# STURAA TEST

# 4 YEAR

# 100,000 MILE BUS

# from

# ELDORADO NATIONAL (KANSAS), INC.

# MODEL AMERIVAN

**OCTOBER 2008**

**PTI-BT-R0809**

PENNSTATE


**The Thomas D. Larson**
**Pennsylvania Transportation Institute**

201 Transportation Research Building (814) 865-1891
The Pennsylvania State University
University Park, PA 16802

**Bus Testing and Research Center**

2237 Old Route 220 N. (814) 695-3404
Duncansville, PA 16635

# TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY ..... 3

ABBREVIATIONS ..... 5

BUS CHECK-IN ..... 6

1. MAINTAINABILITY

1.1 ACCESSIBILITY OF COMPONENTS AND SUBSYSTEMS ..... 18
1.2 SERVICING, PREVENTATIVE MAINTENANCE, AND REPAIR AND MAINTENANCE DURING TESTING ..... 21
1.3 REPLACEMENT AND/OR REPAIR OF SELECTED SUBSYSTEMS ..... 25

2. RELIABILITY - DOCUMENTATION OF BREAKDOWN AND REPAIR TIMES DURING TESTING ..... 29

3. SAFETY - A DOUBLE-LANE CHANGE (OBSTACLE AVOIDANCE TEST) ..... 32

4. PERFORMANCE - AN ACCELERATION, GRADEABILITY, AND TOP SPEED TEST ..... 35

5. STRUCTURAL INTEGRITY

5.1 STRUCTURAL STRENGTH AND DISTORTION TESTS - STRUCTURAL SHAKEDOWN TEST ..... 39
5.2 STRUCTURAL STRENGTH AND DISTORTION TESTS - STRUCTURAL DISTORTION ..... 43
5.3 STRUCTURAL STRENGTH AND DISTORTION TESTS - STATIC TOWING TEST ..... 55
5.4 STRUCTURAL STRENGTH AND DISTORTION TESTS - DYNAMIC TOWING TEST ..... 56
5.5 STRUCTURAL STRENGTH AND DISTORTION TESTS - JACKING TEST ..... 59
5.6 STRUCTURAL STRENGTH AND DISTORTION TESTS - HOISTING TEST ..... 61
5.7 STRUCTURAL DURABILITY TEST ..... 63

6. FUEL ECONOMY TEST - A FUEL CONSUMPTION TEST USING AN APPROPRIATE OPERATING CYCLE ..... 74

7. NOISE

7.1 INTERIOR NOISE AND VIBRATION TESTS ..... 89
7.2 EXTERIOR NOISE TESTS ..... 94

# EXECUTIVE SUMMARY

Eldorado National (Kansas) Inc. submitted a model Amerivan, gasoline-powered 4 seat (including the driver) 16-foot converted mini-van bus, for a 4 yr/100,000 mile STURAA test. The odometer reading at the time of delivery was 1,061 miles. Testing started on June 18, 2008 and was completed on September 29, 2008. The Check-In section of the report provides a description of the bus and specifies its major components.

The primary part of the test program is the Structural Durability Test, which also provides the information for the Maintainability and Reliability results. The Structural Durability Test was started on June 24, 2008 and was completed on August 25, 2008.

The interior of the bus is configured with seating for 5 passengers and one wheelchair position including the driver. The test vehicle is not design to accommodate standing passengers. At 150 lbs per person, this load results in a measured gross vehicle weight of 5,990 lbs. The first segment of the Structural Durability Test was performed with the bus loaded to a GVW of 5,990 lbs. The middle segment was performed at a seated load weight of 5,990 lbs and the final segment was performed at a curb weight of 4,550 lbs. Durability driving resulted in unscheduled maintenance and failures that involved a variety of subsystems. A description of failures, and a complete and detailed listing of scheduled and unscheduled maintenance is provided in the Maintainability section of this report.

Accessibility, in general, was adequate, components covered in Section 1.3 (Repair and/or Replacement of Selected Subsystems) along with all other components encountered during testing, were found to be readily accessible and no restrictions were noted.

