

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

**3. SAFETY - A DOUBLE-LANE CHANGE  
(OBSTACLE AVOIDANCE 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

### 3-I. OBJECTIVE

The objective of this test is to determine handling and stability characteristics of the bus by measuring the forward speed through a double lane change, obstacle avoidance, course.

### 3-II. TEST DESCRIPTION

The safety test consists of performing an obstacle avoidance maneuver to evaluate the handling and stability characteristics of a bus. The test is conducted at the PSBRTF on the vehicle dynamics pad. The bus will be driven through a double-lane change course at increasing speeds until the test is determined to be unsafe or a speed of 45 mph is reached. The test will be determined unsafe if the vehicle handling becomes unstable or if any of the tires break contact with the pavement surface.

The layout of the test course will be defined by placing pylons along painted guide lines. The guide lines will mark off two 12 ft center to center lanes with two 100 ft gates, 100 ft apart. The bus will enter the test course in one lane, crossover to the other lane within the 100 ft gate spacing, travel for 100 ft, and then return to the original lane within the next 100 ft gate. This maneuver will be performed standing from both the right-hand and left-hand lanes. The layout of the test course is illustrated in Figure 3.1.

A test run is considered valid if the bus is able to perform the maneuver at a constant speed without deviating from the test course or striking pylons. If the test driver is not able to successfully complete the maneuver because of vehicle instability, the test will be terminated. The highest speed, up to a maximum of 45 mph, at which the maneuver can be successfully performed, will be recorded on the Safety Data Form.

### 3-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.

### 3-IV. TEST EQUIPMENT/FACILITIES/PERSONNEL

#### 1. Test Equipment

- a. A fifth wheel or non-contacting speed and distance
- b. Ballast to simulate passenger loading to SLW.
- c. Video Camera.

2. Test Facility - The test site is located at the PSBRTF on the vehicle dynamics area. The test site must meet the following conditions:

- a. Dry and free of extraneous surface material
- b. Free of interfering traffic
- c. Wind speed gust < 12 mph
- d. Ambient temperature between 30NF and 90NF

The test site will have two lanes with a 12 ft center to center distance. The test course will be marked with pylons and painted lines as illustrated in Figure 3.1.

3. Test Personnel - This test requires the following personnel:

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

### 3-V. TEST DATA

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

### 3-VI. TEST PREPARATION AND PROCEDURES

The detailed test preparation and procedures are listed in procedure 3-1 and 3-2. This section also includes Safety Data Form - 3.

