8							4	5	1				
S	9						2	3	5					
	10				3	2		2	3					
Total		**0**	**0**	**0**	**6**	**16**	**4**	**14**	**50**	**6**	**2**	**2**	**0**	
Merit		**0.00**	**0.00**	**0.00**	**0.36**	**1.04**	**0.28**	**1.05**	**4.00**	**0.51**	**0.18**	**0.19**	**0.00**	**7.61**

Deposit weight Before : 88.670 g
After : 89.102 g (flame face carbon removed)
Total : **432** mg

Valve 4

		4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	
	1						1	1	8					
S	2							1	7			1	1	
E	3							2	8					
G	4							2	8					
M	5							2	8					
E	6							1	3	3	2	1		
N	7							1	3	3	3			
T	8							2	8					
S	9							2	8					
	10							2	8					
Total		**0**	**0**	**0**	**0**	**0**	**1**	**16**	**69**	**6**	**5**	**2**	**1**	
Merit		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.07**	**1.20**	**5.52**	**0.51**	**0.45**	**0.19**	**0.10**	**8.04**

Deposit weight Before : 89.401 g
After : 89.653 g (flame face carbon removed)
Total : **252** mg

Test number : XB102001
Fuel code : DF12 batch 5
Additive code : Xbee
Treat rate : 4000:1

Inlet valve photography

Valve 1

Valve 2

Valve 3

Valve 4

Unscheduled shutdown and deviations

Unscheduled shutdowns

Test hours	Time off test	Reason for shutdown
		None

Deviations

Test Hours	Duration	Max deviation	Name of 'out of spec' parameter

M-102-E Intake Valve Deposit Test

Test procedure :	**CEC F-05-A-93**
Test Number :	**XB102002**
Client :	**Xbee**
Client Address :	**Avenue de Bielefeld Senne** **29900 Concarneau** **France**
Client Distribution :	**Ronan Pennec**
Client Order Number :	**30003016800020600000**
Fuel Code :	**DF12 batch 5**
Test Fuel Received Date :	**14-Jul-05**
Additive Code :	**Xbee**
Treat Rate :	**4000:1**
Test Additive Received Date :	**11-Jul-05**
Test Oil :	**RL223**
Test Complete Date :	**04-Aug-05**
Project Engineer :	**G.Polkinghorne**

Contents

Test description

This test method is designed to evaluate the propensity of gasoline or gasoline additive formulations to prevent inlet valve deposits in fuel injected engines. Results of tests run under this method are presented as the weight of the inlet valve deposit and as a merit rating based on a scale from 4.5 (extremely heavy inlet valve deposits) to 10 (clean inlet valve). Gasolines giving satisfactory performance in this test will possibly give enhanced protection against the formation of inlet valve deposits when utilised in four stroke gasoline fuelled engines.

The engine

The procedure utilises a Mercedes-Benz M102.982 four cylinder, four stroke 2.3 litre gasoline engine. The engine is equipped with Bosch KE-Jetronic fuel injection equipment and has the following specification :-

Bore/Stroke	-	95.50 / 80.25 mm
Swept Volume	-	2299 cc
Compression Ratio	-	9.0 : 1
Maximum Power	-	100kW @ 5100 rev/min

Engine preparation

The test engine is fitted with a cleaned cylinder head, which in turn has been fitted with new inlet valves. The inlet valves are pegged to prevent rotation. Fresh oil and a new oil filter are used for each test.

Test procedure

The engine is mounted on a test stand and operated for 800 cycles, totalling 60 hours. The cycle consists of four stages and is designed to represent urban driving conditions. Ignition advance and exhaust CO content are set prior to the start of the test.

Test procedure continued

Stage	Time (secs)	Speed (rev/min)	Torque (Nm)
1	30	800 ± 30	<5.0
2	60	1300 ± 30	29.4
3	120	1850 ± 30	32.5
4	60	3000 ± 30	35

Operating parameters

Parameter	Temperature (°C)
Coolant outlet	85 to 95
Oil gallery	90 to 105
Air inlet	25 to 35

End of test assessment

At the end of the test the cylinder head is dismounted from the engine and the valves carefully removed. The weight of deposit on the back of each valve is determined. The valves are then subjected to a visual rating against a photographic reference scale.

Pre-test checks

The following pre-test check run was completed during which ignition timing was checked and reset as necessary. Once the test was on cycle exhaust back pressure was set at stage 4 and blow-by was measured.

Engine Warm-up		
Duration (mins)	**Speed rpm**	**Torque Nm**
4	1500	0
6	3000	0

CO content at idle checked and reset to:	0.57	(0.5 to 1.0 %)
EBP at Stage 4 checked and reset to:	0.18	(10 to 25 mbar)
Ignition timing	13	(15 ± 3 ° BTDC)
Blow-by @ 3000 rev/min (Stage 4)	8	<20l/min

Compressions				
Cylinder number	**1**	**2**	**3**	**4**
Speed (rev/min)	220	217	235	224
Pressure (bar)	12.5	12.5	13.0	12.5

Specification : > 12 bar with a differential of < 1 bar between cylinder at 170 rev min.

