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The Inspection of In-Use Cars in Order to Attain Minimum Emissions of Pollutants and Optimum Energy Efficiency

Detailed Report 4 -Technical Specifications for Transient short tests

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Introduction

This report concerns the technical specifications for the conduction of transient short tests. In the frame of this project idle tests and steady state loaded tests have been investigated, but because of the fact that the procedures and equipment for these tests are well known no further specifications and explanations are necessary.

For tests needing a chassis dynamometer and specifically in the case of a transient loaded short test preliminary investigations are necessary. Taking into account the experiences in the USA different criteria concerning test facility equipment have to be considered in order to define a short test procedure.

This report only presents the results of the preliminary phase of the I/M project. Further results can be taken from the sub-report „Test protocols and results in detail“ and from the main report.

1 Modifications of the type approval procedure and test programme

The objective of this programme was to find acceptable modifications of the type approval procedure so that the short test can be conducted without problems within a few minutes and to reduce the investment costs of the test facility.

The basis for the emission measurements was short cycle A developed by TÜV. The measurements for each vehicle and each modification were repeated four times. Each short cycle measurement consisted of two short cycles A.

Unless otherwise stated the chassis dynamometer setting was in accordance to the type approval procedure. The measurements were performed at ambient temperatures of 22 to 24°C. The ambient pressure was within a range of 995 to 1025 mbar.

In order to take into account the influence of different engine size on the results the preliminary measurements were conducted with three vehicles representing the three classes of engine capacity (1,4 l, 1,4 l - 2,0 l and > 2,0 l). Table 1 contains the technical parameters of the three test vehicles.

Table 1: Technical parameters of the test vehicles for definition of the short test procedure

vehicle type	displacement [l]	power [kW]	weight [kg]	no. of gears	year of production	km-driven
VW Polo	1,27	40	785	4	1991	42242
Opel Vectra	1,80	66	1100	5	1993	22893
Audi 100	2,31	98	1370	5	1991	80870

Modifications of the type approval procedure may be related to the following subjects:

- vehicle preparation
- chassis dynamometer setting
- exhaust gas sampling system
- exhaust gas analysis

Vehicle preparation

Because of short set-up times the connection of tail pipe and measuring system has to be open. A suitable device had to be constructed. With regard to the exhaust gas measurements two different methods had to be considered:

- In the case of emission measurements with an open connection it has to be noticed that in the case of the CVS method usually a close connection between the exhaust gas sampling system and the tail pipe of the vehicle exists. The dilution of the exhaust gas with ambient air takes place in a special mixing chamber. If an open connection is applied a minimum share of the dilution has to take place at this point in order to ensure that no exhaust gas gets lost. In the case of carrying out the complete dilution at the open connection it has to be ensured that the ambient/dilution air is not polluted to much (in a standard CVS system the dilution air is cleaned by filters). Nevertheless the pollution of the dilution air has to be known for the calculation of the emissions.

- In the case of concentration measurements in the raw exhaust gas the sample probe is inserted in the tail pipe of the vehicle. An exhaust blower has to be applied with an open connection in order to prevent the pollution of the test cell.

A special conditioning of the test vehicle is not necessary. In order to ensure that the engine of the vehicle has been warmed up for the test the short cycle is repeated for one time. If the engine of the vehicle to be tested is already warmed up sufficiently at the first cycle so that the vehicle complies with the standards the inspection can be finished.

The chassis dynamometer setting for these tests was in accordance to the type approval procedure.

Chassis dynamometer setting

A chassis dynamometer for type approval testing can be adapted in small steps to the inertia weight of the vehicle.

In order to save investment costs it was investigated if it is possible to use a chassis dynamometer, which simulates only two or three inertia weights.

The dynamometer setting was varied for each vehicle in a way, that the normal setting for type approval testing and two other typical settings for the engine capacity classes were investigated. The reference weight and the power absorbed by the dynamometer can be seen in Table 2.

The additional measurements were repeated four times with the exhaust gas measuring systems in accordance to the type approval procedure (close connection between tail pipe and CVS).

