

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

**4.1 PERFORMANCE - AN ACCELERATION, GRADEABILITY,
AND TOP SPEED TEST**

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

4-I. TEST OBJECTIVE

The objective of this test is to determine the acceleration, gradeability, and top speed capabilities of the bus.

4-II. TEST DESCRIPTION

In this test, the bus will be operated at SLW on a smooth and level test track. The bus will be accelerated at full throttle from a standstill to a maximum "geared", maximum "governed", or maximum "safe" speed not exceeding 50 mph. The maximum "geared" speed is defined as the limited output capabilities of the test vehicle's engine and drivetrain. The maximum "governed" speed, if applicable, is the top speed as limited by the engine control system. The maximum "safe" speed is defined as the maximum speed that the test course can be traveled without jeopardizing the safety of the test vehicle or its passengers. The test vehicle speed will be measured using a fifth wheel or a non-contacting speed measurement system. The time intervals between 10 mph increments will be measured and recorded using a stopwatch with a lap timer. Time and speed data will be recorded on the performance data form. The recorded data will be used to generate a speed vs time plot and a percent grade versus speed curve. When applicable, the "governed" speed will be recorded. The "ungoverned" speed will be predicted using a hyperbolic curve fit method. The hyperbolic curve fit method will use the speed and time data to extrapolate and to predict the top "ungoverned" speed.

4-III. TEST ARTICLE

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

4-IV. TEST EQUIPMENT/FACILITIES/PERSONNEL

1. Test Equipment
 - a. A fifth wheel or non-contacting speed and distance measurement system
 - b. Ballast to simulate passenger loading (SLW)
 - c. Digital stopwatch with lap timer

2. Test Facility - The test site is located at the PSBRTF on the skid pad area and adjoining curves for run in and run out. The test site must meet the following conditions:
 - a. Dry and free of extraneous surface material

- b. Free of interfering traffic
- c. Wind speed gusting less than 12 mph
- d. Ambient temperature between 30E F and 90E F

3. Test Personnel - The PSBRTF personnel consist of the following:

- a. Test driver (TD)
- b. Test personnel (TP)

4-V. TEST DATA

The test data consist of the completed attached Performance Data Form. Upon completion of this test, data shall be forwarded to the ABTC manager.

4-VI. TEST PREPARATION AND PROCEDURES

The detailed test preparation and procedures are listed in procedure 4-1. This section also includes Performance Data Form - 4.

DETAILED TEST PROCEDURES		TITLE: 4. Performance
Procedure 4-1		NOMENCLATURE: 4. Performance - An Acceleration, Gradeability, and Top Speed Test
OPER STEP	ACTION BY	TEST PREPARATION
1	TP	Record the bus number, date, and persons performing the test on the data sheet. Retrieve work order form for this test.
2	TP	Install the speed measuring system on the bus at the correct position. Install speed indicator in the front of the bus so it is visible to TP.
3	TP	Load the bus to SLW minus the weight of TP, TD, and equipment.
4	TD	Drive the bus at least three times around the PSBRTF test track at approximately 45 mph.
5	TP	Record the environmental data on the data form. Make sure the road surface is dry and clean. Make sure the temperature is between 30° and 90° F and wind less than 12 mph. If not, delay the test until such time the conditions are favorable.
6	TD	<p>Set the bus accessories as follows:</p> <ol style="list-style-type: none"> 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 <p>The driver's window may be left open for comfort. During cold weather, the defroster can be run between tests, but not during test. During warm weather, the A/C may be run between tests, but no during the test.</p>

7	TP	Confirm that all preparations have been completed properly.
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DETAILED TEST PROCEDURES		TITLE: 4. Performance
Procedure 4-1		NOMENCLATURE: 4. Performance - An Acceleration, Gradeability, and Top Speed Test
OPER STEP	ACTION BY	TEST PROCEDURE
1	TP	Turn on the speed measuring instrumentation.
2	TD	With the bus at SLW, drive the bus to the East end of the vehicle dynamics area of the PSBRTF. Position the bus facing west at the beginning of the skid pad. Align front of bus at the pre-designated starting point for the clockwise direction.
3	TP	Reset stopwatch, signal driver to begin test when ready.
4	TD	When the technician signals that he is ready, begin full acceleration from a complete stop. Accelerate at maximum throttle in the bus lane along the skid pad. Continue accelerating along the skid pad until the bus reaches maximum geared speed, maximum safe speed, or maximum governed speed. If maximum geared speed cannot be obtained, continue around the track at a safe speed and enter the skid pad at the last 10mph increment previously obtained and the same gear that was used prior to exiting the skid pad. Accelerate along the skid pad to the next higher 10 mph increment. Decelerate and continue around the track to the beginning of the skid pad; come to a complete stop.
5	TP	Start the stopwatch at the exact moment the bus begins accelerating. Record the elapsed time between 10 mph hour increments on the Performance Data Form.
6	TP/TD	Repeat steps 3 thru 5 twice driving in the same direction (total of three runs). Make sure the starting point is the same for each run.
7	TP/TD	Reverse direction and repeat steps 3 thru 6. Again, start the test with the bus positioned at the predetermined starting point for the counter clockwise direction.
8	TP	Indicate whether the maximum speed was "geared", "governed", or "safe" at the bottom of the test data form.
9	SEC	Using the performance computer program, calculate the average time to each speed for each direction from the six test runs and the gradeability calculations.

10	SEC	Using the output from the performance computer program, generate speed vs time plot and the percent grade versus speed curve. Return the output from the performance computer program and plots to ABTC manager.
11	TP	Remove all test instrumentation not needed for future tests.

REVISIONS

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

Revision	Description	Date	Approval
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PERFORMANCE DATA FORM

Bus Number:		Date:	
Personnel:			
Temperature (EF):		Humidity (%):	
Wind Direction:		Wind Speed (mph):	
Barometric Pressure (in.Hg):			
Air Conditioning compressor-OFF		_____ Checked	
Ventilation fans-ON HIGH		_____ Checked	
Heater pump motor-Off		_____ Checked	
Defroster-OFF		_____ Checked	
Exterior and interior lights-ON		_____ Checked	
Windows and doors-CLOSED		_____ Checked	
ACCELERATION, GRADEABILITY, TOP SPEED			
Counter Clockwise Recorded Interval Times			
Speed	Run 1	Run 2	Run 3
10 mph			
20 mph			
30 mph			
40 mph			
Top Test Speed (mph)			
Clockwise Recorded Interval Times			
Speed	Run 1	Run 2	Run 3
10 mph			
20 mph			
30 mph			
40 mph			
Top Test Speed (mph)			

The maximum governed speed (mph) obtained from the manufacturer: _____ mph