The Reliability section compiles failures that occurred during Structural Durability Testing. Breakdowns are classified according to subsystems. The data in this section are arranged so that those subsystems with more frequent problems are apparent. The problems are also listed by class as defined in Section 2. The test vehicle encountered no Class 1 or Class 2 failures. Of the twelve reported failures, eleven were Class 3 and one was a Class 4.

The Safety Test, (a double-lane change, obstacle avoidance test) was safely performed in both right-hand and left-hand directions up to a maximum test speed of 45 mph. The performance of the bus is illustrated by a speed vs. time plot. Acceleration and gradeability test data are provided in Section 4, Performance. The average time to obtain 50 mph was 11.93 seconds.

The Shakedown Test produced a maximum final loaded deflection of 0.053 inches with a permanent set ranging between -0.006 to 0.006 inches under a distributed static load of 2,475 lbs. The Distortion Test was completed with all subsystems, doors and escape mechanisms operating properly. No water leakage was observed throughout the test. All subsystems operated properly.

The test vehicle submitted for testing was not equipped with any type of tow eyes or tow hooks, therefore, the Static Towing Test was not performed. The Dynamic Towing Test was performed by means of a front-lift tow. The towing interface was accomplished using a hydraulic under-lift wrecker. The bus was towed without incident and no damage resulted from the test. The manufacturer does not recommend towing the bus from the rear, therefore, a rear test was not performed. The Jacking and Hoisting Tests were also performed without incident. The bus was found to be stable on the jack stands, and the minimum jacking clearance observed with a tire deflated was 3.0 inches.

A Fuel Economy Test was run on simulated central business district, arterial, and commuter courses. The results were 14.76 mpg, 16.29 mpg, and 13.79 mpg respectively; with an overall average of 14.86 mpg.

A series of Interior and Exterior Noise Tests was performed. These data are listed in Section 7.1 and 7.2 respectively.

# ABBREVIATIONS

| | | |
|---|---|---|
| ABTC | - | Altoona Bus Test Center |
| A/C | - | air conditioner |
| ADB | - | advance design bus |
| ATA-MC | - | The Maintenance Council of the American Trucking Association |
| CBD | - | central business district |
| 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) |
| GVL | - | gross vehicle 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 |
| MECH | - | bus mechanic |
| mpg | - | miles per gallon |
| mph | - | miles per hour |
| PM | - | Preventive maintenance |
| PSBRTF | - | Penn State Bus Research and Testing Facility |
| PTI | - | Pennsylvania Transportation Institute |
| rpm | - | revolutions per minute |
| SAE | - | Society of Automotive Engineers |
| SCH | - | test scheduler |
| SEC | - | secretary |
| SLW | - | seated load weight (curb weight plus 150 lb for every designed passenger seating position and for the driver) |
| STURAA | - | Surface Transportation and Uniform Relocation Assistance Act |
| TD | - | test driver |
| TECH | - | test technician |
| TM | - | track manager |
| TP | - | test personnel |

# TEST BUS CHECK-IN

## I. OBJECTIVE

The objective of this task is to log in the test bus, assign a bus number, complete the vehicle data form, and perform a safety check.

## II. TEST DESCRIPTION

The test consists of assigning a bus test number to the bus, cleaning the bus, completing the vehicle data form, obtaining any special information and tools from the manufacturer, determining a testing schedule, performing an initial safety check, and performing the manufacturer's recommended preventive maintenance. The bus manufacturer must certify that the bus meets all Federal regulations.

## III. DISCUSSION

The check-in procedure is used to identify in detail the major components and configuration of the bus.

The test bus consists of an ElDorado National (Kansas) Inc., model Amerivan. The test vehicle is a convert Dodge Caravan SE with O.E.M. a front driver's and passenger doors rear of the front axle, a right side handicap entrance and a rear hatch. Power is provided by a gasoline-fueled, Daimler Chrysler Corp. model 3.3L V6 engine coupled to a Daimler Chrysler model 62TE transmission.

