FTA
Federal Transit Administration
FTA TRANSIT BUS EMISSIONS TESTING PROGRAM

FTA Transit Bus Emissions Brake &Testing NPRM Workshop

Proposed Emissions Testing Protocol

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Why is this emissions testing program being established?

To meet the requirements of legislation (ISTEA-1991) requiring emissions testing of all new model transit buses procured with Federal funding.

The principal output of the program is a report documenting objective results of each bus test.

There are no minimum performance criteria

There are no pass/fail determinations

What are the objectives of the emissions test program?

- To provide objective, accurate, reproducible and comparable emissions data for transit buses.
- To provide emissions results that are verifiable according to a standardized protocol.
- Data are primarily intended for use during the bus procurement process.

How might the results be used?

- Evaluation and comparison of emissions characteristics for bus procurement activities

- Use in application process for grants and funding for emissions reduction programs

- Comparative evaluation of emissions for local air quality regulations and programs

- Atmospheric emissions inventory modeling initiatives and research

How does this emissions test relate to testing required by the EPA?

- Performed in addition to FMVSS and EPA requirements

- Measures emissions performance of complete integrated vehicles rather than just the engine

- Results bear no direct relation to the engine certification test mandated by EPA.

Why is this test needed if bus engines are already EPA certified?

- EPA certification tests do not characterize emissions advantages that manufacturers may achieve through hybrid drive systems, drivetrain design or well engineered bus integration.

- EPA certification data, in units of g/bhp-hr, are not useful for evaluating bus emissions for procurement decisions.

- Engine certification data are not readily available to the transit agencies.

What emissions will be measured?


- Oxides of Nitrogen (NOx)


- Carbon Monoxide (CO)


- Total Hydrocarbons (THC)


- Methane & Non-methane Hydrocarbons (NMHC) for buses fueled with CNG or LNG


- Particulate Matter (PM)


- Carbon Dioxide (CO_2)


- Fuel consumption (mpg) - reported as diesel energy equivalent during the emissions test cycles

Data Quality Objectives

The goal of the test program is to provide emissions data that can be used compare different bus technology options for procurement decisions.

To accomplish this goal the data must be:

- Of high accuracy that is quantifiable
- Acquired by consistent procedures for all vehicles tested
- Accuracy and consistency will guarantee repeatable results test-to-test, day-to-day and vehicle-to-vehicle

What methods were considered?

- Portable emissions measurement on closed test track
  - Cannot control ambient conditions
  - Cannot measure particulate emissions with required accuracy

- Chassis dynamometer with laboratory grade instrumentation
  - Controlled and repeatable test conditions
  - Superior accuracy

How will the test be conducted?

- Performed on a chassis dynamometer

- Emissions measured following guidance of 40 CFR Part 86

- Heavy-duty buses tested over two cycles
  - Manhattan Cycle (from SAE J2711)
  - Orange County Bus Cycle (from SAE J2711)

- Buses tested at ½ seated passenger load

- Consistent test fuels

Where will the test be performed?

- Protocol was developed for use at the PTI chassis dynamometer facility in State College PA

- Initially the WVU Transportable Emissions Laboratory may perform the testing until PTI emissions laboratory is fully functional.

- Protocol could also be followed at other dynamometer facilities equipped with:
  - A chassis dynamometer capable of simulating transient inertial, aerodynamic and rolling resistance.
  - Emissions measurement equipment referenced in 40 CFR Part 86 and/or Part 1065.

What equipment will be used?

