Annex A1: Test Procedure for Measuring Fuel Economy and Emissions of Low Carbon Emission Buses Powered by Conventional Powertrains

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1. Scope

This document provides an accurate and reproducible procedure for simulating the operation of buses powered by conventional powertrains on dynamometers for the purpose of measuring emissions and fuel economy.

It should be noted that most buses addressed in this recommended practice are expected to be powered by engines that are certified separately for emissions. In these cases the engine certification procedure appears in Regulation 77/88/EC.

This test procedure does not make specific provisions or recommendations for testing of bus emissions with air conditioning deployed because the complexity of such tests is significant. All auxiliary loads will be turned off during the test, unless they affect the normal operation of the vehicle.

The intention is to test the vehicle in its normal road-going condition and operating strategy as far as reasonably practical, within the constraints of the equipment and cycle. Potential exceptions to this include antilock brakes and traction control. Any aspect of vehicle operation which needs to be modified for the test shall be discussed with the test centre and recorded in the test report.

The procedure requires the calculation of Well-to-Wheel (WTW) Greenhouse Gas (GHG) emissions in order to determine if the vehicle qualifies as a Low Carbon Emission Bus.

The vehicle will be tested over the Millbrook London Transport Bus (MLTB) drive cycle representing intermediate-speed bus operation in London. Details of this cycle can be found in Appendix 1 of this document.
Alternative cycles may be used as detailed in the Vehicle Accreditation Requirements document.

Regulated emissions (HC, CO, NOx and PM) and carbon dioxide shall be sampled over the entire cycle and the results presented as gm/km.

For all buses, the concentration of nitrous oxide (N_2O) shall be determined using Fourier Transfer Infra-Red spectroscopy (FTIR) techniques.

For all buses, the concentration of methane (CH_4) shall be determined by separate analysis.

2. Definitions and Terminology

CONSUMABLE FUEL -- Any solid, liquid, or gaseous material that releases energy and is depleted as a result.

PRIME MOVER – Power unit which provides the primary source of mechanical energy used to move the vehicle

PROPULSION ENERGY -- Energy that is derived from the vehicle's consumable fuel to drive the wheels. If an energy source is supplying energy only to vehicle accessories (e.g., a 12-volt battery on a conventional vehicle), it is not acting as a source of propulsion energy.

PROPULSION SYSTEM -- A system that, when started, provides propulsion for the vehicle in an amount proportional to what the driver commands.

TOTAL FUEL ENERGY -- The total energy content of the fuel in MJ consumed during a test as determined by carbon balance or other acceptable method and calculated based on the lower heating value of the fuel.

3. Test Preparations

3.1 Test Site

The ambient temperature levels encountered by the test vehicle shall be maintained at 18°C ± 2°C throughout the test

Ambient temperatures must be recorded at the beginning and end of the test period. Test conditions specified in 70/220/EEC and 77/88/EEC shall apply, where appropriate.

Adequate test site capabilities for safe venting and cooling of batteries, containment of flywheels, protection from exposure to high voltage, or any other necessary safety precaution shall be provided during testing.

One or more speed tracking fans shall direct cooling air to the vehicle in an attempt to maintain the engine operating temperature as specified by the manufacturer during testing. These fans shall only be operating when the vehicle is in operation and shall be switched off for all key off dwell periods. Fans for brake cooling can be utilized at all times. Additional fixed speed fans should be used if required and must be documented in the test report.

3.2 Pre-Test Data Collection

Prior to testing, detailed characteristics of the vehicle should be recorded. These requirements are specified in Appendix 4 of this Annex. The chassis test laboratory will be used to measure actual cycle distance during a test, as it is generally considered a more accurate method of calculation; as a result, an odometer on the vehicle is not required.

For all tests, a fuel sample shall be taken for potential analysis at a later date. The vehicle will be tested using the fuel with which it arrives at the test facility. Fuels should meet the requirements of EN590 and any exceptions to this should be advised by the vehicle manufacturer for reporting purposes.

3.3 Operation of the vehicle

If the vehicle is unable to be driven on the chassis dynamometer in its conventional operating mode then the reasons for this should be provided by the manufacturer in advance of the tests for reporting purposes. Any deviations from standard operation must be approved by the LowCVP prior to the issue of a LCEB certificate (where appropriate).

