HEAVY-DUTY ARTICULATED 500,000-MILE BUS WITH A MINIMUM SERVICE LIFE OF 12 YEARS

6. FUEL ECONOMY TEST - A FUEL CONSUMPTION TEST USING AN APPROPRIATE OPERATING CYCLE

APRIL 2006

ABBREVIATIONS

ABTC	- Altoona Bus Test Center
A/C	- air conditioner
ADB	- advance design bus
CBD	- central business district
CI	- compression ignition
CNG	- compressed natural gas
CW	- curb weight (bus weight including maximum fuel, oil, and coolant; but without passengers or driver)
dB(A)	- decibels with reference to 0.0002 microbar as measured on the "A" scale
DIR	- test director
DR	- bus driver
EPA	- Environmental Protection Agency
FFS	- free floor space (floor area available to standees, excluding ingress/egress areas, area under seats, area occupied by feet of seated passengers, and the vestibule area)
FTA	- Federal Transit Administration
GAWR	- gross axle weight rating
GL	- gross load (150 lb for every designed passenger seating position, for the driver, and for each 1.5 sq ft of free floor space)
GVW	- gross vehicle weight (curb weight plus gross vehicle load)
GVWR	- gross vehicle weight rating
hr	- hour
LNG	- liquefied natural gas
mpg	- miles per gallon
mph	- miles per hour
NBM	- new bus models
PSBRTF	- Penn State Bus Research and Testing Facility
PTI	- Pennsylvania Transportation Institute
rpm	- revolutions per minute
SAE	- Society of Automotive Engineers
SCF	- standard cubic feet
SCFM	- standard cubic feet per minute
SCH	- test scheduler
SEC	- secretary
SI	- spark ignition
SLW	- seated load weight (curb weight plus 150 lb for every designed passenger seating position and for the driver)
TD	- test driver
TM	- track manager
TP	- test personnel

6-I. TEST OBJECTIVE

The objective of this test is to provide accurate comparable fuel consumption data on transit buses produced by different manufacturers. This fuel economy test bears no relation to the calculations done by the Environmental Protection Agency (EPA) to determine levels for the Corporate Average Fuel Economy Program. EPA's calculations are based on tests conducted under laboratory conditions intended to simulate city and highway driving. This fuel economy test, as designated here, is a measurement of the fuel expended by a vehicle traveling a specified test loop under specified operating conditions. The results of this test will not represent actual mileage but will provide data that can be used by recipients to compare buses tested by this procedure.

6-II. TEST DESCRIPTION

This test requires operation of the bus over a course based on the Transit Coach Operating Duty Cycle (ADB Cycle) at seated load weight using a procedure based on the Fuel Economy Measurement Test (Engineering Type) For Trucks and Buses: SAE 1376 July 82. The procedure has been modified by elimination of the control vehicle and by modifications as described below. The inherent uncertainty and expense of utilizing a control vehicle over the operating life of the facility is impractical.

The fuel economy test will be performed as soon as possible (weather permitting) after the completion of the GVW portion of the structural durability test. It will be conducted on the bus test lane at the PSBRTF. Signs are erected at carefully measured points which delineate the test course. A test run will comprise 3 CBD phases, 2 Arterial phases, and 1 Commuter phase. An electronic fuel measuring system will indicate the amount of fuel consumed during each phase of the test. The test runs will be repeated until there are at least two runs in both the clockwise and counterclockwise directions in which the fuel consumed for each run is within ± 4 percent of the average total fuel used over the 4 runs. A 20-minute idle consumption test is performed just prior to and immediately after the driven portion of the fuel economy test. The amount of fuel consumed while operating at normal/low idle is recorded on the Fuel Economy Data Form. This set of four valid runs along with idle consumption data comprise a valid test.

The test procedure is the ADB cycle with the following four modifications:

1. The ADB cycle is structured as a set number of miles in a fixed time in the following order: CBD, Arterial, CBD, Arterial, CBD, Commuter.

A separate idle fuel consumption measurement is performed at the beginning and end of the fuel economy test. This phase sequence permits the reporting of fuel consumption for each of these phases separately, making the data more useful to bus manufacturers and transit properties.

2. The operating profile for testing purposes shall consist of simulated transit type service at seated load weight. The three test phases (figure 6-1) are: a central business district (CBD) phase of 2 miles with 7 stops per mile and a top speed of 20 mph; an arterial phase of 2 miles with 2 stops per mile and a top speed of 40 mph; and a commuter phase of 4 miles with 1 stop and a maximum speed of 40 mph. At each designated stop the bus will remain stationary for seven seconds. During this time, the passenger doors shall be opened and closed.

3. The individual ADB phases remain unaltered with the exception that 1 mile has been changed to 1 lap on the PSBRTF track. One lap is equal to 5,042 feet. This change is accommodated by adjusting the cruise distance and time.