Table 2: Setting of the chassis dynamometer as a function of the reference weight

reference weight	inertia weight	power absorbed by the chassis dynamometer at 80 km/h	engine capacity [l]
Pr <=750	680	4,7	< 1,4
750 < Pr <= 850	800	5,1	< 1,4
850 < Pr <= 1020	910	5,6	< 1,4 and 1,4 - 2,0
1020 < Pr <= 1250	1130	6,3	1,4 - 2,0
1250 < Pr <= 1470	1360	7,0	1,4 - 2,0 and > 2,0
1470 < Pr <= 1700	1590	7,5	> 2,0
1700 < Pr <= 1930	1810	8,1	> 2,0
1930 < Pr <= 2150	2040	8,6	
2150 < Pr <= 2380	2270	9,0	
2380 < Pr <= 2610	2270	9,4	
2610 < Pr	2270	9,8	

As already mentioned the measurements were conducted on a dynamometer according to type approval specifications which was equipped with an mechanical inertia weight simulation in small steps (57 kg).

Besides the reduction of possible mechanical inertia weight settings it is imaginable to have a partial respectively full electric inertia weight simulation accepting that a full inertial simulation during deceleration is not possible. This special investigation was not possible as the applied dynamometer was not suitable for this modifications.

Exhaust gas sampling system

In the case of emission measurements according to the type approval procedure usually a Constant Volume Sampler (CVS) is used.

The CVS flow can be set so that the dilution of the exhaust gas causes no measurement problems. That means the dilution of the exhaust gas has to be high enough so that condensation of water vapour will be avoided. The upper limit of the dilution ratio is determined by the sensitivity of the analysers.

In order to save investment costs it is investigated if it is possible to use a CVS with a fixed flow rate.

The influence of the CVS flow rate was investigated in a way, that each vehicle was measured with flow rates which were significantly lower/higher than the optimum flow rate for type approval and basis testing.

The measurements are repeated four times with the exhaust gas system and the dynamometer setting in accordance to the type approval procedure.

In the case of diesel vehicles for the measurement of particulate matter according to the type approval procedure usually a dilution tunnel in combination with a particulate sampler is used.

Besides the costs of such an equipment there are some technical reasons why this method is not suitable for an Inspection programme. First the period for collecting particulate matter on a filter is too short in case of a short test with a duration of 200 s and second the loaded filters need a conditioning period before weighing which means that the test result is not available at the end of the test. An alternative method how to check the diesel vehicles is the measurement of the opacity in the raw exhaust (see the following section).

Exhaust gas analysis

As it already can be seen from the above described possible modifications of the type approval procedure there are two principle possibilities to analyse the exhaust gas samples:

- In the case of emission measurements with Constant Volume Sampler (CVS) two methods can be distinguished. On the on hand it is possible to collect a sample of diluted exhaust gas during the test in a sample bag and on the other hand it is possible to analyze and record the exhaust gas concentrations continuously. In the first case additional costs are caused by the necessary sample bags and besides the analysis of the sample and the calculation of the test result takes additional time. The difference between the two methods usually is less then plus/minus five percent.

  In both cases the emission measurements have to be corrected to standard temperature and pressure conditions. Caused by the CVS method the concentrations in the sample have to be corrected by the concentrations in the dilution air. As before it is possible to collect a sample of dilution air in a bag which results in the mentioned disadvantages. Another method is to make dilution air concentration measurement prior to each test. In this case criteria have to be established (time window, contamination of the air etc.) which have to be met for a valid inspection test.

  Because of the measurement in the diluted exhaust gas and because of the low exhaust gas concentrations especially for catalyst vehicles the performance of the analytical instruments has to be quite high (lab analyzers).

- In the case of continuous concentration measurement and for diesel vehicles continuous opacity measurement in the raw exhaust gas it is not possible to calculate mass emissions because of the lacking continuous raw exhaust gas volume and additionally for particulate matter the not existing deterministic relation to the opacity.

  Nevertheless it can be expected that there is a good correlation between mass emissions and concentrations (except for CO_2) respectively opacity in the raw exhaust gas.

Because of the measurement in the raw exhaust gas where the concentrations are about 10-times higher compared to the measurement in the diluted exhaust gas the performance of the analytical instruments has to be lower (simplified lab analyzers or even garage analyzers). Opacity meters anyway are constructed for the measurement in raw exhaust gas.

In the frame of inspection of in-use vehicles combinations of these two principle methods are possible as well however measurements were not conducted on this subject.

