Responsible (Name, Organisation) Martin Sanfridson Volvo Technology	**DELIVERABLE REPORT**		Page 1(17)
Issuer (Name, Organisation) Björn Andersson Volvo Technology	Date 2011-07-13	WP No 4100	Report No 1
Subject D4100.1 Early second generation hybrid vehicles and one non-hybrid reference vehicle equipped with logging devices for emissions and fuel consumption			Dissem. Level **PU**

HCV
D4100.1 Early second generation hybrid vehicles and one non-hybrid reference vehicle equipped with logging devices for emissions and fuel consumption

Summary

During the work in WP4100 fuel consumption and exhaust gas emissions have been measurements for two different 12 meter buses, a 9 litre conventional bus and a similar hybrid bus with a 5 litre engine. In this report the prerequisites for the test is summarised. Data for the bus route that is used for the test is shown in this report. Common data for the test buses are also listed in this report. The results are reported in D4100.2.

Emission measurement equipment was from both Volvo and Veolia was installed in the test buses.

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List of abbreviations

HCV	Hybrid Commercial vehicle
WP	Work Package
FTIR	Fourier Transform Infra Red
I-SAM	Integrated Starter Alternator Motor
FT7	Field Test 7
SD2	Single Decker 2
CAN	Controller Area Network
ECU	Electrical Control Unit
EMS	Engine Management System
GPS	Global Positioning System
MCT	Mecury Cadmium Tellurium
CBR85	City Bus Route 85
SOC	State Of Charge
SCR	Selective Catalytic Reduction

Introduction

Background

The measurements are performed as a part of Work Package 4100 in the HCV project. The goal of the project is to develop urban buses and delivery vehicles with advanced second generation of energy efficient hybrid electric power-trains in line with objectives in the Description of work [1]. The final result will be the demonstration of a passenger bus and a distribution truck with this advanced technology.

The project goals regarding fuel economy and emissions are set relative to both a conventional vehicle and an early second generation vehicle. The work in WP4100 is intended to contribute to definition of the base line for HCV project regarding emissions and fuel consumption for a city bus. The measurements will also be used as input for the development of test cycles for hybrid vehicles in WP6100 and creation of target for individual subsystem in the powertrain.

Since the influence of ambient on the measured quantities was considered an important input to the project the measurements were performed at both summer conditions and winter conditions in the Gothenburg area where the demonstrator bus will be evaluated. As a contribution to the drive cycle development the influence of the duration of bus stops were included in the measurements.

Objectives

Targets

The measurements have the following targets:

- Measure fuel economy for a reference bus and an early second generation hybrid bus.
- Measure emission levels for a reference bus and an early second generation hybrid bus.
- Provide data for both summer and winter conditions in drive cycle containing a range of driving conditions.
- Provide input data for the development of test cycles in WP 6100
- Provide input to WP4200 vehicle and drivetrain conceptual design
- Evaluate data form the internal communication system in the vehicle to create targets for subsystem in the second generation of hybrid vehicle.
- Provide an evaluation of drivability
- Provide an evaluation of noise emissions from electric assisted take-off

Test objects and specifications

Three city buses are used as test vehicles in this measurement. One reference standard diesel bus and two hybrid buses, one for the summer measurements and one for the winter measurements were used. For measuring fuel consumption flow meters are used and a FTIR is used for analyzing the engine exhausts.

Buses

The three vehicles used for the tests are city buses, Volvo 7700. Two I-SAM hybrid buses, called FT7 and SD2, with 5 litres diesel engines and as reference the standard bus, B014, with a 9 litre diesel engine and an automatic transmission. Specifications for the buses are shown in tables 1-3. The reason for using two hybrids buses is that there were major hard- and soft ware changes on the hybrid bus used for the summer measurements between the two test occasions and therefore another more comparable bus were chosen for the winter measurements. The total vehicle weight used for the tests was 14500 for all three vehicles.

Table 1: Reference bus specification

Unit	Type/model	Data
Bus ID	B014	
Bus type	7700	
Chassis ID	114449	
Engine	D9B310	Euro 5, 230kW
Transmission	ZF Ecolife 140 NM, 6AP1400B	
Vehicle weight	Half loaded/Empty	14500/12500kg

Figure 1: Conventional bus in workshop.