3.4 Condition of the Vehicle

Vehicle Stabilization -- Prior to testing, the vehicle shall be stabilized to a minimum distance of 3000km. This will be documented in the test report.

Vehicle Test Weight -- Buses shall be tested at kerb weight plus driver weight (75kg) and one quarter of the specified total passenger load using a weight of 63 kg per passenger. The kerb weight of the vehicle shall be determined prior to test by the technical service carrying out the test. For buses which have previously been tested for Transport for London bus approval, this procedure can be followed retrospectively. In this case, the change in CO_2 emissions due to the difference between the LCEB test inertia and the TfL test inertia shall be calculated using the following equation.

$$\mathbf{\Delta CO_2 = 0.0637 * \Delta TI} \qquad \text{(Equation 8)}$$

where:

ΔTI = Difference in test inertia, in kilograms (kg)

Tyres -- Manufacturer’s recommended tyres shall be used and shall be the same size as would be used in service. This will be documented in the test report.

Tyre Pressure -- For dynamometer testing, tyre pressures should be set at the beginning of the test to manufacturer’s recommended pressure. This will be documented in the test report.

Lubricants -- The vehicle lubricants normally specified by the manufacturer shall be used. This specification shall be supplied by the manufacturer in advance of the tests and recorded in the test report.

Gear Shifting – The vehicle shall be driven with appropriate accelerator pedal movement to achieve the time versus speed relationship prescribed by the drive cycle. Both smoothing of speed variations and excessive acceleration pedal perturbations are to be avoided and may cause invalidation of the test run. In the case of test vehicles equipped with manual transmissions, the transmission shall be shifted in accordance with procedures that are representative of shift patterns that may reasonably be expected to be followed by vehicles in use.

Vehicle Preparation & Preconditioning **--** as a minimum, should include:

- The vehicle should be preconditioned using a complete run of the test cycle followed by the appropriate key off dwell period (see Appendix1)

3.5 Dynamometer Specifications

The evaluation of the emissions and fuel economy from a low carbon emission bus powered by conventional powertrain should be performed using a laboratory that incorporates a chassis dynamometer, a full-scale dilution tunnel, and laboratory-grade exhaust gas analyzers as described in 70/220/EEC (Light-duty vehicles) and 88/77/EC (Heavy-duty engines). The chassis dynamometer should be capable of simulating the transient inertial load, aerodynamic drag and rolling resistance associated with normal operations of the vehicle. The transient inertial load should be simulated using appropriately sized flywheels and/or electronically controlled power absorbers. The aerodynamic drag and rolling resistance may be implemented by power absorbers with an appropriate computer control system. The drag and rolling resistance should be established as a function of vehicle speed. The actual vehicle weight for the on-road coast down should be the same as the anticipated vehicle testing weight as simulated on the dynamometer. The vehicle should be mounted on the chassis dynamometer so that it can be driven through a test cycle. The driver should be provided with a visual display of the desired and actual vehicle speed to allow the driver to operate the vehicle on the prescribed cycle.

3.6 Dynamometer Calibrations

The dynamometer laboratory should provide evidence of compliance with calibration procedures as recommended by the manufacturer.

3.7 Inertial Load

Inertial load must be simulated correctly from a complete stop (e.g., total energy used to accelerate the vehicle plus road and aerodynamic losses should equal theoretical calculations and actual coastdowns).

3.8 Road Load

Road load and wind losses should be simulated by an energy device such as a power absorber. Road load should be verified by comparison to previously tested vehicles having similar characteristics or by coastdown analysis on the track.

3.9 Dynamometer Load Coefficient Determination

The dynamometer coefficients that simulate road-load forces shall be determined as specified in Directive 70/220/EEC. The vehicles shall be weighted to the correct dynamometer test weight when the on road coastdowns are performed.

3.10 Dynamometer Settings

The dynamometer's power absorption and inertia simulation shall be set as specified in 70/220/EEC. It is preferable to insure that the dynamometer system provides the appropriate retarding force at all speeds, rather than simply satisfying a coastdown time between two specified speeds. The remaining operating conditions of the vehicle should be set to the same operating mode during coastdowns on road and on the dynamometer (e.g., air conditioning off, etc).