Test number : XB102002
Fuel code : DF12 batch 5
Additive code : Xbee
Treat rate : 4000:1

Results summary

Engine number : TK-M102E-02-02
Total engine hours : 600
Test stand number : 7
Total test fuel consumption : 215 Litres
Total test oil consumption : 155 gm

Inlet valve deposit weights

Deposits					
Valve number	**1**	**2**	**3**	**4**	**Average**
Deposit weight	**364**	**540**	**475**	**499**	**469.50**

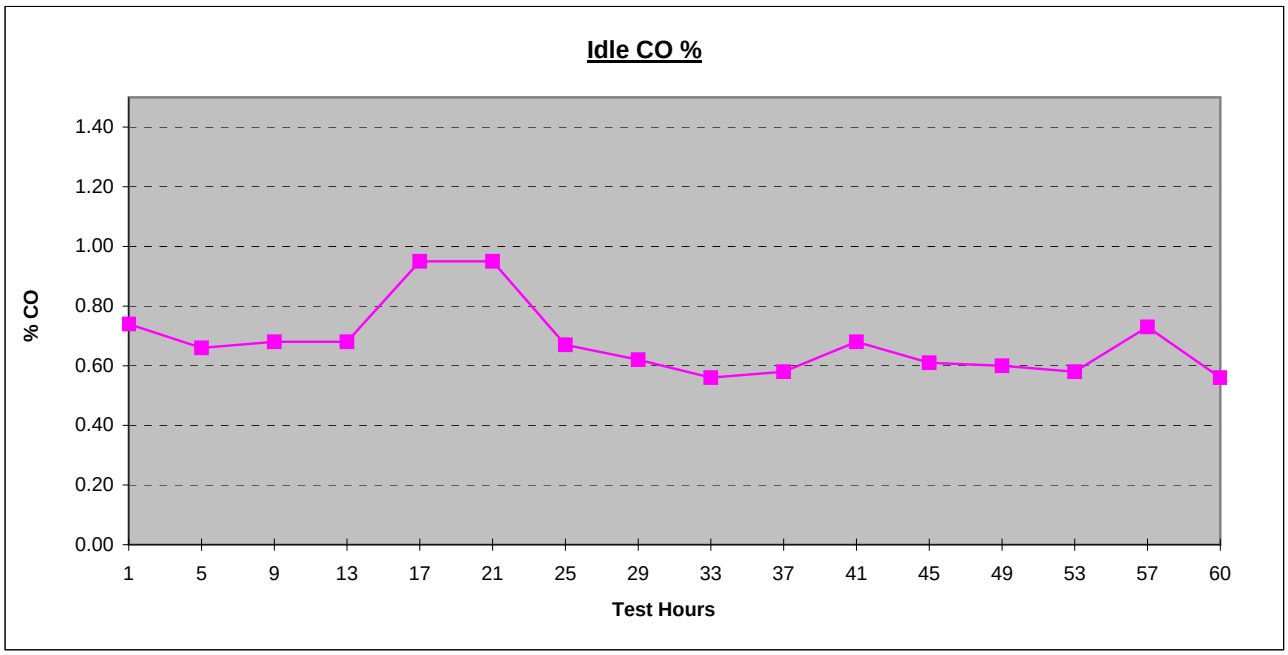
Inlet valve merit ratings

Merit rating					
Valve number	**1**	**2**	**3**	**4**	**Average**
Merit Rating	**7.42**	**7.18**	**7.33**	**6.96**	**7.22**

Test number : XB102002
Fuel code : DF12 batch 5
Additive code : Xbee
Treat rate : 4000:1

Emissions summary

Test Hours	% CO at Idle
1	0.74
5	0.66
9	0.68
13	0.68
17	0.95
21	0.95
25	0.67
29	0.62
33	0.56
37	0.58
41	0.68
45	0.61
49	0.60
53	0.58
57	0.73
60	0.56



Test number : XB102002
Fuel code : DF12 batch 5
Additive code : Xbee
Treat rate : 4000:1

Averaged operational data for each stage of the test cycle

Stage 1

	Engine speed rev/min	Engine load Nm	Fuel cons. kg/hr	Water out °C	Oil sump °C	Air inlet °C	Inlet depn. mbar	Exhaust temperatures Cyl. 1 °C	Cyl. 2 °C	Cyl 3 °C	Cyl 4 °C
Min	752	0.6	0.68	85	94	25	679	435	444	438	450
Max	849	0.9	0.96	95	102	33	736	560	599	567	569
Average	842	0.8	0.82	93	96	29	715	535	560	536	530

Stage 2

	Engine speed rev/min	Engine load Nm	Fuel cons. kg/hr	Water out °C	Oil sump °C	Air inlet °C	Inlet depn. mbar	Exhaust temperatures Cyl 1 °C	Cyl 2 °C	Cyl 3 °C	Cyl 4 °C
Min	1304	29.1	1.60	85	93	25	609	532	547	531	536
Max	1307	29.6	1.97	93	102	32	631	585	595	593	600
Average	1305	29.3	1.76	90	95	29	622	567	580	566	570