Table 2: Hybrid bus, FT7, specification

Unit	Type/model	Data
Bus ID	FT7	
Bus type	7700	
Chassis ID	128317	
Engine	Deutz 5L	Euro 5 160kW
Transmission	I-shift	
Vehicle weight	Half loaded/Empty	14500/12700kg
Hybrid system	I-SAM	70kW cont, 120kW peak

Table 3: Hybrid bus, SD2, specification

Unit	Type/model	Data
Bus ID	SD2	
Bus type	7700	
Chassis ID	100011	
Engine	Deutz 5L	Euro 5 160kW
Transmission	I-shift	
Vehicle weight	Half loaded/Empty	14500/12700kg
Hybrid system	I-SAM	70kW cont, 120kW peak

Figure 2: Hybrid bus in workshop.

Measurement equipment

The fuel consumption has been measured in two ways, with two external flow meters and with the power train CAN bus signal fco_fuel_rate from the EMS.

The external flow meters are installed on the fuel pipe between the fuel tank and the engine. The flow meters measure the feed flow and the return flow of the engine and give a 5V analogue voltage pulse/10ml fuel. For the summer measurement an IPEtronik SIM-CNT pulse counting module was used and configured in a way that it counted the pulses and calculated the fuel consumption into litres/second and sent that information out on CAN. For the winter measurements a CANSAS ISO 8 was used instead of the IPEtronik module. The CANSAS ISO 8 forwards the pulses on to separate CAN bus and the fuel consumption is instead calculated afterwards in this case. The difference between accumulated pulse signals from the flow meters is proportional to the amount of consumed fuel.

With a GPS the exact position of the vehicle has been measured.

CAN data from the IPEtronik, the CANSAS and the GPS are collected by the measurement and calibration tool ATI Vision. CANalyzer are used to collect data from the vehicle communication network.

Table 4: Fuel consumption measurement equipment specification

Unit	Type/model	Measured quantity	Function
Flow meters		10ml/pulse	Measuring fuel cons.
GPS	Garmin 18	5Hz	Mapping position
IPEtronic	SIM-CNT		Analog to CAN
CANSAS	ISO 8		Analog to CAN
ATI vision	3.6.1		Collecting meas. data
CANalyser	7.0.31		Collecting meas. data

Figure 3: Measurement equipment being installed in the hybrid bus.

Emission measurement equipment used by Volvo

In order to measure and analyse the exhaust gases on-line during field tests, a portable gas analyser fed by a sampling unit was chosen. The gas analyser MultiGas™ 2030*HS* uses Fourier transform Infra-red (FTIR) spectrometry and is manufactured by "mks Technology for Productivity. Detection limits of 1ppm or less are achievable with this analyzer by using higher sensitivity narrow range MCT detectors. The MultiGas analyser has analysis software, which can analyze and report concentrations for dozens of compounds simultaneously. All data has been recorded in a separate measurement computer.

Table 5: Engine measurement equipment specification

Unit	Type/model	Measured quantity	Function
Emission…	Multigas™ 2030*HS*	Concentration setting between 10ppb and 100% full scale, 5 scans/sec@0,5 cm-1	Emission of different gas compound such: (H2O, CO2, CO, NO, NO2, NH3, HNCO, N2O, CH4, diesel, …)

The gases are sampled inside the exhaust pipe using a metal probe and pumped to the inlet of the gas analyser through the portable sampling unit. The latter is manufactured by Gasmet and consists of a heated sample pump (316SS), a heated filter as well as temperature controllers for the heated hoses leading the gases to and from the unit. The heated hoses lead the gases from the exhaust system to the heated sampling box and via the heated filter to the gas analyzers. All parts of the gas analyzer as well as the entire sampling line are regulated to a temperature of 180C in order to prevent condensation of the sampled gas. All measuring equipment is powered by a current inverter during the on-road tests. It delivers up to 1kW @ 220VAC and is powered by the 24VDC current from the bus batteries.

Emission measurement equipment used by Veolia

In order to measure exhaust gas emission, Veolia use an HORIBA OBS 2200, witch is dedicated to onboard exhaust emission. The Exhaust Flow is measured by a pitot tube which enables mass emission of pollutants.
Inside the OBS 2200 gas analyser are:

- NDIR (Non-Dispersive Infrared Method) to measure Carbone Monoxyde and Carbone Dioxyde, (CO: 0-0.5 to 0-10 vol% Accuracy within ±2.5% of full scale. CO2: 0-5 to 0-20 vol% Accuracy within ±2.5% of full scale)
- FID (Flame ionization detection method) to measure Total Hydrocarbon (THC: 0-1000 ppmC to 0-10000 ppmC Accuracy within ±2.5% of full scale)
- CLD (Chemi-luminescence detection method) to measure nitrogen oxide or nitrogen dioxide (NO, NOx: 0-100 to 0-3000 ppm Accuracy within ±2.5% of full scale)
- CAN network data logging
- GPS data logging
- Ambient condition data logging

Power for the system is supplied by 2 extra batteries, but the range is limited at 6 hours. For longer operation after 6 hours connection to an external power supply is necessary and in this case it is inverter from Volvo.