3.11 Test Instrumentation

Equipment referenced in 70/220/EEC and 88/77/EC (including exhaust emissions sampling and analytical systems) is required for emissions measurements, where appropriate. All instrumentation shall be traceable. to national standards.

4. Test Procedure

4.1 Vehicle Propulsion System Starting and Restarting

The vehicle's propulsion system – specifically, the unit that provides the primary motive energy, e.g., the internal combustion engine -- shall be started according to the manufacturer's recommended starting procedures in the owner's manual. Only equipment necessary to the primary propulsion of the vehicle during normal service shall be operated. The air conditioner and other auxiliary on-board equipment not generally used during normal service shall be disabled during testing.

4.2 Dynamometer Driving Procedure

The emission test sequence starts with a "hot" vehicle that can be utilized to warm the dynamometer to operating temperature and allow for vehicle rolling loss calibration.

4.3 Dynamometer Warm-up

The test vehicle is used to warm the dynamometer and operated to allow for proper laboratory and vehicle loss calibrations.

4.4 Practice and Warm Up Runs

The test vehicle will be operated through a preliminary run of the desired test cycle. During this preliminary cycle, the driver will become familiar with the vehicle operation, and the suitability of the selected operating range of gas analyzers will be verified. Additional preliminary runs will be made, if necessary, to assure that the vehicle, driver, and laboratory instrumentation are performing satisfactorily.

4.5 Emission Tests

During the actual emission tests the test facility shall measure all emission data from the moment the vehicle is started, excluding the actual start event.

If the vehicle has not been operated for more than 30 minutes then it shall be started and warmed to operating temperature utilizing the same test cycle that will be used for emission characterization. Once the vehicle is at operating temperature it shall be turned off and will be restarted within 30 minutes. The test cycle shall then begin and emission measurements will be taken. At the end of the test cycle the vehicle shall be returned to the "key off" condition. Analysis will be carried out between test cycles

The number of tests runs performed must be sufficient to provide a minimum of three test runs with valid results. If the test sequence lapses in timing, another preliminary warm up run must be performed, after which the schedule can be resumed. Valid data gained prior to the breaking of the schedule may be preserved and reported. It is important to adhere to the time schedule and soak periods because engines and aftertreatment devices are sensitive to operating temperature.

4.6 Test Termination

The test shall terminate at the conclusion of the test run. However, sufficient idle time should be included at the end of a run, such that the analyzers are not missing emissions that are still in the sampling train.

4.7 Air Conditioning

Emissions from air conditioning systems are outside of the scope of this procedure. Air conditioning and conventional heating systems will therefore be switched off for the duration of the test

4.8 Data Recording

The emissions from the vehicle exhaust will be ducted to a full-scale dilution tunnel where the gaseous emissions of carbon monoxide, oxides of nitrogen (both nitric oxide and nitrogen dioxide) and carbon dioxide will be analysed as an integrated bag sample. Emissions of hydrocarbons, methane and nitrous oxide shall be measured on a continuous basis at a frequency of 5 Hz or greater. It is recommended that emissions of carbon monoxide, oxides of nitrogen and carbon dioxide are also measured on a continuous basis, and that these levels be compared to the integrated bag measurements as a quality assurance check. Particulate matter will be measured gravimetrically using fluorocarbon-coated glass fibre filters by weighing the filters before and after testing. Filters will be conditioned to temperature and humidity conditions as specified by 88/77/EEC

For each constituent, a background sample using the same sampling train as used during the actual testing must be measured before and after the emission test, and the background correction must be performed as specified by 70/220/EEC. In cases where some speciality fuels are examined by the test procedure, it may prove necessary to sample for additional species, including alcohols, aldehydes, ketones, or organic toxics if it is suspected that the levels of these additional species might be significantly higher than is normally found for diesel fuel. It is recommended that the tunnel inlet be filtered for PM with a HEPA filter to aid in lowering the detection limits.