2 Influence of different modifications on the test results

Fig. 1 to 3 show a comparison of measurement results for different parameters respective modifications of the type approval test facility. The measurements were performed within a time frame of up to two months. So the base measurements with the equipment of the type approval test facility were after some time repeated. In each diagram therefore are two columns which reflect the mean values of base measurements. As can be seen in some cases very high variations occur for all three vehicles in HC-emissions. The main reason for that is that the HC-emissions of the first short test very often exceed the usual emission values of the vehicle.

The test vehicle Opel Vectra shows an emission behaviour in connection with the variation of the CVS-flow rate which could not be explained in the first step. After checking the vehicle a leak between oxygen sensor and catalyst was detected. The high CVS flow rate caused increased vacuum pressure compared to the lower CVS-flow rate so that the air/fuel ratio was too lean. The effect in emission results was increasing NO_X emissions together with low CO emissions.

Open connection between tailpipe and CVS (open CVS)

The influence is within the variation of the basis measurements.

Inertia weight

The influence on emissions is within the variation of the basis measurements. Concerning fuel consumption increasing masses increase fuel consumption up to 10 % referring to the investigated mass range of the specific test vehicle.

CVS flow rate

Because of the mentioned defect the Opel Vectra should not be considered in this context. The influence for the two other vehicles is within the variation of basis measurements.