4. The acceleration profile, for practical purposes and to achieve better repeatability, has been changed to "full throttle acceleration to cruise speed".

Several changes were made to the Fuel Economy Measurement Test (Engineering Type) For Trucks and Buses: SAE 1376 July 82:

1. Sections 1.1, and 1.2 only apply to diesel, gasoline, methanol, and any other fuel in the liquid state (excluding cryogenic fuels).

   1.1 SAE 1376 July 82 requires the use of at least a 16-gal fuel tank. Such a fuel tank when full would weigh approximately 160lb. It is judged that a 12-gal tank weighing approximately 120 1b will be sufficient for this test and much easier for the test personnel to handle.

   1.2 SAE 1376 July 82 mentions the use of a mechanical scale or a flowmeter system. This test procedure uses a load cell readout combination that provides an accuracy of 0.5 percent in weight and permits on-board weighing of the gravimetric tanks at the end of each phase. This modification permits the determination of a fuel economy value for each phase as well as the overall cycle.

2. Section 2.1 applies to compressed natural gas (CNG), liquefied natural gas (LNG), cryogenic fuels, and other fuels in the vapor state.

   2.1 A laminar type flowmeter will be used to determine the fuel consumption. The pressure and temperature across the flow element will be monitored by the flow computer. The flow computer will use this data to calculate the gas flow rate. The flow computer will also display the flow rate (scfm) as well as the total fuel used (scf). The total fuel used (scf) for each phase will be recorded on the Fuel Economy Data Form.

3. Use both sections 1 and 2 for dual fuel systems.

6-III. TEST ARTICLE

The test article is a heavy-duty articulated transit bus with a minimum service life of 12 years or 500,000 mi.

6-IV. TEST EQUIPMENT

A. The following describes the equipment used for diesel, gasoline, methanol, and any other fuel in the liquid state (excluding cryogenic fuels).

Note: A fire extinguisher must be present during testing.

A fuel flow meter (shown in figure 6-2) is used to measure the fuel consumption. The fuel flow systems calculate fuel flow based on the known displacement of four precision engineered cylinders. Hall sensors located around the crankshaft transform each piston stroke into a pulse signal proportional to fuel consumption. A magnet integrated into the crankshaft works with the non-contact Hall sensors to produce the signals. A data acquisition computer is used to convert the Hall sensors signals to gallons of fuel used. A digital display is mounted on the windshield to display fuel used, speed, distance and test time. A thermocouple is placed inline with the fuel from the tank. The system consists of the following important components.

1. Corrsys-Datron DFL-1 Fuel Flow Meter (Gasoline)
2. Corrsys-Datron DFL-3 Fuel Flow Meter (Diesel)
3. Corrsys-Datron DAQ computer
4. Thermocouple and digital display

B. The following describes the equipment used for CNG, LNG, cryogenic fuels or any other fuel that is stored in the vapor state.

Note: A fire extinguisher must be present during testing.

The methods for storing CNG and LNG on-board a vehicle are vastly different; CNG is stored as a very high pressure gas, and LNG as a cryogenic liquid. These differences and the safety considerations associated with handling the stored fuels render gravimetric measurement systems for CNG and LNG impractical.

Although their methods of storage are quite different, both CNG and LNG systems deliver the fuel to the engine in the vapor state. This

procedure exploits this commonality between the two systems by using a flow measurement device in series with the fuel line, just prior to delivery to the engine. The flow measurement system uses a computer to compensate for pressure and temperature variations. The flow computer uses the ideal gas law to calculate and display the flow rate in standard cubic feet per minute (SCFM) and total fuel consumed in standard cubic feet (SCF). The system consists of the following important components:

1. Laminar flow element: AccuRa Flow Element Model LFE-0100/40 scfm
2. Differential Pressure Transducer: Viatran Model 574-24-0
3. Flow Computer
4. RTD Temperature Sensor

6-V. FACILITIES/PERSONNEL

The fuel economy test is performed on the bus lane of the PSBRTF. This test requires the following personnel:

1. Test driver (TD)
2. Test personnel (TP)

6-VI. TEST PREPARATION AND PROCEDURES

All vehicles are prepared for testing in accordance with the Fuel Economy Pre-Test Maintenance Form. This is done to ensure that the bus is tested in optimum operating condition. The manufacturer-specified preventive maintenance shall be performed before this test. Any manufacturer-recommended changes to the pre-test maintenance procedure must be noted on the revision sheet. The Fuel Economy Pre-Test Inspection Form will also be completed before making a test run. Both the Fuel Economy Pre-Test Maintenance Form and the Fuel Economy Pre-Test Inspection Form are found on the following pages.