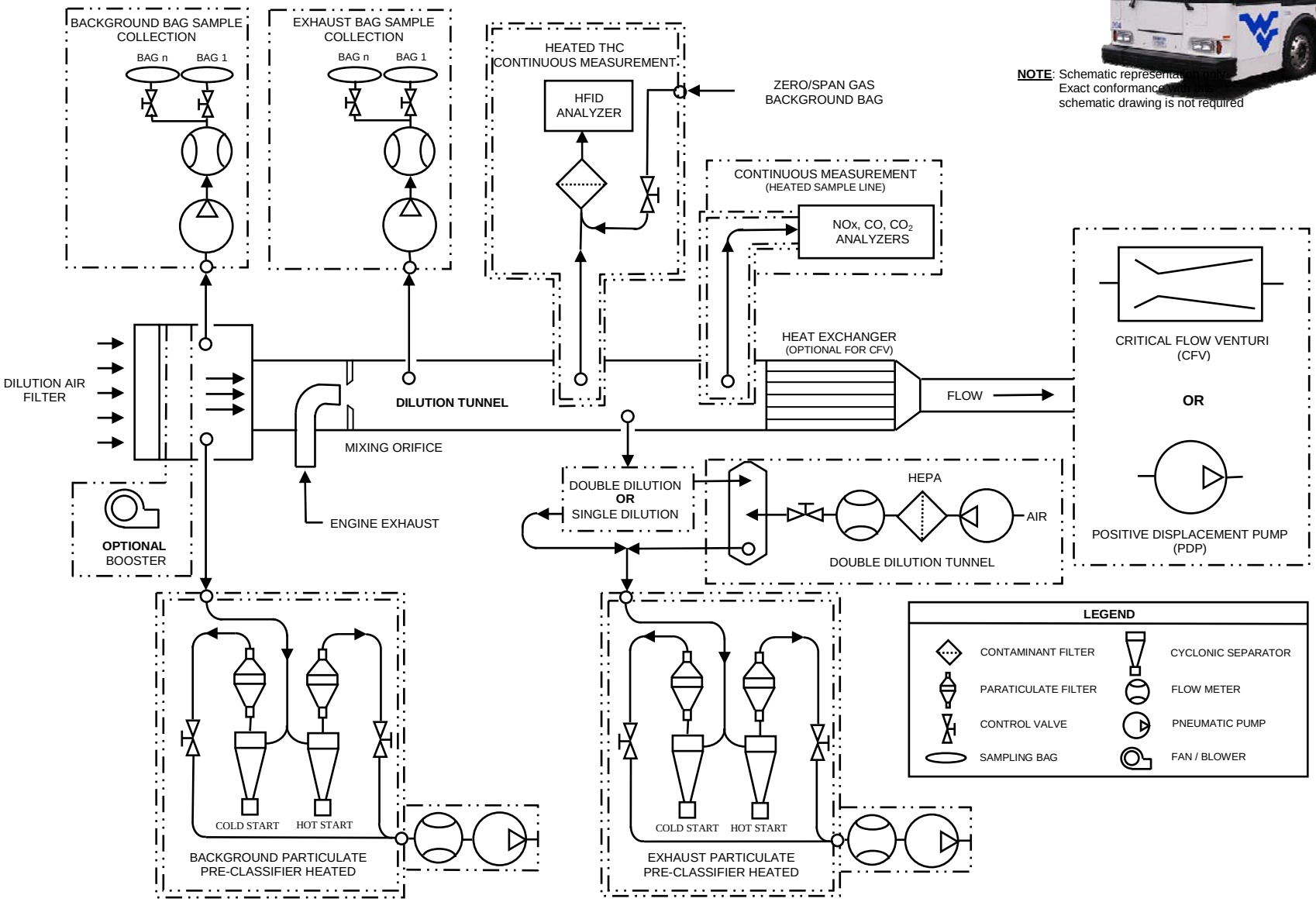
Chassis Dynamometer

- Capable of duplicating inertial, road and aerodynamic loads associated with operating the vehicle in real use.
- Simulate inertial loads during both acceleration and deceleration throughout full speed regime of test cycles

Exhaust Dilution System

- Compliant with 40 CFR Part 86 for 2007 and newer vehicles
- Full-exhaust dilution tunnel
- Constant volume sampling system using one of the following
  - Critical Flow Venturi with heat exchanger
  - Positive Displacement Pump with heat exchanger,
  - Subsonic Venturi with electronic flow compensation
- HEPA filtered dilution air for PM measurement

NOTE: Schematic representation only. Exact conformance with this schematic drawing is not required



Gaseous Emissions

- THC – heated flame ionization detector HFID

- CH_4 – GC analysis of integrated bag samples

- CO/CO_2 – non-dispersive infrared (NDIR)

- NOx – chemiluminescent analyzer
  - All measurement made following requirements of 40 CFR Part 86 Subpart N
  - Emissions will be background corrected levels of constituents in the ambient dilution air