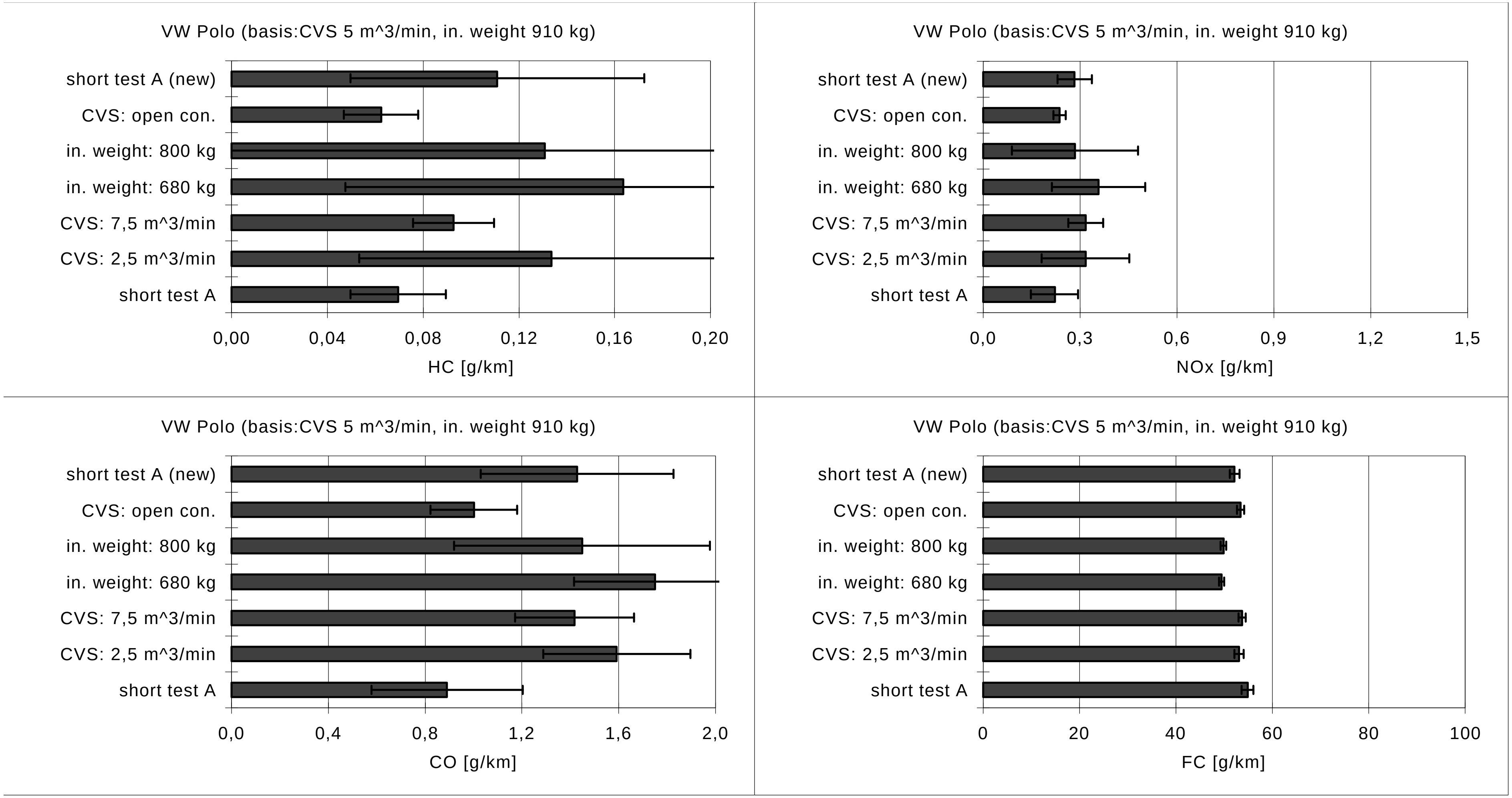

Fig. 1: Influence of different parameters of the test facility on emissions and fuel consumption in short test A for the vehicle type VW Polo