Warm-up consists of driving the bus for one hour on the bus lane at the PSBRTF. The course layout is defined by green, yellow, and red signs for accelerate, decelerate, and stop points respectively; while different shaped signs delineate the Commuter, Arterial, and CBD cycles of the test. The test personnel coaches the driver through the course along with recording cycle run times, fuel temperature, fuel consumption data, and weather conditions using the Fuel Economy Data Form.

All buses are tested at SLW. The base line fuel economy data are obtained at the following conditions:

1. Air conditioning off
2. Evaporator fan or ventilation fan on
3. Seated load weight
4. Appropriate test fuel with energy content (BTU/LB) noted on Fuel Economy Data Form
5. Exterior and interior lights on
6. Heater Pump Motor off
7. Defroster off
8. Windows and Doors closed

The test tanks or the bus fuel tank(s) will be filled prior to the fuel economy test with the appropriate grade of test fuel. The fuel economy test is started adjacent to the entrance of the bus lane with the front of the bus aligned with the white triangular sign. After the cycle is complete, the total fuel used will be recorded on the Fuel Economy Data Form.

See figures 6-1, 6-2, and 6-3, and the three forms, which follow.

6-VI. FUEL ECONOMY CALCULATION PROCEDURE

A. For diesel, gasoline, methanol and fuels in the liquid state.

The reported fuel economy is based on the following: measured test quantities--distance traveled (miles) and fuel consumed (pounds); standard reference values--density of water at 60•F (8.3373 lbs/gal) and volumetric heating value of standard fuel; and test fuel specific gravity (unitless) and volumetric heating value (BTU/gal). These combine to give a fuel economy in miles per gallon (mpg) which is corrected to a standard gallon of fuel referenced to water at 60•F. This eliminates fluctuations in fuel economy due to fluctuations in fuel quality. This calculation has been programmed into a computer and the data processing is performed automatically.

The fuel economy correction consists of three steps:

1.) Divide the number of miles of the phase by the number of pounds of fuel consumed

phase	miles per phase	total miles per run
CBD	1.9097	5.7291
ART	1.9097	3.8193
COM	3.8193	3.8193

$$\mathbf{FEo_{mi/lb}} = \text{Observed fuel economy} = \frac{\text{miles}}{\text{lb of fuel}}$$

2.) Convert the observed fuel economy to miles per gallon [mpg] by multiplying by the specific gravity of the test fuel Gs (referred to water) at 60•F and multiply by the density of water at 60•F

$$\mathbf{FEo_{mpg}} = \mathbf{FEc_{mi/lb}} \times Gs \times Gw$$

where **Gs** = Specific gravity of test fuel at 60•F (referred to water)
Gw = 8.3373 lb/gal

3.) Correct to a standard gallon of fuel by dividing by the volumetric heating value of the test fuel (H) and multiplying by the volumetric heating value of standard reference fuel (Q). Both heating values must have the same units.

$$\mathbf{FEc} = \mathbf{FEo_{mpg}} \times \frac{Q}{H}$$

where

H = Volumetric heating value of test fuel [BTU/gal]
Q = Volumetric heating value of standard reference fuel

Combining steps 1-3 yields

$$\Rightarrow \quad FEc = \frac{\text{miles}}{\text{lbs}} \times (Gs \times Gw) \times \frac{Q}{H}$$

4.) Covert the fuel economy from mpg to an energy equivalent of miles per BTU. Since the number would be extremely small in magnitude, the energy equivalent will be represented as miles/BTUx10^6.

Eq = Energy equivalent of converting mpg to mile/BTUx10^6.

$$Eq = ((mpg)/(H))x10^6$$

B. CNG, LNG, cryogenic and other fuels in the vapor state.

The reported fuel economy is based on the following: measured test quantities--distance traveled (miles) and fuel consumed (scf); density of test fuel, and volumetric heating value (BTU/lb) of test fuel at standard conditions (P=14.73 psia and T=60 •F). These combine to give a fuel economy in miles per lb. The energy equivalent (mile/BTUx10^6) will also be provided so that the results can be compared to buses that use other fuels.

1.) Divide the number of miles of the phase by the number of standard cubic feet (scf) of fuel consumed.

phase	miles per phase	total miles per run
CBD	1.9097	5.7291
ART	1.9097	3.8193
COM	3.8193	3.8193

$$\mathbf{FEo_{mi/scf}} = \text{Observed fuel economy} = \frac{\text{miles}}{\text{scf of fuel}}$$

2.) Convert the observed fuel economy to miles per lb by dividing FEo by the density of the test fuel at standard conditions (Lb/ft^3).