The measured curb weight is 2,430 lbs for the front axle and 2,120 lbs for the rear axle. These combined weights provide a total measured curb weight of 4,550 lbs. There are 5 seats including the driver and room for 1 wheelchair position. (the test vehicle is not designed for standing passengers), bringing the total passenger capacity to 4 + one wheelchair position. Gross load is 150 lb x 4 = 600 lbs + 600 lbs (wheelchair position) = 1,200 lbs. At full capacity, the measured gross vehicle weight is 5,990 lbs.

# VEHICLE DATA FORM

| | |
|---|---|
| Bus Number: 0809 | Arrival Date: 6-18-08 |
| Bus Manufacturer: ElDorado National (Kansas), Inc. | Vehicle Identification Number (VIN): 2D8HN44HX8R135601 |
| Model Number: 0809 | Date: 6-18-08 |
| Personnel: T.S. & P.D. | Chassis: Dodge Grand Caravan |

WEIGHT:

Individual Wheel Reactions:

| Weights (lb) | Front Axle | | Middle Axle | | Rear Axle | |
|---|---|---|---|---|---|---|
| | Right | Left | Right | Left | Right | Left |
| CW | 1,170 | 1,260 | N/A | N/A | 1,090 | 1,030 |
| SLW | 1,545 | 1,315 | N/A | N/A | 1,440 | 1,690 |
| GVW | 4,545 | 1,315 | N/A | N/A | 1,440 | 1,690 |

Total Weight Details:

| Weight (lb) | CW | SLW | GVW | GAWR |
|---|---|---|---|---|
| Front Axle | 2,430 | 2,860 | 2,860 | 2,950 |
| Middle Axle | N/A | N/A | N/A | N/A |
| Rear Axle | 2,120 | 3,130 | 3,130 | 3,100 |
| Total | 4,550 | 5,990 | 5,990 | GVWR: 6,050 |

Dimensions:

| | |
|---|---|
| Length (ft/in) | 16 / 9.5 |
| Width (in) | 77.0 |
| Height (in) | 72.5 |
| Front Overhang (in) | 36.0 |
| Rear Overhang (in) | 43.5 |
| Wheel Base (in) | 122.0 |
| Wheel Track (in) | Front: 65.5 |
| | Rear: 64.6 |

| | |
|---|---|
| Bus Number: 0809 | Date: 6-18-08 |

CLEARANCES:

| | |
|---|---|
| Lowest Point Outside Front Axle | Location: Engine support Clearance(in): 6.7 |
| Lowest Point Outside Rear Axle | Location: Muffler Clearance(in): 11.7 |
| Lowest Point between Axles | Location: Exhaust pipe Clearance(in): 4.8 |
| Ground Clearance at the center (in) | 4.8 |
| Front Approach Angle (deg) | 11.9 |
| Rear Approach Angle (deg) | 16.5 |
| Ramp Clearance Angle (deg) | 4.5 |
| Aisle Width (in) | N/A |
| Inside Standing Height at Center Aisle (in) | N/A |

BODY DETAILS:

| | | | |
|---|---|---|---|
| Body Structural Type | Monocoque | | |
| Frame Material | Steel | | |
| Body Material | Steel / plastic | | |
| Floor Material | Steel | | |
| Roof Material | Steel | | |
| Windows Type | ■ Fixed | □ Movable | |
| Window Mfg./Model No. | Mopar / DOT 15 LOF M-127 | | |
| Number of Doors | 2 Front | 1 Rear | 2 side sliding |
| Mfr. / Model No. | Daimler Chrysler / O.E.M. | | |
| Dimension of Each Door (in) | Front– 34.4 x 43.7 | Rear- 48.5 x 40.2 | Sliding- 33.2 x 56.5 |
| Passenger Seat Type | □ Cantilever | ■ Pedestal | □ Other (explain) |
| Mfr. / Model No. | Daimler Chrysler / O.E.M. | | |
| Driver Seat Type | □ Air | ■ Spring | □ Other (explain) |
| Mfr. / Model No. | Daimler Chrysler / O.E.M. | | |
| Number of Seats (including Driver) | 4 + 1 wheelchair position | | |

| | |
|---|---|
| Bus Number: 0809 | Date: 6-18-08 |

BODY DETAILS (Contd..)

