

# **FEDERAL TRANSIT BUS TEST**

**Performed for the Federal Transit Administration U.S. DOT  
In accordance with 49 CFR, Part 665**

## **Altoona Bus Testing and Research Center Test Bus Procedure**

### **8. EMISSIONS TEST – DYNAMOMETER-BASED EMISSIONS TEST USING TRANSIT DRIVING CYCLES**

Pass/Fail  
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**LTI BUS RESEARCH  
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## 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
LTI	Larson Transportation Institute
mpg	Miles per gallon
mph	Miles per hour
NBM	New bus models
PSTT	Penn State Test Track
rpm	Revolutions per minute
SAE	Society of Automotive Engineers
SCF	Standard cubic feet
SCFM	Standard cubic feet per minute
SCH	Test scheduler
SA	Staff Assistant
SI	Spark ignition
SLW	Seated load weight (curb weight plus 150 lb. for every designated passenger seating position and for the driver)
TD	Test driver
TM	Track manager
TP	Test personnel

## **8-I. TEST OBJECTIVE**

The objective of this test is to provide comparable emissions data on transit buses produced by different manufacturers. This chassis-based emissions test bears no relation to engine certification testing performed for compliance with the Environmental Protection Agency (EPA) regulation. EPA's certification tests are performed using an engine dynamometer operating under the Federal Test Protocol. This emissions test is a measurement of the gaseous engine emissions CO, CO<sub>2</sub>, NO<sub>x</sub>, HC and particulates (diesel vehicles) produced by a vehicle operating on a large-roll chassis dynamometer. The test is performed for three differed driving cycles intended to simulate a range of transit operating environments. The cycles consist of Manhattan Cycle, the Orange County Bus driving cycle, and the Urban Dynamometer Driving Cycle (UDDS) and the test is performed under laboratory conditions in compliance with EPA 1065 and SAE J2711. The results of this test may not represent actual in-service vehicle emissions but will provide data that can be used by recipients to compare buses tested under different operating conditions.

## **8-II. TEST DESCRIPTION**

This test is performed in the emissions bay of the LTI Vehicle Testing Laboratory. The Laboratory is equipped with a Schenk Pegasus 300 HP, large-roll (72 inch diameter) chassis dynamometer suitable for heavy-vehicle emissions testing. The dynamometer is located in the end test bay and is adjacent to the control room and emissions analysis area. The emissions laboratory provides capability for testing heavy-duty diesel and alternative-fueled buses for a variety of tailpipe emissions including particulate matter, oxides of nitrogen, carbon monoxide, carbon dioxide, and hydrocarbons. It is equipped with a Horiba full-scale CVS dilution tunnel and emissions sampling system. The system includes Horiba Mexa 7400 Series gas analyzers and a Horiba HF47 Particulate Sampling System. Test operation is automated using Horiba CDTCS software. The computer controlled dynamometer is capable of simulating over-the-road operation for a variety of vehicles and driving cycles.

The emissions test will be performed as soon as permissible after the completion of the GVW portion of the structural durability test. The driving cycles are the Manhattan cycle, a low average speed, highly transient urban cycle (Figure 1), the Orange County Bus Cycle which consists of urban and highway driving segments (Figure 2), and the EPA UDDS Cycle (Figure 3). An emissions test will comprise of two runs for the three different driving cycles, and the average value will be reported. Test results reported will include the average grams per mile value for each of the gaseous emissions for gasoline buses, for all the three driving cycles. In addition, the particulate matter emissions are included for diesel buses, and non-methane hydrocarbon emissions (NMHC) are included for CNG buses. Testing is performed in accordance with EPA CFR49, Part 1065 and SAE J2711 as practically determined by the FTA Emissions Testing Protocol developed by West Virginia University and Penn State University.