Note: The density of test fuel must be determined at standard conditions as described above. If the density is not defined at the above standard conditions, then a correction will be needed before the fuel economy can be calculated.

$$\mathbf{FEo}_{mi/lb} = FEo / Gm$$

where Gm = Density of test fuel at standard conditions

3.) Convert the observed fuel economy (FEomi/lb) to an energy equivalent of (miles/BTUx10^6)by dividing the observed fuel economy (FEomi/lb) by the heating value of the test fuel at standard conditions.

$$Eq = ((FEomi/lb)/H)x10^6$$

where Eq = Energy equivalent of miles/lb to mile/BTUx10^6
H = Volumetric heating value of test fuel at standard conditions

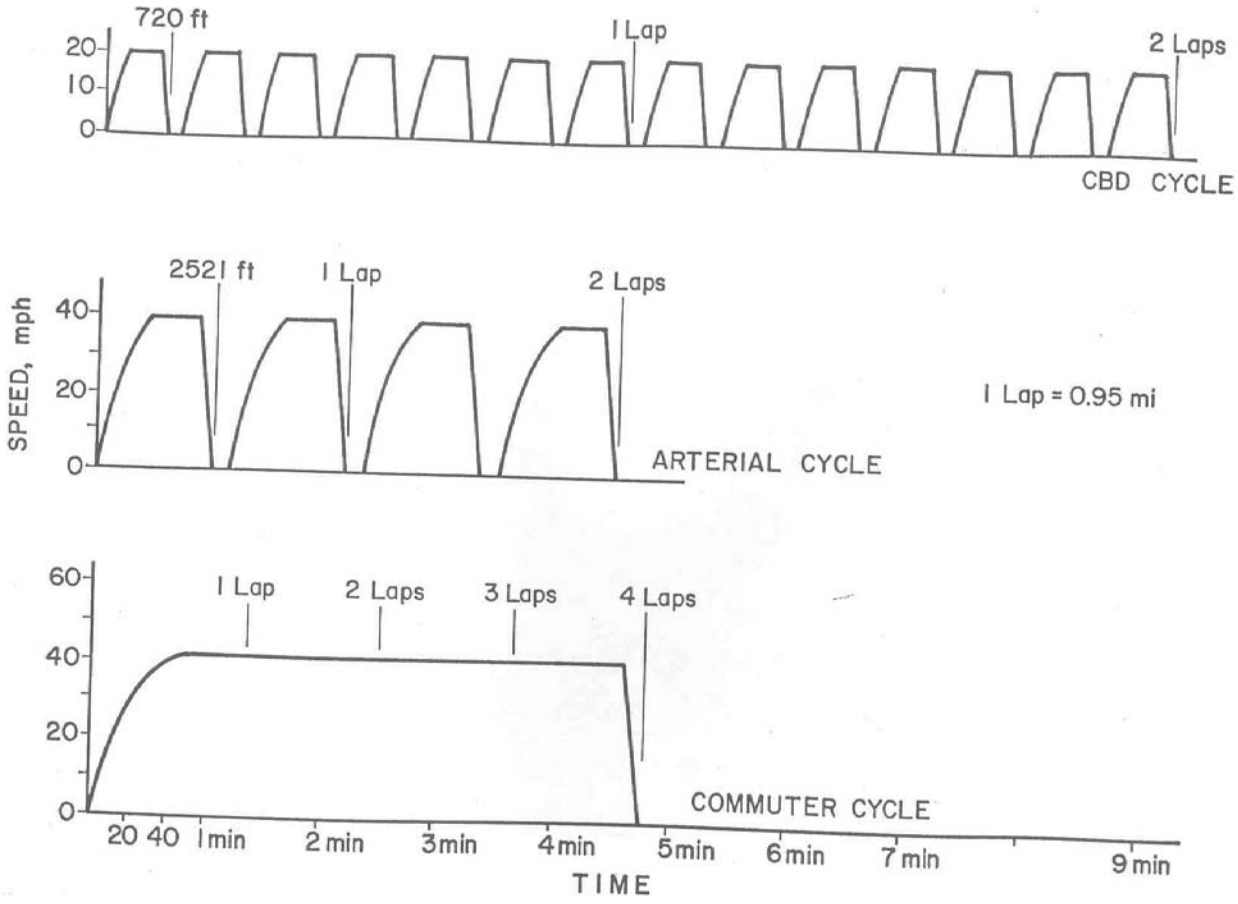
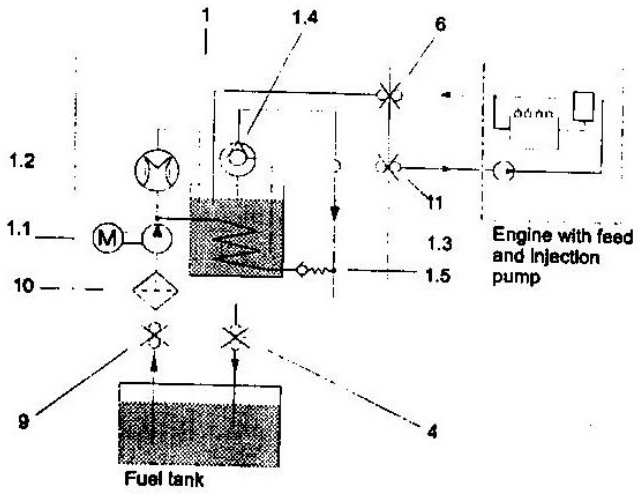
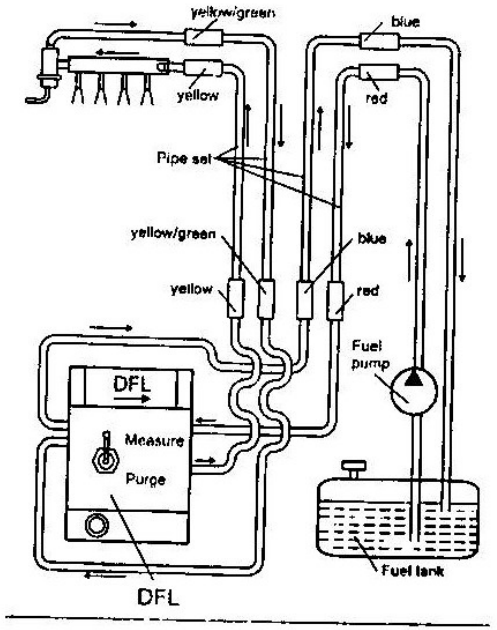