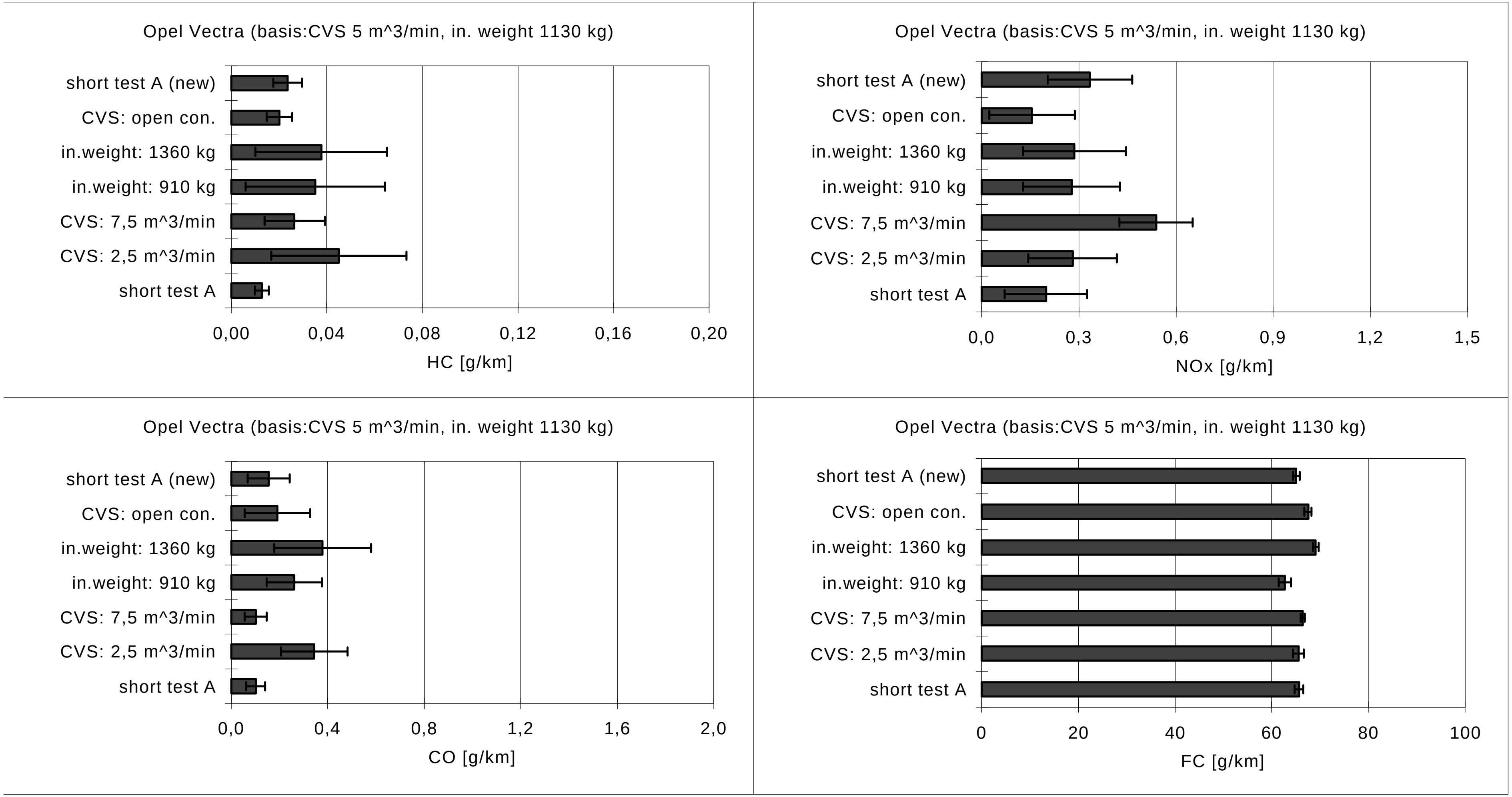

Fig. 2: Influence of different parameters of the test facility on emissions and fuel consumption in short test A for the vehicle type Opel Vectra

