

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

5. STRUCTURAL INTEGRITY

**5.1. STRUCTURAL STRENGTH AND DISTORTION TESTS -  
STRUCTURAL SHAKEDOWN 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

#### 5.1-I. TEST OBJECTIVE

The objective of this test is to determine certain structural characteristics (e.g., bus frame deflection, permanent structural deformation, etc.) under static loading conditions.

#### 5.1-II. TEST DESCRIPTION

In this test, the bus will be isolated from the suspension by removing the necessary suspension components and blocking the vehicle under the suspension points. The bus will then be loaded and unloaded not more than three times with a distributed load equal to 2.5 times gross load. Gross load is defined as 150 lb for every designed passenger seating position, for the driver, and for each 1.5 sq ft<sup>2</sup> of free floor space. For a distributed load equal to 2.5 times gross load, place a 375 lb load on each seat and on every 1.5 ft<sup>2</sup> of free floor space. The first loading and unloading sequence will "settle" the structure. The second, and third if applicable, loading and unloading sequence will determine the permanent deflection. If the maximum permanent deflection after the second loading and unloading sequence is less than .005 inches, then the third sequence is not needed. Deflections will be measured at various locations during the loading and unloading sequence.

#### 5.1-III. TEST ARTICLE

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

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

The test will be performed on a smooth level area at the ABTC. The following test equipment is required for this test:

1. Sufficient ballast to provide a distributed load equal to 2.5 times gross load.
2. Displacement gauges with at least .001 inch resolution.
3. Smooth, level area.
4. Support blocks.
5. Three copies of the Structural Shakedown Data Form.

The following personnel are required for this test:

1. Test personnel (TP).

5.1-V. TEST DATA

The test data consist of the Structural Shakedown Data Form. Upon completion of this test, data shall be forwarded to the ABTC manager.

5.1-VI. TEST PREPARATION AND PROCEDURES

Detailed test preparation and procedures are listed in procedure 5.1-1. This section also includes Structural Shakedown Data Form.

DETAILED TEST PROCEDURES		TITLE: 5. Structural Integrity
Procedure 5.1-1		NOMENCLATURE: 5.1 Structural Strength and Distortion Tests - Structural Shakedown Test
OPER STEP	ACTION BY	TEST PREPARATION AND PROCEDURE
1	TP	Record the test bus number on the Structural Shakedown Data Form. Retrieve a Work Order Form for this test.
2	TP	Maneuver the bus onto a smooth level surface at the ABTC.
3	TP	Block out the suspension by supporting the bus under the suspension points using the support blocks. Photograph the support blocks in place.
4	TP	Locate and mark at least 10 reference points in a grid pattern covering the entire underside of the bus. Remove dirt and undercoating at each reference point. Indicate the approximate location of the reference points by placing numbers on the data sheet.
5	TP	Record the height of each reference point above the floor on the Structural Shakedown Data Form (A). Photograph the location of each reference point.
6	TP	Load the bus to a distributed load equal to 2.5 times gross load by placing 375 lb at each seating position and on every 1.5 ft <sup>2</sup> of available free floor space.
7	TP	With the bus loaded, measure and record the height of each reference point on the Structural Shakedown Data Form (B). Indicate the loading sequence on data sheet (B).
8	TP	Calculate the deflection at each of the reference points (A-B).
9	TP	Unload the bus.
10	TP	Measure and record the height of each reference point (C).
11	TP	Calculate and record the permanent deflection (A-C).
12	TP	Repeat steps 5 through 11.
13	TP	Repeat steps 5 through 11 if the permanent deflection after the second loading sequence is greater than .005 inches.
14	TP	File the completed Structural Shakedown Data Forms and a 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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## STRUCTURAL SHAKEDOWN DATA FORM

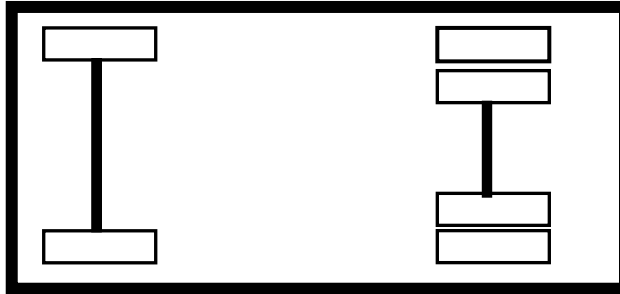
Bus Number:	Date:
Personnel:	Temperature (EF):
Loading Sequence:    • 1    • 2    • 3    (check one)	
Test Load (lbs):	

Indicate Approximate Location of Each Reference Point

Right

Front  
of  
Bus

Left



Top View

Reference Point No.	A (in) Original Height	B (in) Loaded Height	A-B (in) Loaded Deflection	C (in) Unloaded Height	A-C (in) Permanent Deflection
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					