Figure 6-1. Bus Operating Profile.

DIESEL FUEL TEST



GAS



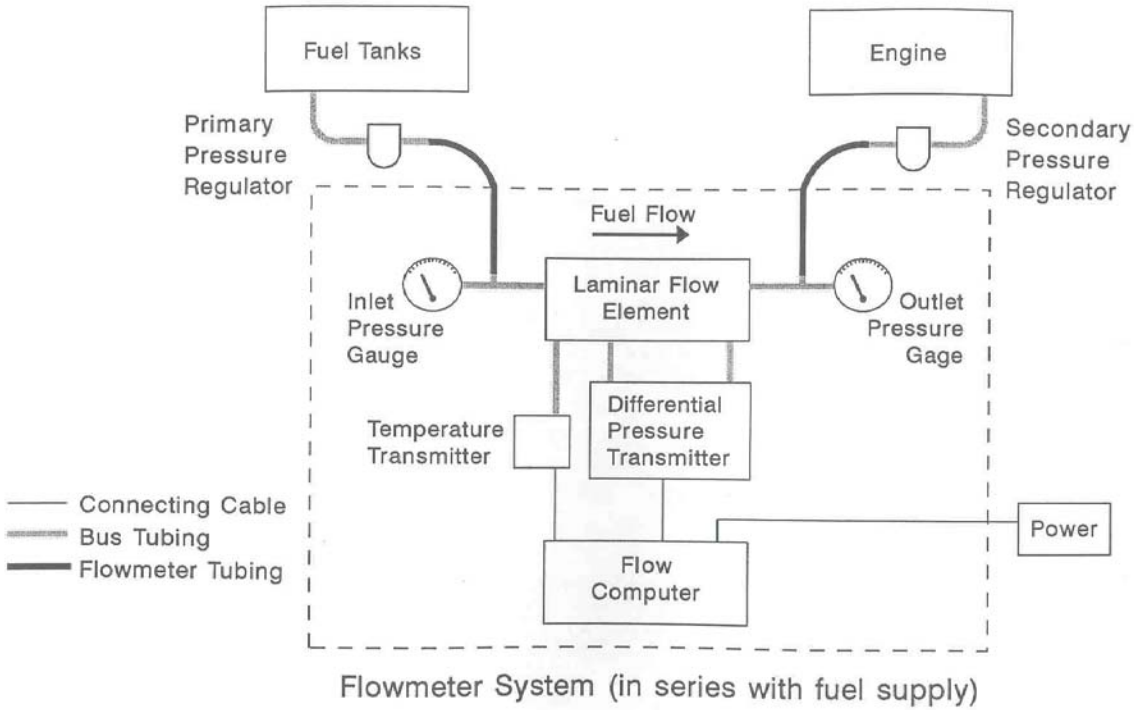


Figure 6-3. Gaseous Fuel Test Schematic.