Noise measurement

When the vehicle is operating in city traffic the largest contribution to noise is the combustion engine. Another contribution is tyre-road interaction. Auxiliary loads like compressors and fans can also be generating notable noise levels. The noise emissions changes for a hybrid vehicle; the hybrid can also be operated in electric mode only. This is an advantage since city environments today can be very noisy. The noise measurement in the bus follows the procedure in ISO 5128, [3].

Test routes

To evaluate fuel consumption and emissions level for typical city driving the route CBR85 is used. The route contains both urban and sub urban parts. In Figure 1 a map with CBR85 is shown. A height profile of the CBR85 is shown in Figure 2. The 23 km long route takes 4000 s to travel. The test vehicles stop at each bus stop for 15 seconds in order to simulate passengers getting on and off the bus. However the doors and kneeling are not operated at the bus stops.

Figure 4: Map of CBR85

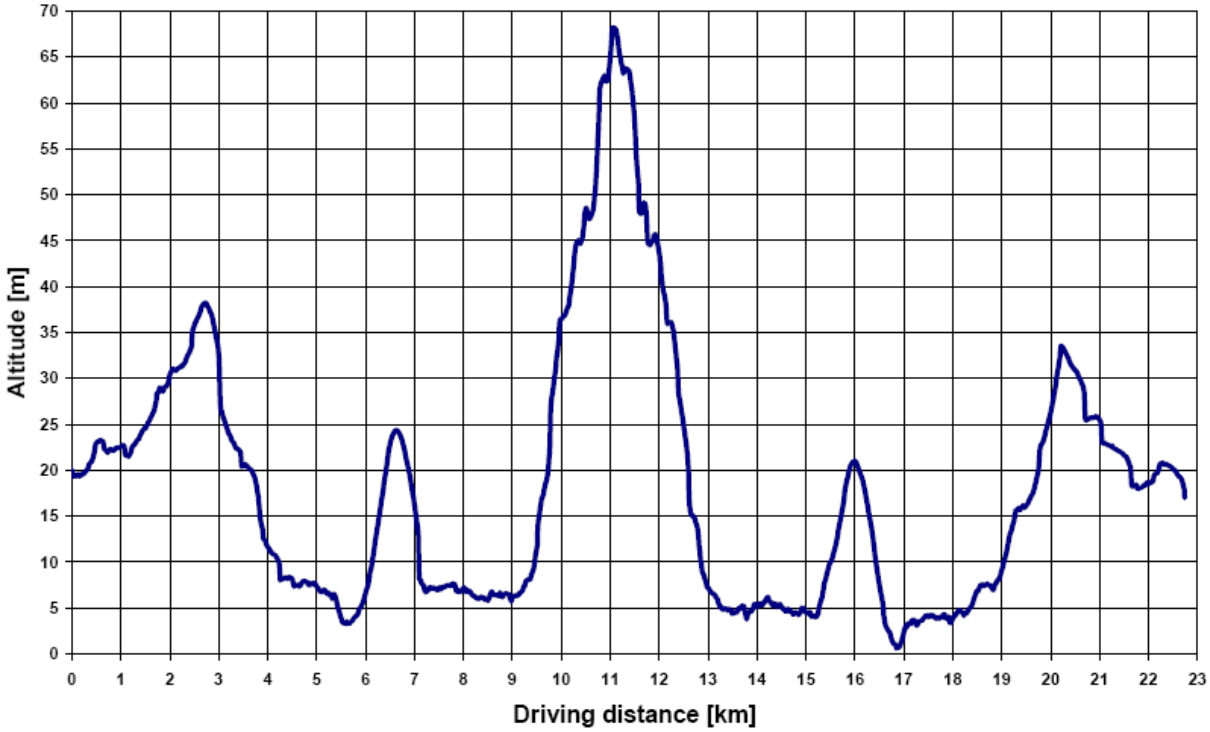

Figure 2: Height profile of CBR85.

Conclusions

Both a conventional reference bus and equivalent hybrid of early second generation have successfully been prepared for emission and fuel consumption measurement.

References

[1] Grant Agreement No 234019. Annex I – Description of work

[2] D4100.2 Emission and fuel consumption measurement data from early second generation vehicles in inner-city and outer-city routes.

[3] ISO 5128 Acoustics – Measurement of noise inside motor vehicles, 1980.