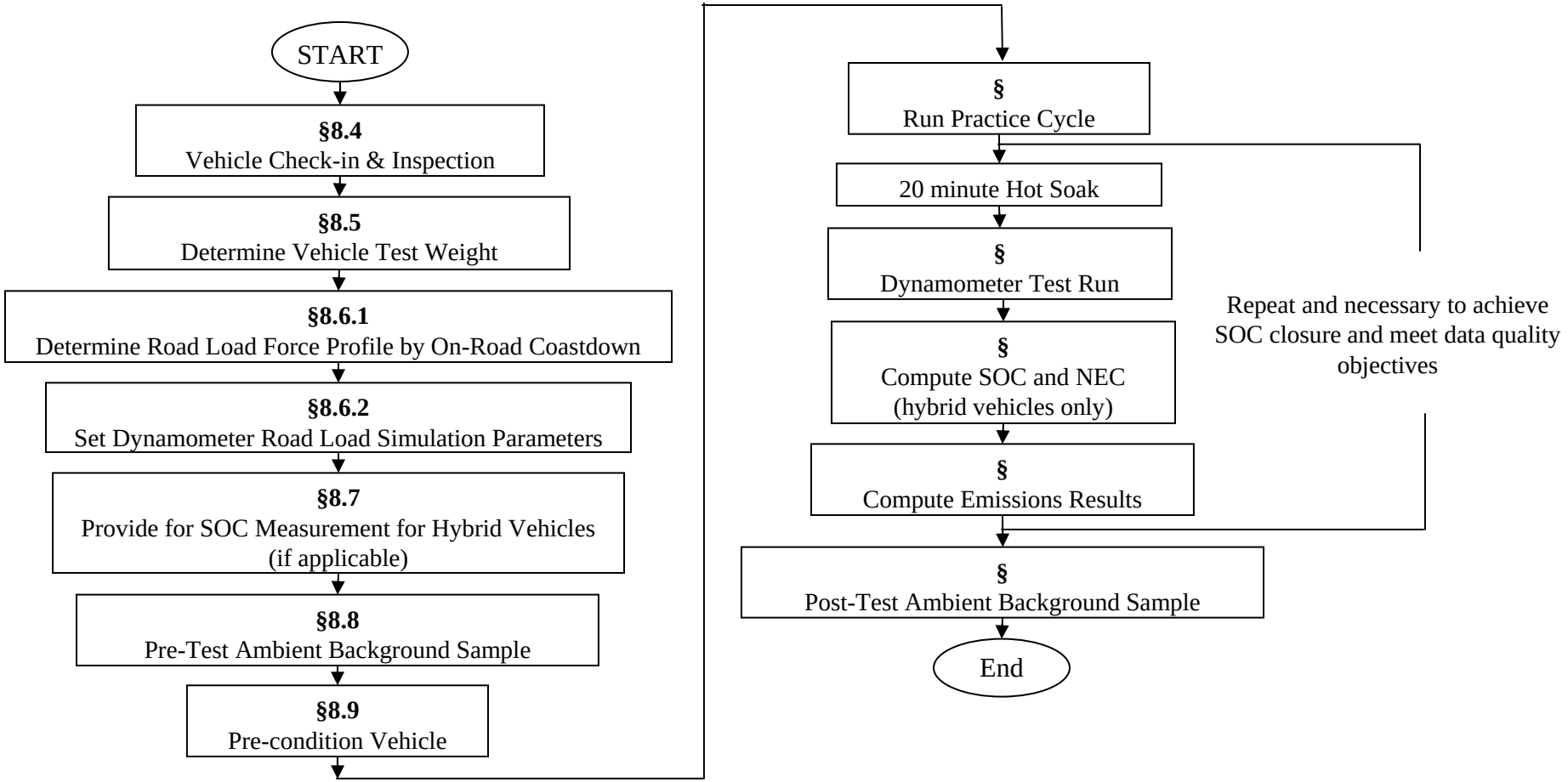
Particulate Emissions

- Proportional double diluted sample collected on PM collection filters
  - Sample maintained at 117°F ± 9F at filter face
  - Particle preclassifier with cut point particle diameter between 2.5 and 10 µm to remove coarse mechanically generated particles.
  - Environmentally controlled clean room maintained at 71.6 ± 5.4°F and dew point of 49.1 ± 1.8F required for PM sample conditioning and weighing

What fuels will be used?

- For repeatability and comparability of the results, consistent fuels need to but used
- Fuels meeting the specifications of 40 CFR Part 86 Subpart N are proposed
  - Gasoline: 40 CFR 86.1313-2004
  - Diesel Fuel: 40 CRF 86.1313-2007
  - CNG/LNG: 40 CFR 86.1313-98
  - LPG: ASTM D2163-91
  - Ethanol: To be defined later
  - Hydrogen: To be defined later

Test Sequence



Vehicle Configuration for Testing

The intent is to test the bus in the configuration/calibration in which it will be offered for sale.