FUEL ECONOMY PRE-TEST MAINTENANCE FORM

Bus Number:	Date:	SLW (lbs):
Personnel:		

FUEL SYSTEM	OK	Date	Initials
Install fuel measurement system			
Replace fuel filter			
Check for fuel leaks			
Specify fuel type (refer to fuel analysis)			
Remarks:			
BRAKES/TIRES	OK	Date	Initials
Inspect hoses			
Inspect brakes			
Relube wheel bearings			
Check tire inflation pressures (mfg. specs.)			
Remarks:			
COOLING SYSTEM	OK	Date	Initials
Check hoses and connections			
Check system for coolant leaks			
Remarks:			

FUEL ECONOMY PRE-TEST MAINTENANCE FORM (page 2)

Bus Number:	Date:
Personnel:	

ELECTRICAL SYSTEMS	OK	Date	Initials
Check battery			
Inspect wiring			
Inspect terminals			
Check lighting			
Remarks:			
DRIVE SYSTEM	OK	Date	Initials
Drain transmission fluid			
Replace filter/gasket			
Check hoses and connections			
Replace transmission fluid			
Check for fluid leaks			
Remarks:			
LUBRICATION	OK	Date	Initials
Drain crankcase oil			
Replace filters			
Replace crankcase oil			
Check for oil leaks			
Check oil level			
Lube all chassis grease fittings			
Lube universal joints			
Replace differential lube including axles			
Remarks:			

FUEL ECONOMY PRE-TEST MAINTENANCE FORM (page 3)

Bus Number:	Date:
Personnel:	

EXHAUST/EMISSION SYSTEM	OK	Date	Initials
Check for exhaust leaks			
Remarks:			

ENGINE	OK	Date	Initials
Replace air filter			
Inspect air compressor and air system			
Inspect vacuum system, if applicable			
Check and adjust all drive belts			
Check cold start assist, if applicable			
Remarks:			

STEERING SYSTEM	OK	Date	Initials
Check power steering hoses and connectors			
Service fluid level			
Check power steering operation			
Remarks:			

	OK	Date	Initials
Ballast bus to seated load weight			

TEST DRIVE	OK	Date	Initials
Check brake operation			
Check transmission operation			
Remarks:			

FUEL ECONOMY PRE-TEST INSPECTION FORM

Bus Number:	Date:
Personnel:	

PRE WARM-UP	If OK, Initial
Fuel Economy Pre-Test Maintenance Form is complete	
Cold tire pressure (psi): Front____ Middle____ Rear____	
Tire wear: less than 50%	
Engine oil level	
Engine coolant level	
Interior and exterior lights on, evaporator fan on	
Fuel economy instrumentation installed and working properly.	
Fuel line -- no leaks or kinks	
Speed measuring system installed on bus. Speed indicator installed in front of bus and accessible to TP and Driver.	
Bus is loaded to SLW	
WARM-UP	**If OK, Initial**
Bus driven for at least one hour warm-up	
No extensive or black smoke from exhaust	
POST WARM-UP	**If OK, Initial**
Warm tire pressure (psi): Front____ Middle____ Rear____	
Environmental conditions Average wind speed <12 mph and maximum gusts <15 mph Ambient temperature between 30EF(-1EC) and 90EF(32EC) Track surface is dry Track is free of extraneous material and clear of interfering traffic	

DETAILED TEST PROCEDURES		TITLE: 6. Fuel Economy
Procedure 6-1		**NOMENCLATURE: 6. Fuel Economy Test – A Fuel Consumption Test Using and Appropriate Operating Cycle**
OPER STEP	**ACTION BY**	**TEST PROCEDURE: For diesel, gasoline, methanol an other fuels in the liquid state.**
		NOTE: Keep fire extinguisher at hand during test.
1	TD	Drive the bus to the white, triangle sign. Align the front bumper of the bus with the sign.
2	TD/TP	Check that all windows and vents are closed. Driver's window may be open.
3	TD	Set the Bus Accessories as follows: 1. Air conditioning compressor OFF 2. Ventilation fans ON HIGH 3. Heater Pump Motor OFF 4. Defroster OFF 5. Exterior and Interior Lights ON 6. Windows and Doors CLOSED
4	TP	Record the starting fuel temperature(20-minute idle section).
5	TP	Operate the bus for 20 minutes at low idle. After 20 minutes, measure and record the finish temperature and fuel used on LCD.
6	TD	Record starting times, fuel temperature, and fuel used for CBD phase.
7	TP	Signal TD to begin the first, 2-lap CBD (square sign) phase.
8	TD	On signal, accelerate at full throttle to reach 20 mph. Cruise at 20 mph until the yellow, square sign. At the yellow sign, smoothly decelerate to a complete stop at the red square sign. Open and close passenger doors while idling for 7 seconds.
9	TP	Repeat step 10 for remainder of 2 laps.

