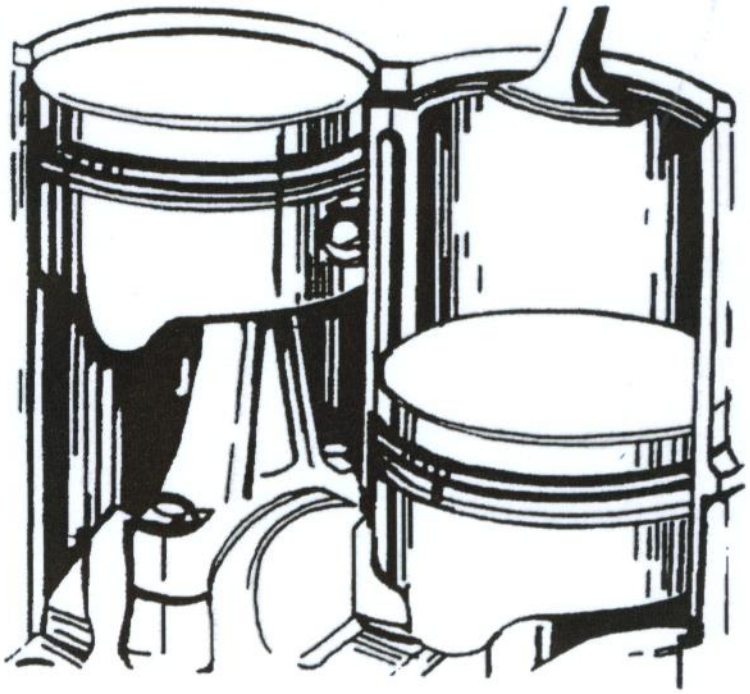
# TEST REPORT

Truck Emissions Tests - Firepower



Emissions / Fuel Economy Tests with Volvo FM 12
Hamburg, 27. January 2004

PAE-Laboratory
Hamburg

**Test Laboratory:**
Deutsche Shell GmbH
**PAE-Labor, OGME/32**
Hohe-Schaar-Straße 36

21107 Hamburg

**Customer:**
Mr. Les Green
Firepower Wholesale Ltd
Garden Studios
11-15 Betterton Street
Covent Garden
London
WC2H 9BP

| | |
|---|---|
| **Project No.:** | 5383 0169 |
| **Date of Measurements:** | 21. – 26. January 2004 |
| **Test Type:** | Emissions/FE tests with a truck on chassis dyno |
| **Vehicle Type:** | Volvo FM 12, reg. BX 02 ZVL (UK) |
| **Test Products:** | Fuel additive "Polyfuel Type #1" |
| **Test Procedure:** | Truck emissions test in European Transient Cycle "ETC" before and after 1000 miles mileage accumulation. FE calculated from c-Balance |

**Summary of Results:**

**Date:**

**27.01.2004**

**Signature:**

## 1. Test description

Emissions tests were conducted with a Volvo truck provided by the customer.
The test cycle chosen for the emissions tests was the "European Transient Cycle (ETC")
also known as FIGE 3-phase cycle.
After initial tests with European market fuel the additive provided by the customer was blended into the fuel according to manufacturers prescription. Tests were repeated on the same day as the initial tests.
A mileage accumulation run was conducted over 1000 miles in constant gear at 60 km/h in variable loads. Final emissions tests, at the end of the mileage accumulation, were conducted in the same way as the initial tests.