Hybrid system, transmission and drive system calibrations should representative of the production model.

Emissions tests will be conducted with configuration/calibration as fuel economy and performance tests

FTA is seeking input related to vehicle configuration/calibration during testing.

Vehicle Configuration for Testing

- Test with HVAC system turned off

- Test with interior and exterior lighting switched off.

- Traction control and ABS system modified to achieve normal operation of vehicle systems on the dynamometer

- Transmission operated in manner consistent with in-use operation

Vehicle Test Weight

- Emissions testing will be performed at a simulated vehicle weight representing ½ seated passenger load.

$$Inertial\ Weight = curb\ weight + 150 + \frac{1}{2}(seated\ \ passenger\ load) * (150)\ lb$$

- This test weight is different from the weight used for other PTI tests but is consistent with industry standard practice for emissions testing

Road Load Determination

- Vehicle road load force will be determined by the coastdown method on a road way or test track following guidelines of SAE J2263.

- Road load retarding force will be simulated on the dynamometer following guidelines of SAE J2264.

- Road load will be verified by matching the on-road coast down with a coast down on the dynamometer

State of Charge for Hybrid Buses

- Emission results for hybrid buses will be corrected for State of Charge of the on-board ESS.

- State of Charge Correction Procedures from SAE J2711.

- The protocol specifies pre-conditioning procedures for each type of ESS

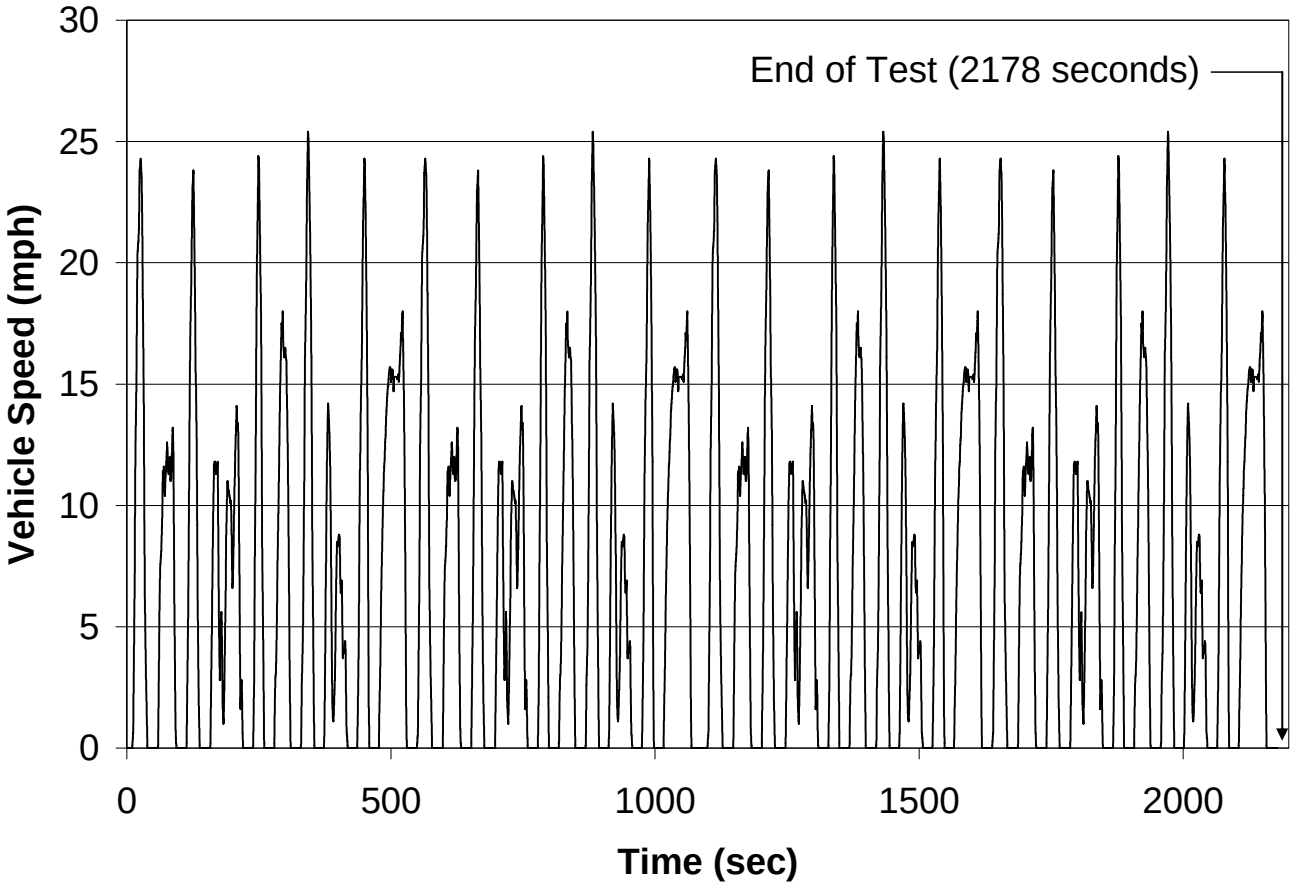
Drive Cycles

- Each bus will be tested on two drive cycles
  - Manhattan Cycle
  - Orange County Bus Cycle

	Average Speed (mph)	Stdev of Speed	Max Speed	Idle Time (sec)	Number of Idle Periods
Manhattan x2	6.83	7.34	25.3	786	41
OCTA	12.33	10.3	40.63	406	30