DETAILED TEST PROCEDURES		TITLE: 6. Fuel Economy
Procedure 6-1		**NOMENCLATURE: 6. Fuel Economy Test – A Fuel Consumption Test Using An Appropriate Operating Cycle (continued)**
OPER STEP	**ACTION BY**	**TEST PROCEDURE: For diesel, gasoline, methanol and other fuels in the liquid state.**
10	TP	After 7-second idle at white sign, at end of 2 laps, record the time.
11	TP	Immediately record fuel temperature and fuel used.
12	TP	Reset clock. Signal TD to begin first, 2-lap, ART (diamond sign) phase.
13	TD	On signal, accelerate at full throttle to reach 40 mph. Cruise at 40 mph until the yellow, diamond sign. At the yellow sign, smoothly decelerate to a complete stop at the red diamond sign. Open and close passenger doors while idling for 7 seconds.
14	TD	Repeat step 16 for remainder of 2-lap ART phase.
15	TP	After 7-second idle at white sign at end of 2 laps, record the time.
16	TP	Immediately record finish fuel temperature and fuel used.
17	TP/TD	Repeat CBD phase, steps 8-13.
18	TP/TD	Repeat ART phase, steps 14-19.

DETAILED TEST PROCEDURES		TITLE: 6. Fuel Economy
Procedure 6-1		**NOMENCLATURE: 6. Fuel Economy Test - A Fuel Consumption Test Using An Appropriate Operating Cycle (continued)**
OPER STEP	**ACTION BY**	**TEST PROCEDURE: For diesel, gasoline, methanol and other fuels in the liquid state.**
19	TP/TD	Repeat CBD phase, steps 8-13.
20	TP	Record the fuel starting temperature and fuel used for the COM phase.
21	TP	Start clock, and signal TD to begin 4-lap, COM (hexagonal sign) phase.
22	TD	On signal, accelerate at full throttle to reach 40 mph. Cruise for 4 laps at 40 mph until the yellow, hexagonal sign. At the yellow sign, begin decelerating to a complete stop at the white sign. Open and close passenger doors while idling for 7 seconds.
23	TP	Immediately record finish time, fuel temperature, and fuel used.
24	TP	Total the times and fuel used during the CBD, ART, and COM phases.
25	TD/TP	Repeat steps 1-27 in the opposite direction around the track. Continue alternating steps 1-27 in a clockwise and a counterclockwise direction until a minimum of two runs in each direction are within $\pm$ 4 percent of the total average fuel used.
26	TP	Repeat idle consumption test, steps 6-7.

DETAILED TEST PROCEDURES		TITLE: 6. Fuel Economy
Procedure 6-2		NOMENCLATURE: 6. Fuel Economy Test – A Fuel Consumption Test Using An Appropriate Operating Cycle
OPER STEP	ACTION BY	TEST PROCEDURE: For CNG, LNG, cryogenic fuels, and other fuels stored in the vapor state
		NOTE: Keep fire extinguisher at hand during test.
1	TP	Turn on the flow meter system and press the "Total" button on the flow computer.
2	TD	Drive the bus to the white triangle sign. Align the front of the bus with the sign.
3	TD/TP	Check that all doors, windows and vents are closed. Driver's window may be open.
4	TD	Set the Bus Accessories as follows: 1. Air conditioning compressor OFF 2. Ventilation fans ON HIGH 3. Heater Pump Motor OFF 4. Defroster OFF 5. Exterior and Interior Lights ON 6. Windows and Doors CLOSED
5	TP	Press and hold the "Program" button on the flow computer until the "t" is displayed. Record the fuel temperature. Confirm that the flow computer is in the totalize mode by pressing the "Total" button. Press the "Reset" button on the flow computer, and start the clock for the first 20 minute idle.
6	TD/TP	At the end of the 20 min idle record the total fuel used (SCF) on the Fuel Economy Data Form. Press the "Rate" button on the flow computer. Record the flowrate (SCFM) at idle and at full throttle with the buses transmission in neutral/park. Press the "Total" button on the flow computer to re-enter the totalize mode. **NOTE: When in the totalize mode, depressing the depressing the reset button will reset the total to zero and will immediately begin totalizing.**
7	TP	Record starting times. Press and hold the "Program" button on the flow computer and record the fuel temperature.