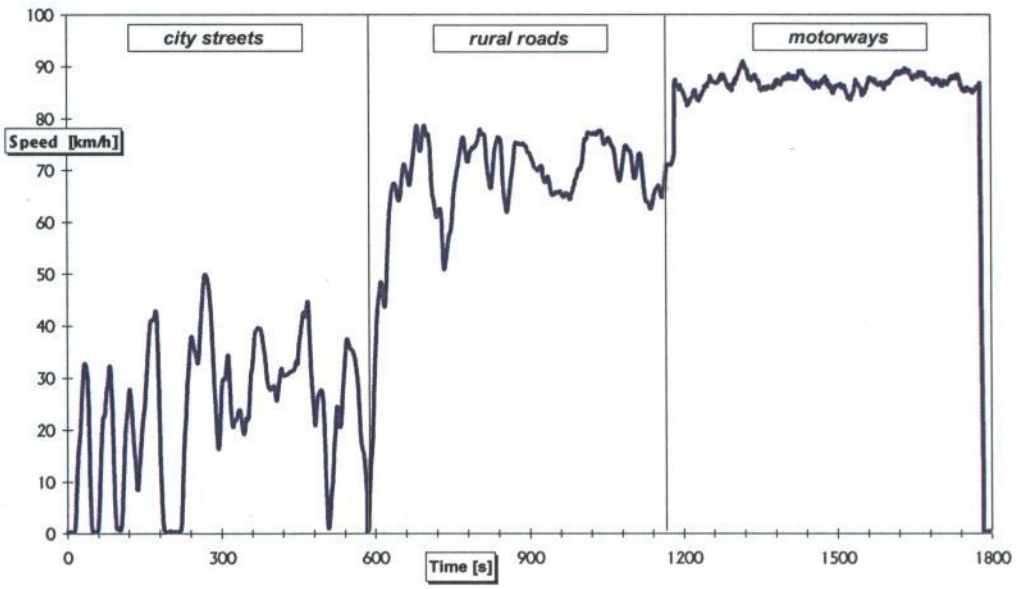
## 2. Test vehicle, Preconditioning

A Volvo FM 12, registration BX 02 ZVL from UK, was collected from the ferry in Cuxhaven on the 20th Jan. 04 and driven on the road to Hamburg, PAE-Laboratory.
On arrival the tyres of the driven axle were exchanged to chassis dyno tyres (slicks) to ensure constant rolling resistance on the chassis dynamometer over the driven test distance of about 1200 miles on the chassis dynamometer. Safety trips were installed for unmanned mileage accumulation over 1000 miles.
The exhaust tailpipe was connected to the full-stream dilution tunnel for exhaust emissions measurements.

## 3 CD operation and Measurement equipment

The chassis dynamometer, an AVL- Zoellner twin roller design with 20" roller diameter and 330 kW nominal brake power, was setup to simulate road load conditions for a 20 tons truck.
Road load parameters: F0 = 15000 N; F1 = 0.8 N*m/sec; F2 = 1.55 N*m²/sec².
The truck was driven by an operator, trained in driving the European Transient Cycle (ETC) with a variety of trucks and buses including Volvo models.
The ETC cycle, shown in the following graph, consists of 3 phases representing city driving, rural roads and motorway traffic.

ETC Cycle



Emissions were measured in each of the 3 cycles using the full-stream dilution tunnel with a CVS (constant volume sampler) volume stream of 60 m³/minute. Emissions analysers were Horiba 9000 series with analysers for CO, CO2, NOx and THC (total hydrocarbons). Particulates were sampled and analysed gravimetrically.
The fuel consumption was calculated from the carbon balance, based on the principle that all the carbon from the emissions components CO, CO2 and THC has been fed into the engine as carbon from the fuel.
The standard equation, as described in the European regulations 80/1268/EC for fuel economy measurements with diesel vehicles is as following:

$$FC = (0.1155/D) * [(0.866*THC)+(0.429*CO)+(0.273*CO2)]$$

FC fuel consumption [L/100km]
D fuel density
THC, CO, CO2 emissions concentrations [g/km]

## 4 Fuel and Additive, preparation and blending

The fuel used was a marketed EN590 specification winter grade containing usual additive as found in the market place with standard fuels.
Key fuel parameters:
Density 0.8367 kg/L
Sulphur content 10 ppm
Total fuel volumes used: 600 Litres.

A 250 ml plastic container with a very high viscous liquid, description:
**Polyfuel Type #1**
**Date 1-6-04 10 oz**
With a dosing prescription:
**Use as 1 ounce of Polyfuel to 15 gallons of diesel fuel**
Was delivered to PAE Laboratory on the 20th January 2004 in the late afternoon. As too viscous to treat as described above, the customer asked us to pre-dilute the product 1:1 with the test fuel and store over night at +30°C, which resulted in a gelly-like composition. This was further diluted to 2.5 litres but did not dissolve homogenously. Finally a pre-dilution of 254,4 grams of the additive in 10 litres of diesel fuel gave a satisfactory solution. This solution was used to treat total 509.33 litres Diesel fuel with the treat rate of 1 oz at 56.76 litres (15 gallons).