Fuel consumed shall typically be determined by carbon balance from the gas analyzers, and the actual distance travelled by the dynamometer roll surface shall be used to provide the distance travelled during the driving cycles. Alternative methods for fuel consumption, such as direct mass measurement of the fuel tank, shall be considered if they are sufficiently accurate. This would require that the mass measurement system has an accuracy of greater than 1% of the fuel amount consumed during the test cycle. This method would be required for vehicles consuming hydrogen fuel. Mass measurement is preferred to volumetric measurement.

In the case where the vehicle is to be tested and operated on multiple fuels with different GHG pathways it is essential that the individual flows of each fuel can be resolved to an accuracy of 1% or better, either by measuring the flow of each fuel separately, or by introducing them at a fixed ratio into the engine. In this case the GHG analysis in Annex 5 shall be performed separately for each fuel and the final values combined.

4.9 Deviations from Standard Procedure

It is permissible to deviate from the prescribed procedure in cases where it can clearly be shown that this would result in a more realistic simulation of real-world vehicle operation.

For example:

> Where technology exists to enable the internal combustion engine to be switched off at bus stops, the MLTB cycle may be modified to include a series of simulated stops.
>
> In this case the stops are defined as all periods where the vehicle remains stationary for 15 seconds or more and this results in 19 simulated stops with a total duration of 411 seconds.

During each 'stop' the bus may be operated in a manner which is consistent with normal operation, i.e. park or neutral transmission, park brake applied, doors opened.

Any deviations from the standard test procedure must be recorded in the test report and approved by the LowCVP prior to the issue of a LCEB certificate (where appropriate).

5. Test Validation

The value of the mass emission rates for each species will be averaged over the test distance (i.e. reported in g/km). There will be a minimum of three valid runs for each type of drive cycle. For a group of three tests to be valid the 'total GHG emissions' from each test, must lie within a 5% range. Any obvious error in the data should be identified and removed from the dataset; however, a minimum of three successful runs should be used in reporting the data.

At the end of each run, the total distance travelled by the vehicle over the test run will be noted from the dynamometer distance measurements. Adherence of the driver to the test cycle target speeds will be noted, and a regression will be performed to compare actual speeds with target speeds on a second-by-second basis. Target speed (x) and actual speed (y) should be charted in 1Hz increments and a trend line inserted with a zero intercept. If the resulting trend line has a slope that varies from unity by more than 10% or an R^2 of less than 0.8 the test run should be considered an invalid representation of that test cycle. The actual distance travelled by the dynamometer roller(s) should be used for the test cycle distance value.

If at any point during the test, vehicle propulsion is not possible or the driver is warned by the vehicle to discontinue driving then the test is considered invalid.

6. Reporting

The final test report shall include all measured parameters including vehicle configuration, vehicle statistics, test cycle, measured parameters and calculated test results. See Appendix 5.

The following information will be included in the report:

Exhaust Emissions and Fuel Economy - The exhaust emissions and fuel economy of the vehicle shall be measured during each test. The measurements shall be reported in grams per kilometre and litres per 100 kilometre, respectively. Total fuel energy shall be reported in MJ.

Actual Distance Travelled - The actual distance that the dynamometer roll surface travelled shall be measured during each test phase.

Tank-to Wheel emissions - Values for TTW emissions will be presented for CO, HC, NOx, PM, CO_2, N_2O and CH_4

Well-to-Tank GHG emissions - Values for WTT GHG emissions will be presented as appropriate to the fuel in-use. For biodiesel, standard diesel WTT emissions should be used