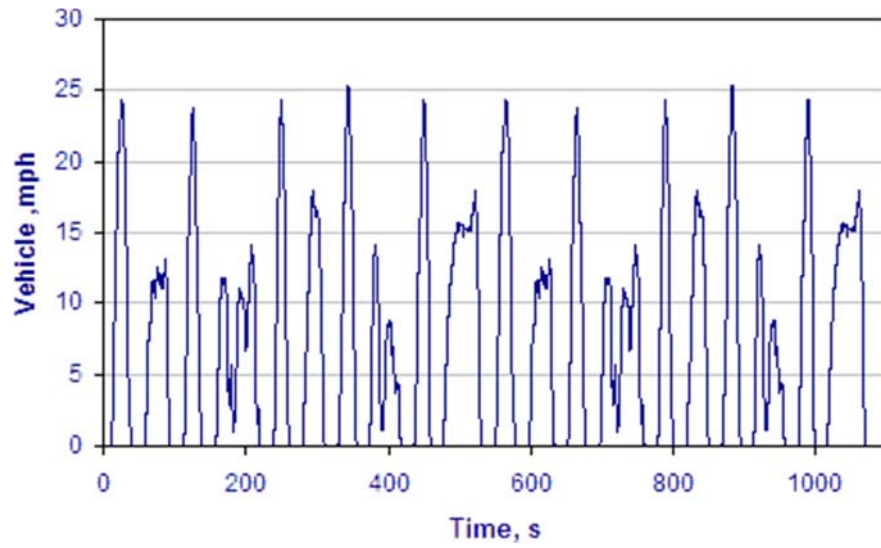


Figure 1. Manhattan Driving Cycle (duration 1089 sec, Maximum speed 25.4 mph, average speed 6.8 mph)

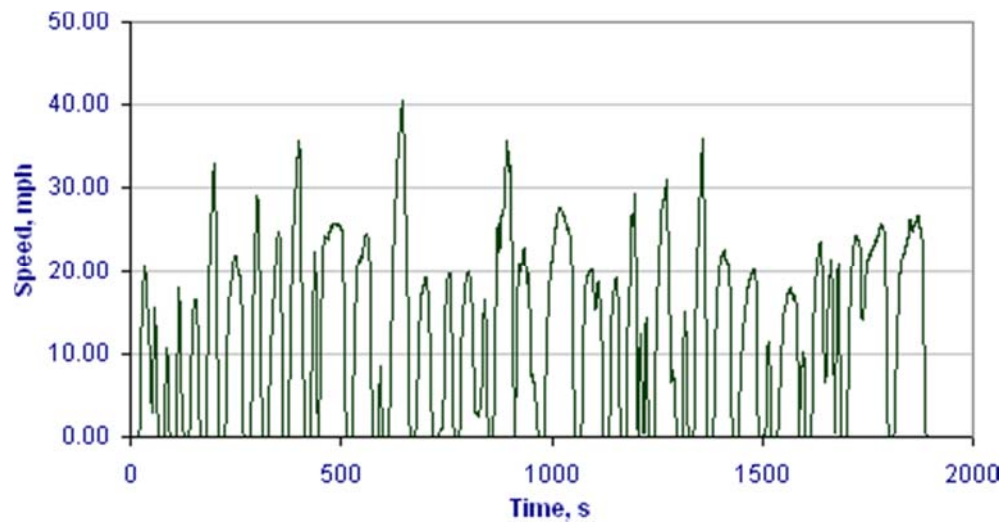


Figure 2. Orange County Bus Cycle (Duration 1909 Sec, Maximum Speed 41 mph, Average Speed 12 mph).