## 5 Test results

The emissions and fuel economy data for the 3 phases of the drive cycle are shown in the Attachment 1 and 2.
The average of the 3 repeat tests is calculated. The differences of the 3 test series (base-Polyfuel-polyfuel after 1000 mls) are calculated from the averages.
The data has been verified as valid tests, but not been statistically analysed. Any differences shown in the data summary may be within the repeatability of the method.

# Abgas - Rollenprüfstand 3

## Deutsche Shell GmbH - PAE-Labor - OGME/ 32

| | | | | | |
|---|---|---|---|---|---|
| Projekt | : | 220258 | Car Model | : | Volvo FM12 Zugm. |
| Test Type | | Fige4 04004 | Vehicle Code | : | 220355 |
| Auftrag Nr. | : | 04004 | Odometer | : | 264463 |
| Test Number | : | 3004012105 | Engine Displ. [ccm] | : | |
| Oil Code | : | 229999 | Operator | : | E. Meyer |
| Fuel Code | : | 221695 | Fuel Density [Kg/l] | : | 0.837 |
| Fuel Serie | : | | H/C-Ratio | : | 0.000 |
| | | | Driving Cycle | : | Fige 4 04004 |

**Remarks:** Einmessung additiviert

| **Testparameter** | | | **Phase 1** | **Phase 2** | **Phase 3** |
|---|---|---|---|---|---|
| Ambient Pressure | [hPa] | : | 1021 | 1021 | 1021 |
| Ambient Temperature | [°C] | : | 19.9 | 20.6 | 20.6 |
| Relative Humidity | [%] | : | 18.1 | 17.5 | 16.7 |
| Absolute Humidity | [g/Kg air] | : | 2.57 | 2.61 | 2.48 |
| NOX - corr. factor | [ - ] | : | 0.789 | 0.790 | 0.787 |
| Dilution Factor | [ - ] | : | 32.444 | 19.245 | 16.112 |
| Corr. CVS-Volume | [m^3] | : | 595.650 | 606.120 | 608.970 |
| Avg. CVS Pressure | [kPa] | : | 100.8 | 100.8 | 100.8 |
| Avg. CVS Temperature | [°C] | : | 24.1 | 31.0 | 37.8 |
| Blower Position | [ - ] | : | 4 | 4 | 4 |
| max. Tunnel Temperature | [°C] | : | | | |
| Avg. HFID-Line Temperature | [°C] | : | | | |
| Avg. HFID-Temperature | [°C] | : | | | |
| Avg. Presampler Temperature | [°C] | : | | | |
| Corr. PMU-Volume | [ l ] | : | 219.64 | 248.01 | 252.90 |
| Start Oiltemperature | [°C] | : | | | |
| Aldehyde volume Line 1 | [ l ] | : | 0.00 | 0.00 | 0.00 |
| Aldehyde volume Line 2 | [ l ] | : | 0.00 | 0.00 | 0.00 |
| Testdistance | [m] | : | 3845 | 11301 | 14595 |
| Testtime | [sec] | : | 586 | 602 | 612 |

***Volume corrected for 273.15 K and 1013.25 hPa***

| **Analysis results** | | | | | FC[l/100Km] | FC [l/100Km] |
|---|---|---|---|---|---|---|
| **Phase 1** | **THC** | **CO** | **CO2** | **NOx** | *mit C-Anteil* | *nach 80/1268* |
| Concentration | 4.759 | 44.674 | 3607 | 42.721 | 0.00 | 42.20 |
| g/Phase | 1.755 | 33.263 | 4247.09 | 41.142 | | |
| g/km | 0.456 | 8.652 | 1104.65 | 10.701 | | |
| **Phase 2** | | | | | | |
| Concentration | 6.676 | 72.797 | 6381 | 77.687 | 0.00 | 25.82 |
| g/Phase | 2.505 | 55.155 | 7646.86 | 76.210 | | |
| g/km | 0.222 | 4.880 | 676.64 | 6.744 | | |
| **Phase 3** | | | | | | |
| Concentration | 8.960 | 38.516 | 7720 | 64.291 | 0.00 | 24.15 |
| g/Phase | 3.378 | 29.319 | 9294.86 | 63.162 | | |
| g/km | 0.231 | 2.009 | 636.86 | 4.328 | | |
| **Summary [g/km]** | 0.257 | 3.959 | 712.45 | 6.070 | 0.00 | 27.11 |