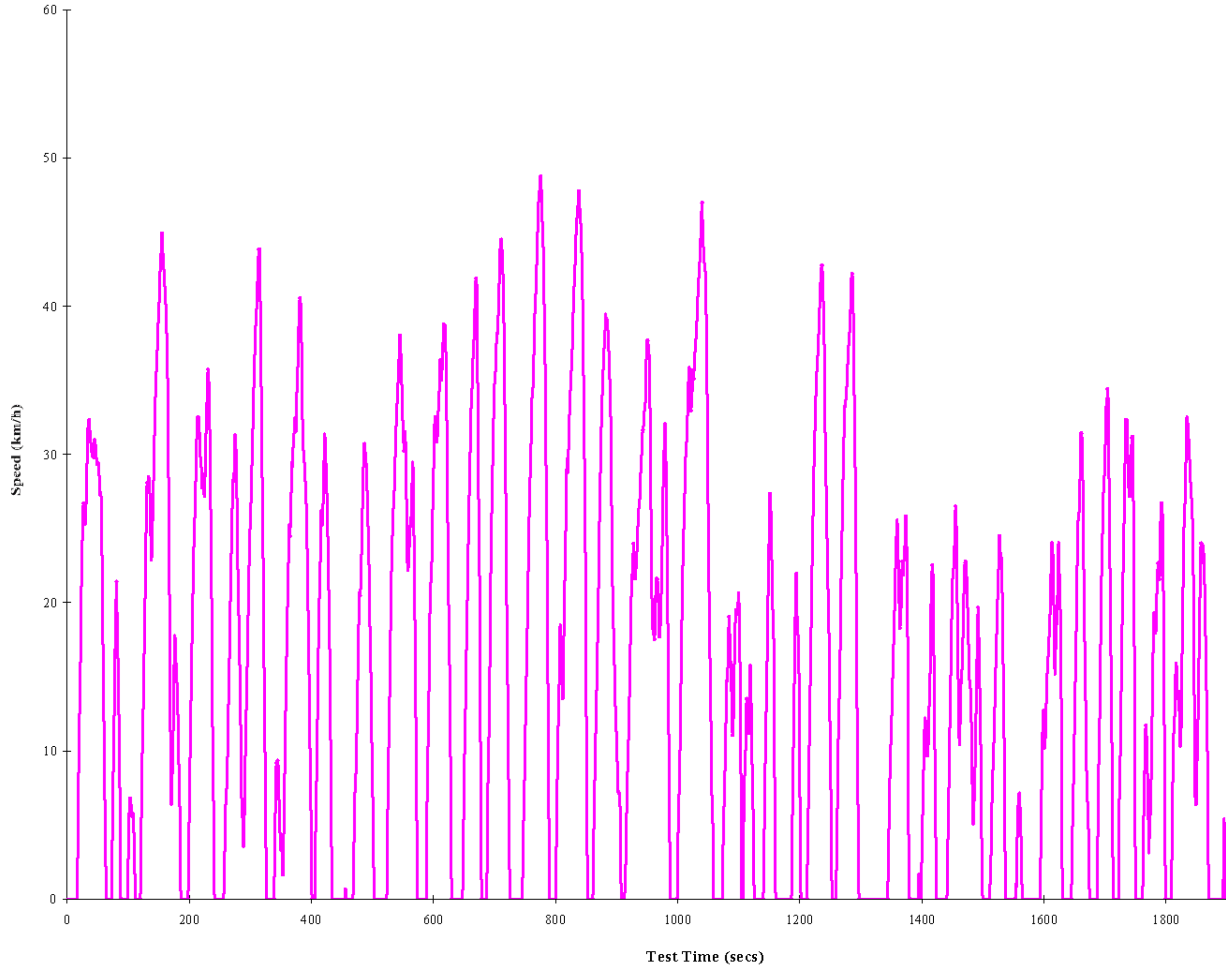
Well-to-Wheel GHG emissions - Values for WTW GHG emissions will be presented as appropriate to the fuel in-use

Appendix 1: MILLBROOK LONDON TRANSPORT BUS (MLTB) DRIVE-CYCLE
(Also known as Route 159 Drive Cycle)

This test cycle was specifically developed for use with buses and was derived from data logged from a bus in service within inner London.
The drive cycle consists of two phases, a medium speed 'Outer London' phase simulating a journey from Brixton Station to Trafalgar Square and a low speed 'Inner London' phase simulating a journey from Trafalgar Square to the end of Oxford Street.

The cycle is composed of two phases:

(1) Outer London Phase, nominal distance 6.45 km, 1,380 seconds in duration
(2) Inner London Phase, nominal distance 2.47 km, 901 seconds duration



General information
The overall length of the test is 2,281 seconds and the nominal distance covered is 8.92 km.
Test cell ambient temperature for duration of test = 18°C ± 2°C

Appendix 2 : Well-to-Wheel Calculations

Worked Example from a test on a single deck bus with a conventional powertrain

Base Vehicle Data: 36 seated passengers, 20 standees, total 56 Passengers.