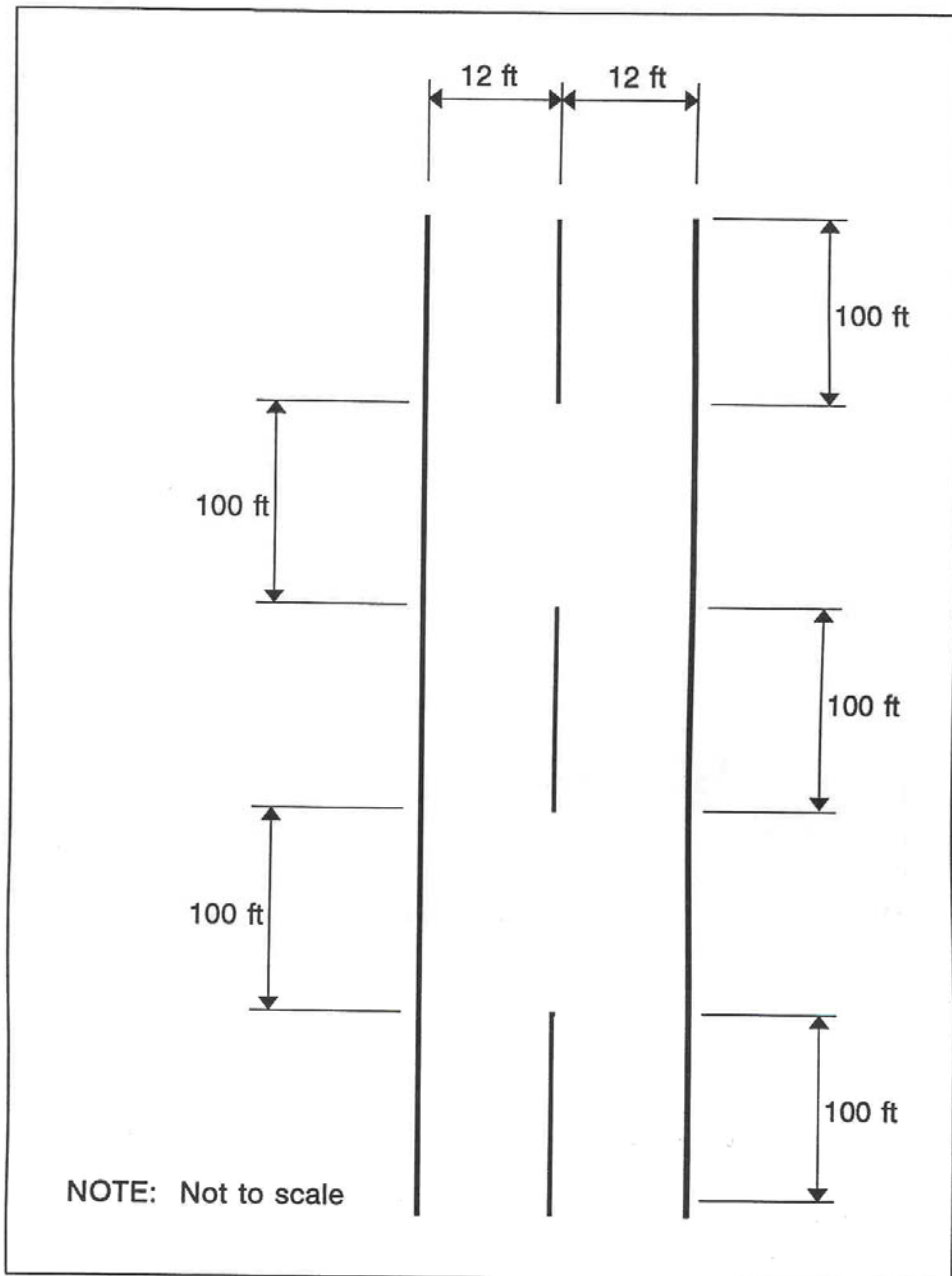


Figure 3.1. Double lane change test course.

**DETAILED TEST PROCEDURES****TITLE: Safety - A Double-Lane Change****Procedure 3-1****NOMENCLATURE: 3. Safety - A Double-Lane Change  
(Obstacle Avoidance 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

TD

Fill the fuel tanks.

3

TD

Insure that all tires are properly inflated.

4

TP

Install the speed measuring system on the bus. Install speed indicator in the front of the bus so it is visible to the test driver.

5

TP

Insure that the bus is loaded to SLW minus the weight of TD and equipment.

6

TP

Set up video equipment so that the tire-ground contact patch and the position of the bus can be seen during lane changeover.

7

TD

Drive the bus at least three times around the PSBRTF test track at approximately 45 mph.

8

TP

Make sure the road surface is dry and clean. If not, delay the test until such time that conditions are favorable.

9

TP

Verify the proper configuration of test course and the correct placement of pylons (see figure 3.1).

10

TP

Confirm that all preparations have been completed properly.

**DETAILED TEST PROCEDURES**

**TITLE: Safety - A Double-Lane Change**

Procedure 3-1		NOMENCLATURE: 3. Safety - A Double-Lane Change (Obstacle Avoidance Test)
OPER STEP	ACTION BY	TEST PROCEDURE
1	TP	Videotape lane change at an approximately 30 degree angle from the test site at a distance sufficient to capture the tire-ground contact patch as well as the entire bus.
2	TD	Begin in the right lane at 20 mph (as indicated by the speed indicator) and perform the double-lane change maneuver to the left lane and back as marked off by the pylons. Maintain constant speed ( $\pm 1$ mph) throughout the maneuver.
3	TD	Once through the lane change course, safely proceed around the track and return to the beginning of the course at a speed increase of 5 mph from the previous run.
4	TD	Repeat steps 1 and 2 with speed increases of 5 mph until the maneuver is determined to be unsafe by TD and TP or a speed of 45 mph is achieved successfully.  NOTE: Do not perform this maneuver at unsafe speeds. The maximum safe speed will be determined by the TD in concurrence with TP.
5	TP	Record the maximum safe speed for the double-lane change to the left on the Safety Data Form.
6	TD	Repeat steps 1 through 3 beginning in the left lane and performing the double-lane change to the right lane and back.
7	TP	Record the maximum safe speed for the double-lane change to the right on the Safety Data Form.
8	TP	Remove all test instrumentation not needed for further testing.
9	TP	Sign the Safety Data Form to indicate completion, including comments on handling braking.
10	TP	File the completed performance data sheet and work order form.

## REVISIONS

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

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Revision	Description	Date	Approval
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## SAFETY DATA FORM

Bus Number:	Date:
Personnel:	

Temperature (EF):	Humidity (%):
Wind Direction:	Wind Speed (mph):
Barometric Pressure (in.Hg):	

<b>SAFETY TEST: DOUBLE LANE CHANGE</b>	
Maximum safe speed tested for double-lane change to left	mph
Maximum safe speed tested for double-lane change to right	mph
Comments of the position of the bus during the lane change:	
Comments of the tire/ground contact patch:	