# Abgas - Rollenprüfstand 3

## Deutsche Shell GmbH - PAE-Labor - OGME/ 32

| | | | | | |
|---|---|---|---|---|---|
| Projekt | : | 220258 | Car Model | : | Volvo FM 12 |
| Test Type | | Fige4 04004 | Vehicle Code | : | 220355 |
| Auftrag Nr. | : | 04004 | Odometer | : | 266502 |
| Test Number | : | 304012604 | Engine Displ. [ccm] | : | |
| Oil Code | : | 229998 | Operator | : | E. Meyer |
| Fuel Code | : | 221695 | Fuel Density [Kg/l] | : | 0.837 |
| Fuel Serie | : | 2 | H/C-Ratio | : | 0.000 |
| | | | Driving Cycle | : | Fige4 04004 |

**Remarks:** Rückmessung nach Dauerlauf 1600 km

| **Testparameter** | | | **Phase 1** | **Phase 2** | **Phase 3** |
|---|---|---|---|---|---|
| Ambient Pressure | [hPa] | : | 1008 | 1008 | 1008 |
| Ambient Temperature | [°C] | : | 20.3 | 20.8 | 21.1 |
| Relative Humidity | [%] | : | 19.0 | 18.1 | 17.2 |
| Absolute Humidity | [g/Kg air] | : | 2.31 | 2.74 | 2.87 |
| NOX - corr. factor | [ - ] | : | 0.794 | 0.792 | 0.791 |
| Dilution Factor | [ - ] | : | 33.548 | 19.435 | 16.367 |
| Corr. CVS-Volume | [m^3] | : | 592.280 | 593.470 | 596.380 |
| Avg. CVS Pressure | [kPa] | : | 99.4 | 99.5 | 99.4 |
| Avg. CVS Temperature | [°C] | : | 29.7 | 35.3 | 41.0 |
| Blower Position | [ - ] | : | 4 | 4 | 4 |
| max. Tunnel Temperature | [°C] | : | | | |
| Avg. HFID-Line Temperature | [°C] | : | | | |
| Avg. HFID-Temperature | [°C] | : | | | |
| Avg. Presampler Temperature | [°C] | : | | | |
| Corr. PMU-Volume | [ l ] | : | 223.98 | 229.91 | 225.15 |
| Start Oiltemperature | [°C] | : | | | |
| Aldehyde volume Line 1 | [ l ] | : | 0.00 | 0.00 | 0.00 |
| Aldehyde volume Line 2 | [ l ] | : | 0.00 | 0.00 | 0.00 |
| Testdistance | [m] | : | 3828 | 11306 | 14804 |
| Testtime | [sec] | : | 586 | 602 | 612 |

***Volume corrected for 273.15 K and 1013.25 hPa***

| **Analysis results** | | | | | FC[l/100Km] | FC [l/100Km] |
|---|---|---|---|---|---|---|
| **Phase 1** | **THC** | **CO** | **CO2** | **NOx** | *mit C-Anteil* | *nach 80/1268/EM* |
| Concentration | 4.126 | 40.222 | 3446 | 39.112 | 0.00 | 39.55 |
| g/Phase | 1.487 | 29.276 | 3967.19 | 37.052 | | |
| g/km | 0.389 | 7.648 | 1036.34 | 9.679 | | |
| **Phase 2** | | | | | | |
| Concentration | 6.830 | 72.121 | 6280 | 76.298 | 0.00 | 24.87 |
| g/Phase | 2.509 | 53.502 | 7366.11 | 73.551 | | |
| g/km | 0.222 | 4.732 | 651.70 | 6.505 | | |
| **Phase 3** | | | | | | |
| Concentration | 8.755 | 30.638 | 7602 | 61.309 | 0.00 | 23.33 |
| g/Phase | 3.243 | 22.917 | 5993.58 | 59.472 | | |
| g/km | 0.222 | 1.569 | 615.84 | 4.072 | | |
| **Summary [g/km]** | 0.243 | 3.554 | 683.61 | 5.719 | 0.00 | 26.00 |