The chassis dynamometer emission results are shown in the table below:

Test No.	CO_2 Emissions (g/km)	CH_4 Emissions (g/km)	CO_2 Equivalent (g/km)	N_2O Emissions (g/km)	CO_2 Equivalent (g/km)	Calculated GHG Emissions (TTW) (CO_2 Equivalent g/km)
1	687.9	0.000	0.0	0.006	1.9	689.8
2	703.8	0.000	0.0	0.007	2.2	706.0
3	689.7	0.000	0.0	0.005	1.6	691.3
Average						695.7

The bus was found to have an average Tank to Wheel (TTW) GHG output of 695.7 g/km.

<u>Calculation of Well to Wheel GHG</u>

Test No.	Fuel Used Over Cycle (Litres)	Net Heating Energy (MJ/Litre)	Total Fuel Energy (MJ)	WTT GHG Equivalence Factor * (CO_2 Equivalent g/MJ)	Calculated WTT GHG Emissions (CO_2 Equivalent g/km)	Calculated WTW GHG Emissions (CO_2 Equivalent g/km)
1	2.250	35.67	80.24	14.2	127.7	817.5
2	2.375	35.67	84.70	14.2	134.8	840.8
3	2.218	35.67	79.13	14.2	126.0	817.2
Average						825.2

Note, this calculation must be carried out separately for each fuel if more than one has been used during the test.

<u>Test Validity Check</u>

Test No.	Total WTW GHG Emissions ($CO2_{equiv}$ g/km)	Variation from Average (%)
1	817.5	-0.93%
2	840.8	1.90%
3	817.2	-0.96%
Average	825.2	

All tests lie within 5% range and are therefore valid.

* Equivalence factor from JRC-CONCAWE-EUCAR WTW Report Version 2, 3rd November 2008

The bus was found to have a CO_2 output of 693.8 g/km.

This was equivalent to a TTW GHG output of 695.7 g/km

This would result in a WTW (well to wheel) GHG level of 825.2 g/km.

WTW CO_2 target for a bus with a total passenger capacity of 56 passengers is 853.7 g/km

Overall Well-to-Wheel is 825.2 g/km.
Low Carbon Status: Pass

Appendix 3: Passenger Capacity vs. Greenhouse Gas Emissions (CO_2 equivalent)

LCEB 30% WTW GHG Emission Reduction Target in g/km vs. Maximum Passenger Capacity					
Passengers	g/km	Passengers	g/km	Passengers	g/km
22	640.2	61	885.1	100	1130.0
23	646.4	62	891.4	101	1136.3
24	652.7	63	897.6	102	1142.6
25	659.0	64	903.9	103	1148.8
26	665.3	65	910.2	104	1155.1
27	671.6	66	916.5	105	1161.4
28	677.8	67	922.8	106	1167.7
29	684.1	68	929.0	107	1174.0
30	690.4	69	935.3	108	1180.2
31	696.7	70	941.6	109	1186.5
32	703.0	71	947.9	110	1192.8
33	709.2	72	954.2	111	1199.1
34	715.5	73	960.4	112	1205.4
35	721.8	74	966.7	113	1211.6
36	728.1	75	973.0	114	1217.9
37	734.4	76	979.3	115	1224.2
38	740.6	77	985.6	116	1230.5
39	746.9	78	991.8	117	1236.8
40	753.2	79	998.1	118	1243.0
41	759.5	80	1004.4	119	1249.3
42	765.8	81	1010.7	120	1255.6
43	772.0	82	1017.0	121	1261.9
44	778.3	83	1023.2	122	1268.2
45	784.6	84	1029.5	123	1274.4
46	790.9	85	1035.8	124	1280.7
47	797.2	86	1042.1	125	1287.0
48	803.4	87	1048.4	126	1293.3
49	809.7	88	1054.6	127	1299.6
50	816.0	89	1060.9	128	1305.8
51	822.3	90	1067.2	129	1312.1
52	828.6	91	1073.5	130	1318.4
53	834.8	92	1079.8	131	1324.7
54	841.1	93	1086.0	132	1331.0
55	847.4	94	1092.3	133	1337.2
56	853.7	95	1098.6	134	1343.5
57	860.0	96	1104.9	135	1349.8
58	866.2	97	1111.2	136	1356.1
59	872.5	98	1117.4	137	1362.4
60	878.8	99	1123.7	138	1368.6

Valid for:

- MLTB test cycle only.
- Vehicles tested at: Mass of vehicle in running order (including 75kg driver), plus 25% of total passenger load.
- Passengers assumed to weigh 63kg each.
- "Maximum passenger capacity" = Stated capacity, OR (GVW - Mass of vehicle in running order)/63, whichever is the lower.