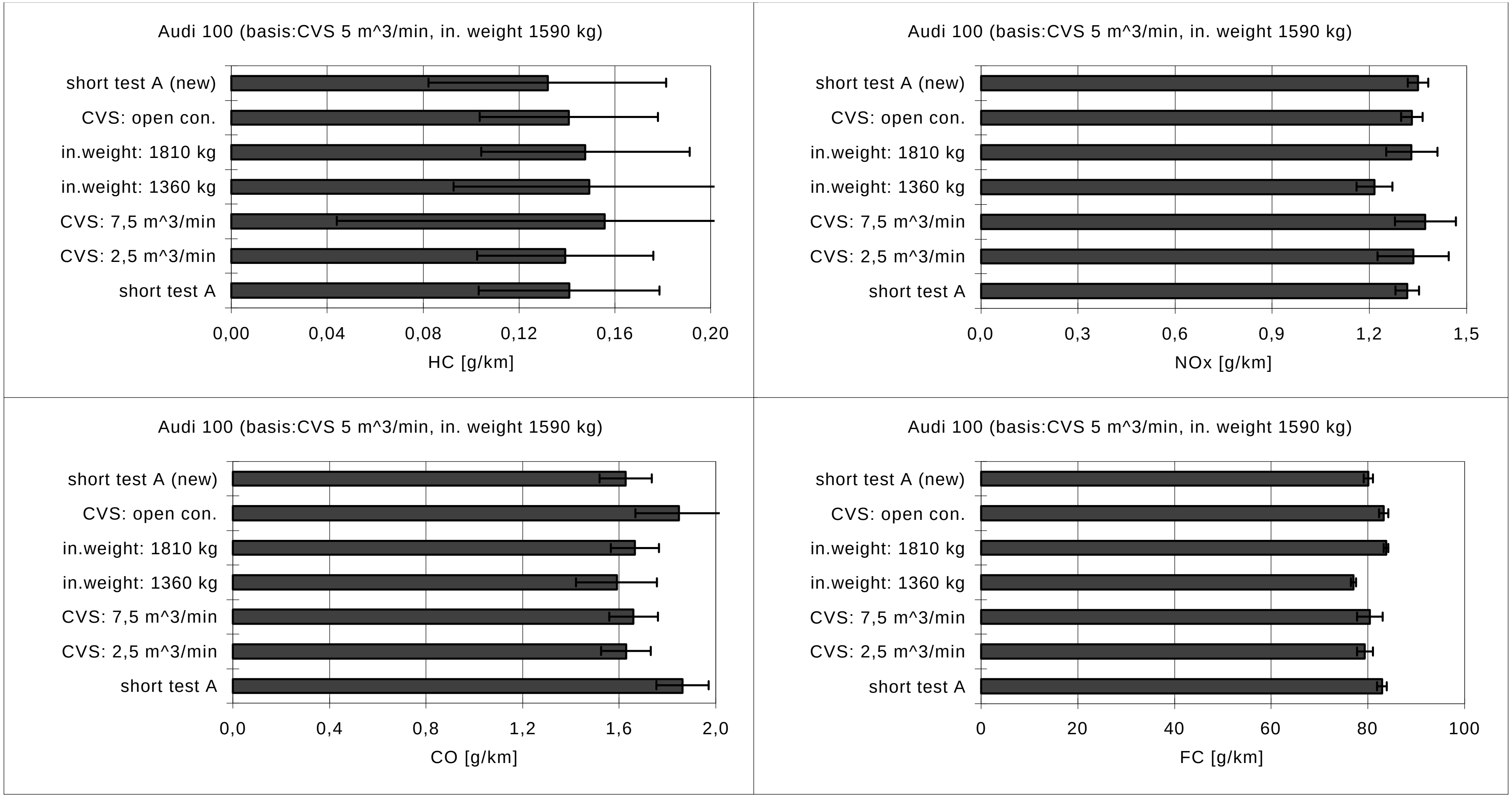

Fig. 3: Influence of different parameters of the test facility on emissions and fuel consumption in short test A for the vehicle type Audi 100

3 Correlation between different methods for measurement

Concentration measurement of the raw exhaust gas

It can be seen from Fig. 4 that a strong correlation exists between the mean raw exhaust concentrations and the emissions in the short test A for the components HC, CO and NO_x. No correlation exists for CO_2. To what extent the correlation will be affected by defective vehicles cannot be assessed.

The main disadvantage of raw gas concentration measurements is that the fuel consumption cannot be calculated.

Opacity measurement in the raw exhaust gas for diesel vehicles

Fig. 5 shows the Correlation between particulate matter in the NEDC and mean opacity in the raw exhaust gas in short cycle A. It has to be mentioned that these results do not come from the preliminary investigations but from the measurement of different diesel vehicles in the frame of phase two of the project.

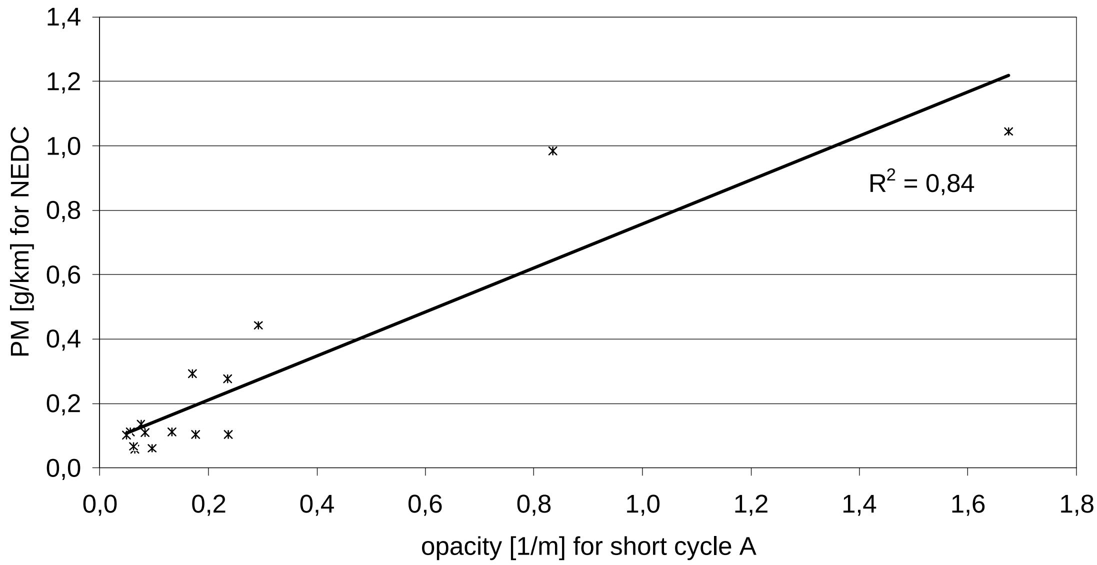

Fig. 5: Correlation between particulate matter in the NEDC and mean opacity in the raw exhaust gas in short cycle A