DETAILED TEST PROCEDURES		TITLE: 6. Fuel Economy
Procedure 6-2		NOMENCLATURE: 6. Fuel Economy Test – A Fuel Consumption Test Using An Appropriate Operating Cycle (continued)
OPER STEP	ACTION BY	TEST PROCEDURE: For CNG, LNG, cryogenic fuels, and other fuels stored in the vapor state
8	TP	Simultaneously press the "Reset" button on the flow computer, start clock, and signal TD to begin the first, 2-lap CBD (square sign) phase.
9	TD	On signal, accelerate at full throttle to reach 20 mph. Cruise at 20 mph until the yellow square sign. At the yellow sign, smoothly decelerate to a complete stop at red square sign. Open and close the passenger door while idling for 7 seconds.
10	TD	Repeat step 10 for remainder of 2 laps.
11	TP	After 7-second idle at white sign, at end of 2 laps, record the total fuel used (SCF) from the display on the flow computer. Record the cycle time.
12	TP	Press and hold the "Program" button on the flow computer and record the fuel temperature for the ART phase.
13	TP	Simultaneously press the "Reset" button on the flow computer, start clock, and signal TD to begin first, 2-lap, ART (diamond sign) phase.
14	TD	On signal, accelerate at full throttle to reach 40 mph. Cruise at 40 mph until the yellow, diamond sign. At the yellow sign, smoothly decelerate to a complete stop at the red, diamond sign. Open and close the passenger door while idling for 7 seconds.
15	TD	Repeat step 14 for remainder of 2-lap ART phase.
16	TP	After 7-second idle at white sign at end of 2 laps, record the total fuel used (SCF) from the flow computer. Record the cycle time.
17	TP	Press and hold the "Program" button on the flow computer and record the fuel temperature for the second CBD phase.
18	TP	Simultaneously press the "Reset" button on the flow computer, start clock, and signal TD to begin the second 2-lap CBD phase.

DETAILED TEST PROCEDURES		TITLE: 6. Fuel Economy
Procedure 6-2		**NOMENCLATURE: 6. Fuel Economy Test - A Fuel Consumption Test Using An Appropriate Operating Cycle (continued)**
OPER STEP	**ACTION BY**	**TEST PROCEDURE: For CNG, LNG, cryogenic fuels, and other fuels stored in the vapor state**
19	TP/TD	Repeat 9-11 for the second CBD phase.
20	TP	Press and hold the "Program" button on the flow computer and record the fuel temperature for the second ART phase.
21	TP/TD	Repeat 13-16 for the second ART phase.
22	TP	Press and hold the "Program" button on the flow computer and record the fuel temperature for the third CBD phase.
23	TP/TD	Repeat 9-11 for the third CBD phase.
24	TP	Press and hold the "Program" button on the flow computer and record the fuel temperature for the COM phase.
25	TP	Simultaneously press the "Reset" button the flow computer, start clock and signal TD to begin 4-lap, COM (hexagonal sign) phase.
26	TD	On signal, accelerate at full throttle to reach 40 mph. Cruise for 4 laps at 40 mph until the yellow, hexagonal sign. At the yellow sign, smoothly decelerate to a complete stop at the white sign. Open and close the passenger door while idling for 7 seconds.
27	TP	After 7 second idle at white sign, record the total fuel used (SCF) from the display on the flow computer. Record the cycle time.
28	TP	Total the fuel used during the CBD, ART, and COM phases.
29	TD/TP	Repeat steps 1-28 in the opposite direction around the track. Continue alternating steps 1-28 in a clockwise and a counterclockwise direction until a minimum of two runs in each direction are within $\pm$4 percent of the total average fuel used.
30	TP	Repeat idle consumption test, steps 5-6.

REVISIONS

All revisions to this test procedure must be identified on this page. Briefly describe each revision in the space provided below.

Revision	Description	Date	Approval

FUEL ECONOMY DATA FORM (Liquid Fuels)

Bus Number:	Manufacturer:	Date:
Run Number:	Personnel:	
Test Direction: GCW or GCCW	Temperature (EF):	Humidity (%):
SLW (lbs):	Wind Speed (mph) & Direction:	Barometric Pressure (in.Hg):

Cycle Type	Time (min:sec)		Cycle Time (min:sec)	Fuel Temperature (EC)	gallons		Fuel Used (gals)
	Start	Finish		Start	Start	Finish	
CBD #1							
ART #1							
CBD #2							
ART #2							
CBD #3							
COMMUTER							
						Total Fuel =	gls

20 minute idle : Total Fuel Used = gls
Heating Value = BTU/LB
Comments:

FUEL ECONOMY DATA FORM (Gaseous Fuels)

Bus Number:	Manufacturer:	Date:

Run Number:	Personnel:	
Test Direction: GCW or GCCW	Ambient Temperature (EF):	Humidity (%):
SLW (lbs):	Wind Speed (mph) & Direction:	Barometric Pressure (in.Hg):

Cycle Type	Run Time (min:sec)		Cycle Time (min:sec)	Fuel Temperature (EF)	Total Fuel Used (SCF)
	Start	Finish		Start	
CBD #1					
ART #1					
CBD #2					
ART #2					
CBD #3					
COMMUTER					
Total Fuel: SCF					

20 minute idle : Total Fuel Used = SCF	
No Load Flow Rate at Idle = SCFM	No Load Flow Rate at Full Throttle = SCFM
Heating Value = BTU/LB	
Comments:	