Appendix 4: Essential Characteristics of the Vehicle powered by a Conventional Powertrain

The following information, when applicable, shall be supplied.

If there are drawings, they shall be to an appropriate scale and show sufficient detail. They shall be presented in A4 format or folded to that format. In the case of microprocessor controlled functions, appropriate operating information shall be supplied.

1. GENERAL

1.1. Make (name of manufacturer):..
1.2. Type and commercial description (mention any variants): ....
1.3. Means of identification of type, if marked on the vehicle: ....
1.3.1. Location of that mark:...
1.4. Name and address of manufacturer:...
1.5. Name and address of manufacturer's authorized representative where appropriate:
1.6. Vehicle stabilization distance: ....

2. GENERAL CONSTRUCTION CHARACTERISTICS OF THE VEHICLE

2.1. Photographs and/or drawings of a representative vehicle:.....................
2.2. Powered axles (number, position, interconnection): ....

3. MASSES (kilograms) (refer to drawing where applicable)

3.1. Mass of the vehicle with bodywork in running order (including coolant, oils, fuel, tools, spare wheel and driver): ....
3.2. Technically permissible maximum laden mass as stated by the manufacturer:..
3.3. Vehicle test mass:...
3.4. Theoretical maximum passenger capacity (3.2. – 3.1.)/63:....................

4. DESCRIPTION OF POWER TRAIN AND POWER TRAIN COMPONENTS

4.1. **Internal combustion engine**
4.1.1. Engine manufacturer:
4.1.2. Manufacturer's engine code (as marked on the engine, or other means of identification):
4.1.2.1. Working principle: positive-ignition/compression-ignition, four-stroke/two-stroke 1/
4.1.2.2. Number and arrangement of cylinders:...
4.1.2.3. Engine capacity: 2/ ....cm^3
4.1.2.4. Maximum net power: …………. kW at ………………. min^{-1}
4.1.2.5. Maximum net torque:…………...Nm at ………………..min-1
4.1.3. Fuel type: …………..
4.1.4. Intake system:
4.1.4.1. Pressure charger: yes/no 1/
4.1.4.2 Charge-air cooler: yes/no 1/
4.1.5. Exhaust system
4.1.5.1. Description and drawings of the exhaust system:...
4.1.6. Lubricant used:
4.1.6.1. Make:...
4.1.6.2. Type:..

4.2. **Measures taken against air pollution**
4.2.1. Additional pollution control devices (if any, and if not covered by another heading:
4.2.1.1. Catalytic converter: yes/no 1/
4.2.1.1.1. Number of catalytic converters and elements:...
4.2.1.1.2. Dimensions and shape of the catalytic converter(s) (volume,...):.....................
4.2.1.1.3. Type of catalytic action:..
4.2.1.1.4. Regeneration systems/method of exhaust after-treatment systems, description:
4.2.1.1.5. The number of MLTB operating cycles, or equivalent engine test bench cycles, between two cycles where regenerative phases occur under the conditions equivalent to MLTB test. ....
4.2.1.1.6. Parameters to determine the level of loading required before regeneration occurs (i.e. temperature, pressure etc.):..
4.2.1.1.7. Description of method used to load system during the test: ....
4.2.1.2. Oxygen sensor: yes/no 1/
4.2.1.3. Air injection: yes/no 1/
4.2.1.3.1. Type (pulse air, air pump,...): ....
4.2.1.4. Exhaust gas recirculation (EGR): yes/no 1/
4.2.1.5. Evaporative emission control system: yes/no 1/
4.2.1.6. Particulate trap: yes/no 1/
4.2.1.6.1. Dimensions and shape of the particulate trap (capacity): ....
4.2.1.6.2. Type of particulate trap and design: ....
4.2.1.6.3. Location of the particulate trap (reference distances in the exhaust system):..
4.2.1.6.4. Regeneration system/method. Description and drawing:................................
4.2.1.6.5. The number of MLTB operating cycles, or equivalent engine test bench cycle, between two cycles where regeneration phases occur under the conditions equivalent to MLTB test:...
4.2.1.6.6. Parameters to determine the level of loading required before regeneration occurs (i.e. temperature, pressure, etc.):...
4.2.1.6.7. Description of method used to load system during the test: ....