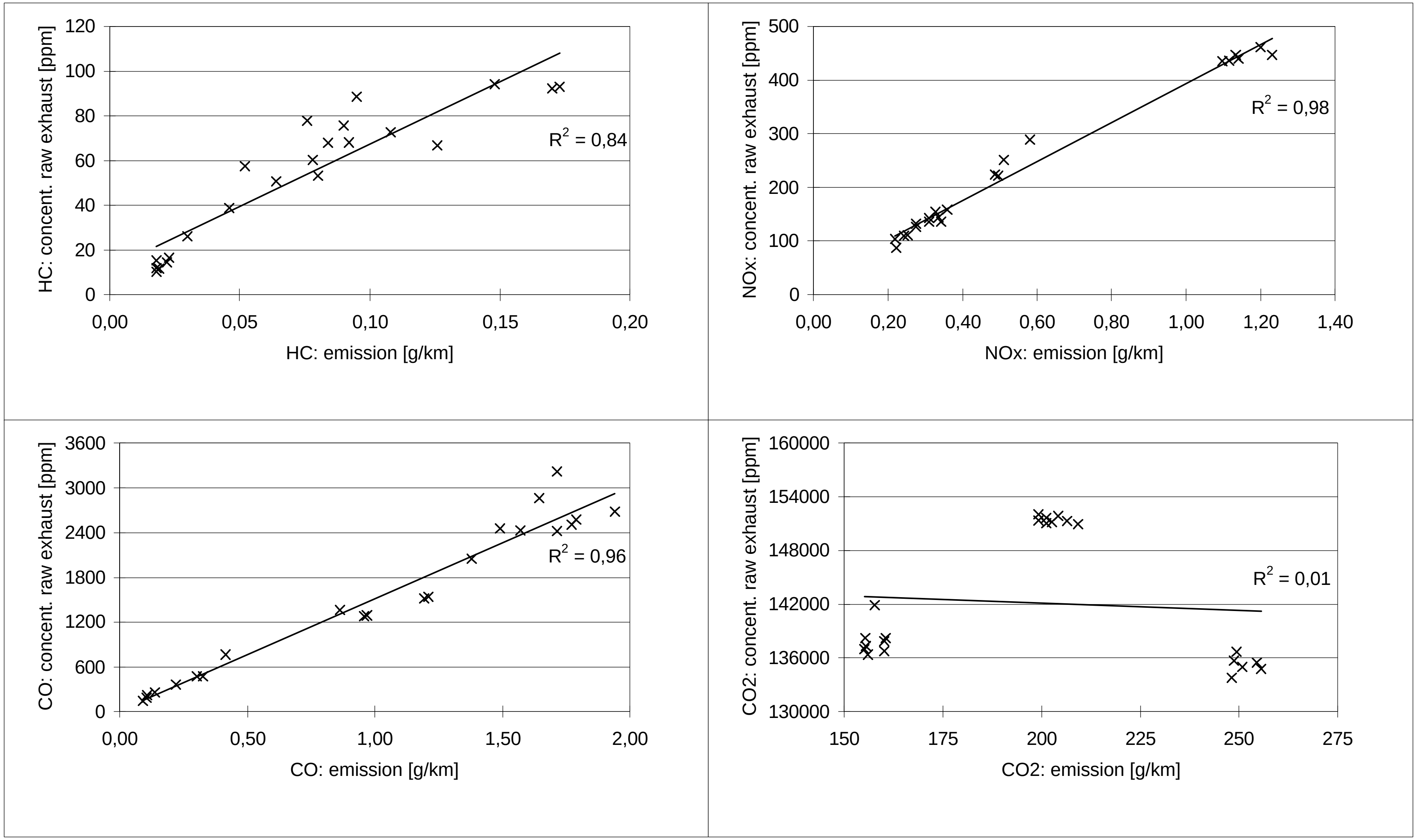

Fig. 4: Mean concentration in the raw exhaust as a function of emissions in short test A

4 Conclusions

The following statements can be derived from the results of the investigation:

- The influence of the open connection between tail pipe and CVS on emission results can be neglected.

- In order to get realistic results three inertia weights should be possible to be simulated:
  800 kg (reference weight ≤ 1020 kg)
  1130 kg (reference weight > 1020 kg ≤ 1470 kg)
  1590 kg (reference weight > 1470 kg)

- The volume flow of the CVS should be in the range of 5 m^3/min to 7,5 m^3/min. The dilution ratio will affect the sensitivity of the analysers. The dilution ratio has to be high enough to avoid condensing water and low enough so that the ranges of concentration measurements for I/M-analysers are met because of cost reasons.

- For diesel vehicles a continuous opacity measurement in the raw exhaust gas shows a good correlation to particulate matter.