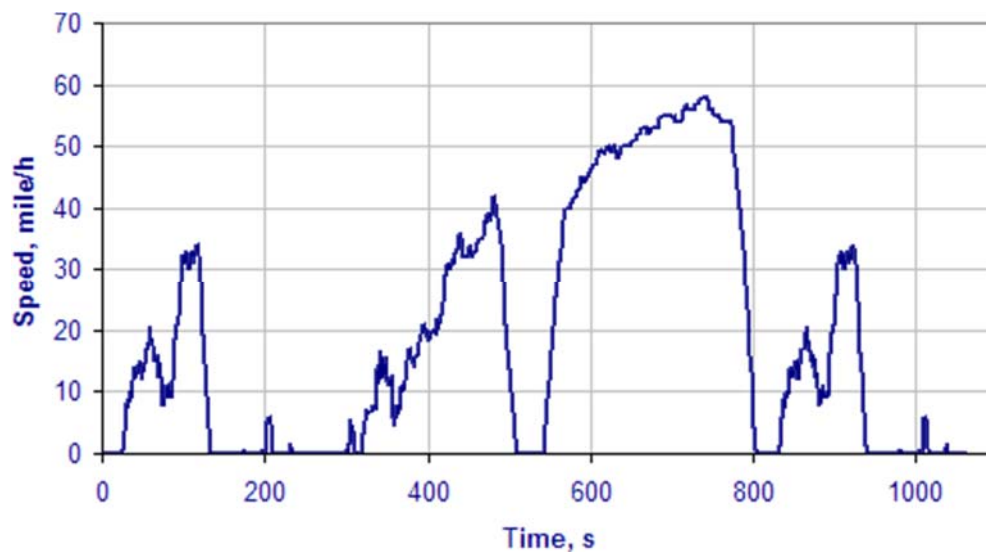


Figure 3. HD-UDDS Cycle (duration 1060 seconds, Maximum Speed 58 mph, Average Speed 18.86 mph).

### 8-III. TEST ARTICLE

The test article is a transit bus.

### 8-IV. TEST EQUIPMENT

Testing is performed in the LTI Vehicle Testing Laboratory emissions testing bay. The test bay is equipped with a Schenk Pegasus 72-inch, large-roll chassis dynamometer. The dynamometer is electronically controlled to account for vehicle road-load characteristics and for simulating the inertia characteristics of the vehicle. Power to the roller is supplied and absorbed through an electronically controlled 3-phase ac motor. Absorbed power is dumped back onto the electrical grid.

Vehicle exhaust is collected by a Horiba CVS, full-flow dilution tunnel. The system has separate tunnels for diesel and gasoline/natural gas fueled vehicles. In the case of diesel vehicles, particulate emissions are measured gravimetrically using 47 mm Teflon filters. These filters are housed in a Horiba HF47 particulate sampler, per EPA 1065 test procedures. Heated gaseous emissions of hydrocarbons and NO<sub>x</sub> are sampled by Horiba heated oven analyzers. Gaseous emissions for CO, CO<sub>2</sub> and cold NO<sub>x</sub> are measured using a Horiba Mexa 7400 series gas analyzer. System operation, including the operation of the chassis dynamometer, and all calculations are controlled by a Dell workstation running Horiba CDCTS test control software. Particulate Filters are weighed in a glove box using a Sartorius microbalance accurate to microgram.

### 8-V. TEST PREPARATION AND PROCEDURES

All vehicles are prepared for emissions testing in accordance with the Fuel Economy Pre-Test Maintenance Form. (In the event that fuel economy test was performed immediately prior to emissions testing, this step does not have to be repeated). This is done to ensure that the bus is tested in optimum operating condition. The manufacturer-specified preventative maintenance shall be performed before this test. The ABS system and when applicable, the regenerative braking system are disabled for operation on

the chassis dynamometer. 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 performing.

Prior to performing the emissions test, each bus is evaluated to determine its road-load characteristics using coast-down techniques in accordance with SAE J1263. This data is used to program the chassis dynamometer to accurately simulate over-the-road operation of the bus.

Warm-up consists of driving the bus for 20 minutes at approximately 40 mph on the chassis dynamometer. The test driver follows the prescribed driving cycle watching the speed trace and instructions on the Horiba Drivers-Aid monitor which is placed in front of the windshield. The CDCTS computer monitors driver performance and reports any errors that could potentially invalidate the test.

All buses are tested at seated load weight. The base line emissions data are obtained at the following conditions:

1. Air conditioning off
2. Evaporator fan or ventilation fan on
3. Bus at seated load weight
4. Appropriate test fuel with energy content (BTU/LB) noted in CDTCS software
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.