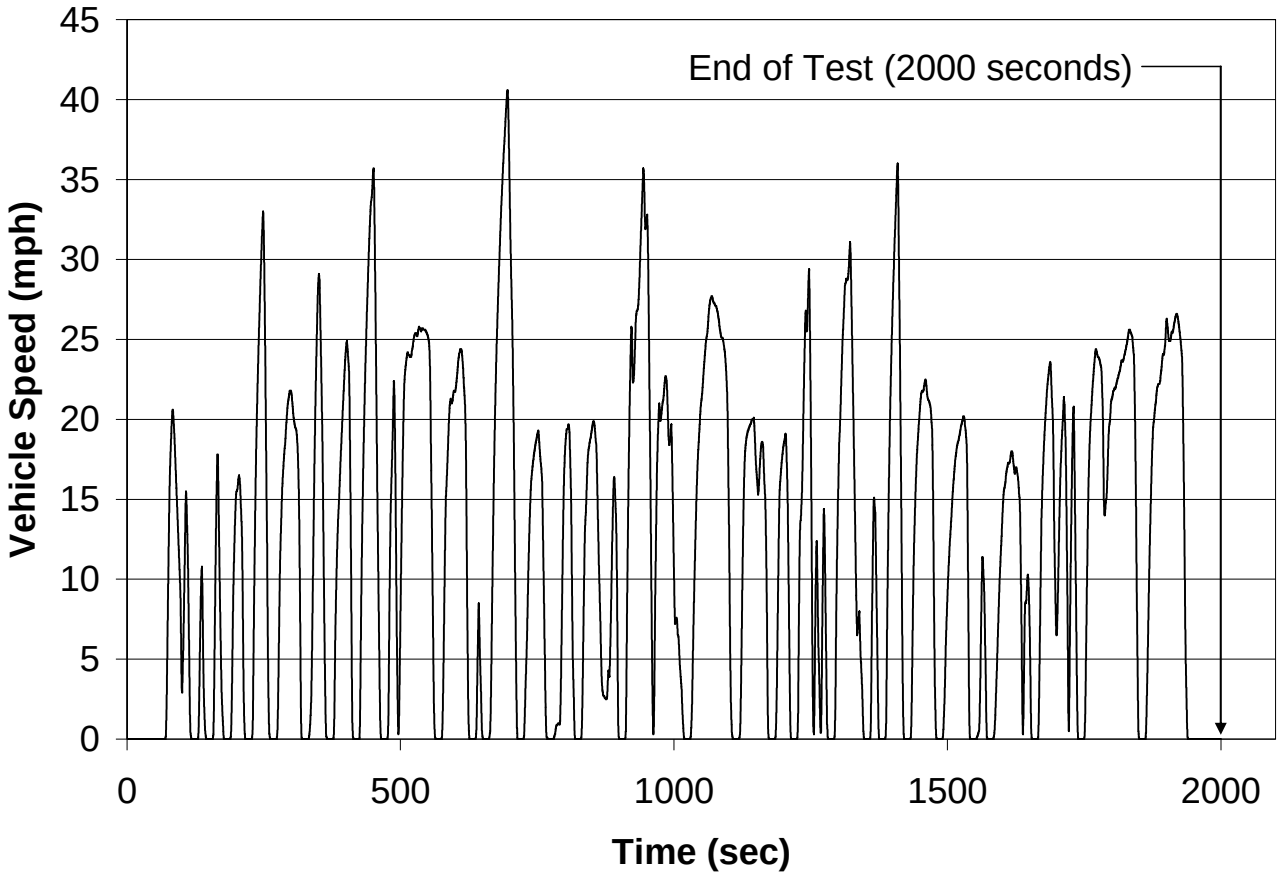
Drive Cycles

Manhattan x 2



Drive Cycles

Orange County Bus Cycle



Data Post Processing

- Emissions results will be computed according to the equations in 40 CFR Part 86 Subpart N

- SOC correction of emissions results for hybrid buses will be performed according to SAE J2711.

Partial Testing Criteria

- Partial testing provisions will reduce the testing requirements for bus models that have completed full testing but are subsequently produced with major changes in configuration or components.

- Partial testing may be required when changes made to a bus are expected to produce significantly different data.

- Consistent with current policy, partial testing determinations will be made on a case-by-case basis.

Partial Testing Criteria

- FTA seeks comments "major changes" that would require previously-tested buses to undergo the emissions test.
- Examples may include:
  - A change to a different engine
  - A major chance in calibration of the engine transmission, or hybrid system
  - A change in the type of fuel
  - A major change in engine out emissions or emissions control system, in-cylinder combustion control, EGR or aftertreatment devices.
  - A major change to drive axle ratios

Discussion Topics

- General Questions & Discussion

- Applicability of emissions testing for different classes of buses.

- Phase in for various classes of bus.

- Bus configuration/calibration during emission testing

- Partial emissions testing criteria

- Discussion on brake testing

Additional Slides

General Information

- Test protocol designed primarily for use at PTI for testing new model transit buses
- But generally applicable for chassis dynamometer testing of transit buses for other purposes at other facilities