4.3. **Internal combustion engine control unit**
4.3.1. Manufacturer: ....
4.3.2. Type: ....
4.3.3. Software Identification number: ....
4.3.4 Calibration identification number: ....

4.4. Transmission
4.4.1. Clutch (type): ....
4.4.1.1. Maximum torque conversion: ....
4.4.2. Gearbox:
4.4.2.1. Type:..
4.4.2.2. Location relative to the engine: ....
4.4.3. Control Unit:..
4.4.3.1. Type: ....
4.4.3.2. Software Identification number: ....
4.4.3.3. Calibration identification number: ....

5. <u>SUSPENSION</u>
5.1. Tyres and wheels
5.1.1. Tyre/wheel combination(s) (for tyres indicate size designation, minimum load-capacity index, minimum speed category symbol; for wheels, indicate rim size(s) and off-set(s):
5.1.1.1. Axle 1:...
5.1.1.2. Axle 2:...

5.1.1.3. Axle 3:..

5.1.1.4. Axle 4: etc. ....

5.1.2. Tyre pressure(s) as recommended by the manufacturer: .... kPa

6. BODYWORK

6.1. Seats:

6.1.1. Number of seats:

6.1.2. Number of standing passengers permitted

1/ Strike out what does not apply.

2/ This value must be calculated with π = 3.1416 and rounded to the nearest cm^3.

Appendix 5: Test Report and Approval

Note, only results from valid tests should be presented for approval

[Vehicle description and serial number] was submitted for accreditation as a Low Carbon Emission Bus on [date/month/year] by [supplier name and address]

The vehicle was tested to Low Carbon Emission Bus test protocol Annex A1: Test Procedure for Measuring Fuel Economy and Emissions of Low Carbon Emission Buses powered by Conventional Powertrains at [technical service carrying out test]

The bus was inspected by [name of inspector] of [name of accreditation organization]

The Essential Characteristics of the Vehicle are recorded in Appendix 4 of this document.

The test was witnessed by [name of inspector] of [name of accreditation organization]

Emissions results

Test Number	CO (g/km)	HC (g/km)	NOx (g/km)	PM (g/km)	CO_2 (g/km)	CH_4 (g/km)	N_2O (g/km)
Average							

Total Tank-to-Wheel GHG – CO_2 equivalent

CO_2 (g/km)	CH_4 (g/km ×21)	N_2O (g/km ×310)	Calculated TTW GHG (g/km)

Well-to-Wheel GHG – CO_2 equivalent

Test No.	Fuel Used Over Cycle (Litres)	Net Heating Energy (MJ/Litre)	Total Fuel Energy (MJ)	WTT Diesel GHG Equivalence Factor* (CO_2 Equivalent g/MJ)	Calculated WTT GHG Emissions (CO_2 Equivalent g/km)	Calculated WTW GHG Emissions (CO_2 Equivalent g/km)
Average						

Test Validity Check

Test No.	Total WTW GHG Emissions ($CO2_{equiv}$ g/km)	Variation from Average (%)
Average		

Well-to- Wheel Summary

Total Tank-to-Wheel GHG (g/km)	
Fuel Energy Consumption (MJ)	
Fuel type	
Fuel Well-to-Tank pathway value (g/MJ)	
Fuel Well-to-Tank GHG (g/km)	
Total Well-to-Wheel GHG (g/km)	
Target WTW for [passenger capacity of bus] Passengers (g/km)	
Approved as Low Carbon emission bus	Yes/No

Approval

Low Carbon Vehicle Partnership approves the following vehicle(s) as a Low Carbon Emission Bus for [number of passengers] and above

Manufacturer
Vehicle Type

Limitations

All vehicle characteristics to be as defined in Appendix 4 of this document