Stage 3

	Engine speed rev/min	Engine load Nm	Fuel cons. kg/hr	Water out °C	Oil sump °C	Air inlet °C	Inlet depn. mbar	Exhaust temperatures Cyl 1 °C	Cyl 2 °C	Cyl 3 °C	Cyl 4 °C
Min	1849	32.2	2.55	86	90	26	605	615	602	590	608
Max	1852	32.8	2.86	93	98	32	621	645	647	628	643
Average	1850	32.5	2.75	90	92	29	613	634	633	614	628

Stage 4

	Engine speed rev/min	Engine load Nm	Fuel cons. kg/hr	Water out °C	Oil sump °C	Air inlet °C	Inlet depn. mbar	Exhaust temperatures Cyl 1 °C	Cyl 2 °C	Cyl 3 °C	Cyl 4 °C
Min	2978	34.8	4.41	89	91	27	594	709	709	715	705
Max	2998	35.2	4.68	94	98	33	612	750	775	752	743
Average	2996	35.0	4.51	92	93	29	604	730	747	732	714

According to procedure CEC F-05-A-93 this test is deemed to be valid.

Test number : XB102002
Fuel code : DF12 batch 5
Additive code : Xbee
Treat rate : 4000:1

Inlet valve merit ratings

Valve 1

		4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	
	1						3	3	3		1			
S	2						3		6			1		
E	3						5		4			1		
G	4						6		3			1		
M	5				6			2	1			1		
E	6				4		1	3	1			1		
N	7					6	1	1	1			1		
T	8					4	2	2	1		1			
S	9						4	3	2		1			
	10						3	3	3		1			
Total		**0**	**0**	**0**	**10**	**10**	**28**	**17**	**25**	**0**	**4**	**6**	**0**	
Merit		**0.00**	**0.00**	**0.00**	**0.60**	**0.65**	**1.96**	**1.28**	**2.00**	**0.00**	**0.36**	**0.57**	**0.00**	**7.42**

Deposit weight Before : 90.624 g
After : 90.988 g (flame face carbon removed)
Total : **364** mg

Valve 2

		4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	
	1						7	2				1		
S	2						6	3				1		
E	3						7	2				1		
G	4					3	5	1				1		
M	5					3	5	1				1		
E	6			4		2	2	1				1		
N	7			4		2	2	1				1		
T	8					1	4	4				1		
S	9					2	3	4				1		
	10						5	4				1		
Total		**0**	**0**	**8**	**0**	**13**	**46**	**23**	**0**	**0**	**0**	**10**	**0**	
Merit		**0.00**	**0.00**	**0.44**	**0.00**	**0.85**	**3.22**	**1.73**	**0.00**	**0.00**	**0.00**	**0.95**	**0.00**	**7.18**

Deposit Weight Before : 90.498 g
After : 91.038 g (flame face carbon removed)
Total : **540** mg

Test number : XB102002
Fuel code : DF12 batch 5
Additive code : Xbee
Treat rate : 4000:1

Inlet valve merit ratings continued

Valve 3

		4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	
	1					8	1					1		
S	2					9						1		
E	3					9						1		
G	4					9						1		
M	5				3	5					1	1		
E	6						3	4	2		1			
N	7						2	4	3		1			
T	8							2	5		3			
S	9							1	4	3	1	1		
	10					2	5	2				1		
Total		**0**	**0**	**0**	**3**	**42**	**11**	**13**	**14**	**3**	**7**	**7**	**0**	
Merit		**0.00**	**0.00**	**0.00**	**0.18**	**2.73**	**0.77**	**0.98**	**1.12**	**0.26**	**0.63**	**0.67**	**0.00**	**7.33**

Deposit weight Before : 90.802 g
After : 91.277 g (flame face carbon removed)
Total : **475** mg

Valve 4

		4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	
	1					7	2					1		
S	2					9						1		
E	3				2	7						1		
G	4				4	5						1		
M	5				5	4					1			
E	6				3	3	3				1			
N	7					3	3	3			1			
T	8						5	4			1			
S	9						5	4			1			
	10						7	2			1			
Total		**0**	**0**	**0**	**14**	**38**	**25**	**13**	**0**	**0**	**6**	**4**	**0**	
Merit		**0.00**	**0.00**	**0.00**	**0.84**	**2.47**	**1.75**	**0.98**	**0.00**	**0.00**	**0.54**	**0.38**	**0.00**	**6.96**

Deposit weight Before : 91.352 g
After : 91.851 g (flame face carbon removed)
Total : **499** mg

Test number : XB102002
Fuel code : DF12 batch 5
Additive code : Xbee
Treat rate : 4000:1

Inlet valve photography

Valve 1

Valve 2

Valve 3

Valve 4

Unscheduled shutdown and deviations

Unscheduled shutdowns

Test hours	Time off test	Reason for shutdown
		None

Deviations

Test Hours	Duration	Max deviation	Name of 'out of spec' parameter