- Protocol should not conflict with other accepted testing practices such as SAE J2711, 40 CFR, the pending EPA SmartWay protocol.

Test Fuel Specifications

- Gasoline

Item	Units	ASTM Test Method	Value
Octane, Research, min.		D2699	-
Sensitivity, min.			7.5
Lead (organic), max.	g/US gal (g/liter)	D3237	0.050 (0.013)
Distillation Range	°F (°C)	D86	
IBP			75-95 (23.9-35)
10% point			120-135 (48.9-57.2)
50% point			200-230 (93.3-110)
90% point			300-325 (148.9-162.8)
EP			415 (212.8)
Sulfur	wt. %	D1266	0.0015-0.008
Phosphorous, max	g/US gal (g/liter)	D3231	0.005 (0.0013)
Reid Vapor Pressure,	psi (kPa)	D323	8.7-9.2 (60.0-63.4)
Hydrocarbon Composition		D1319	
Olefins, max.	%		10
Aromatics, max.	%		35
Saturates			Remainder

Test Fuel Specifications

- Diesel Fuel

Item	Units	ASTM Test Method	Type 1-D	Type 2-D
Cetane Number		D613	40-54	40-50
Cetane Index		D976	40-54	40-50
Distillation Range	°F (°C)	D86		
IBP			330-390 (165.6-198.9)	340-400 (171.1-204.4)
10% Point			370-430 (187.8-221.1)	400-460 (204.4-237.8)
50% Point			410-480 (210.0-248.9)	470-540 (243.3-282.2)
90% Point			460-520 (237.8-271.1)	560-630 (293.3-332.2)
EP			500-560 (260.0-293.3)	610-690 (321.1-365.6)
Gravity	°API	D287	40-44	32-37
Total Sulfur	ppm	D2622	7-15	7-15
Hydrocarbon Composition				
Aromatics, min.[1]	%	D5186	8	27
Flashpoint, min.	°F (°C)	D93	120 (48.9)	130 (54.4)
Viscosity	centistokes	D445	1.6-2.0	2.0-3.2

Test Fuel Specifications

- Natural Gas

Item	Units	ASTM Test Method	Value
Methane, min.	mole %	D1945	89.0
Ethane, max.	mole %	D1945	4.5
C_3 and higher, max.	mole %	D1945	2.3
C_6 and higher, max.	mole %	D1945	0.2
Oxygen, max	mole %	D1945	0.6
Inert gases: Sum of CO_2 and N_2, max	mole %	D1945	4.0
Odorant[1]			