| | | | | |
|---|---|---|---|---|
| Free Floor Space ( $ft^2$ ) | N/A | | | |
| Height of Each Step at Normal Position (in) | Front | 1. 19.4 | 2. N/A | 3. N/A | 4. N/A |
| | Middle | 1. 10.1 | 2. N/A | 3. N/A | 4. N/A |
| | Rear | 1. N/A | 2. N/A | 3. N/A | 4. N/A |
| Step Elevation Change - Kneeling (in) | N/A | | | |

ENGINE

| | | | |
|---|---|---|---|
| Type | □ C.I. | □ Alternate Fuel | |
| | ■ S.I. | □ Other (explain) | |
| Mfr. / Model No. | Daimler Chrysler Corp. / 3.3 L V6 | | |
| Location | ■ Front | □ Rear | □ Other (explain) |
| Fuel Type | ■ Gasoline | □ CNG | □ Methanol |
| | □ Diesel | □ LNG | □ Other (explain) |
| Fuel Tank Capacity (indicate units) | 20 gals. | | |
| Fuel Induction Type | ■ Injected | □ Carburetion | |
| Fuel Injector Mfr. / Model No. | Daimler Chrysler Corp. / 3.3 L V6 | | |
| Carburetor Mfr. / Model No. | N/A | | |
| Fuel Pump Mfr. / Model No. | Daimler Chrysler Corp. / 3.3 L V6 | | |
| Alternator (Generator) Mfr. / Model No. | Denso / 04801-304AA | | |
| Maximum Rated Output (Volts / Amps) | 12 / 160 | | |
| Air Compressor Mfr. / Model No. | Airlift / Wabco 0806 | | |
| Maximum Capacity ($ft^3$ / min) | N/A | | |
| Starter Type | ■ Electrical | □ Pneumatic | □ Other (explain) |
| Starter Mfr. / Model No. | Denso / 428000-3070 | | |

| | |
|---|---|
| Bus Number: 0809 | Date: 6-18-08 |

TRANSMISSION

| | | | |
|---|---|---|---|
| Transmission Type | □ Manual | ■ Automatic | |
| Mfr. / Model No. | Daimler Chrysler / 62TE | | |
| Control Type | ■ Mechanical | □ Electrical | □ Other |
| Torque Converter Mfr. / Model No. | Daimler Chrysler / 62TE | | |
| Integral Retarder Mfr. / Model No. | N/A | | |

SUSPENSION

| | | | |
|---|---|---|---|
| Number of Axles | 2 | | |
| Front Axle Type | ■ Independent | □ Beam Axle | |
| Mfr. / Model No. | Daimler Chrysler / 62TE | | |
| Axle Ratio (if driven) | N.A | | |
| Suspension Type | □ Air | ■ Spring | □ Other (explain) |
| No. of Shock Absorbers | 2 | | |
| Mfr. / Model No. | Daimler Chrysler / O.E.M. | | |
| Middle Axle Type | □ Independent | □ Beam Axle | |
| Mfr. / Model No. | N/A | | |
| Axle Ratio (if driven) | N/A | | |
| Suspension Type | □ Air | □ Spring | □ Other (explain) |
| No. of Shock Absorbers | N/A | | |
| Mfr. / Model No. | N/A | | |
| Rear Axle Type | □ Independent | ■ Beam Axle | |
| Mfr. / Model No. | Daimler Chrysler / O.E.M. | | |
| Axle Ratio (if driven) | N/A | | |
| Suspension Type | ■ Air | □ Spring | □ Other (explain) |
| No. of Shock Absorbers | 2 | | |
| Mfr. / Model No. | Air-Lift / na | | |

| | |
|---|---|
| Bus Number: 0809 | Date: 6-18-08 |

WHEELS & TIRES

| | | |
|---|---|---|
| Front | Wheel Mfr./ Model No. | Daimler Chrysler / 16 x 6.5 |
| | Tire Mfr./ Model No. | Yokohama / 225/65 R16 100S |
| Rear | Wheel Mfr./ Model No. | Daimler Chrysler / 16 x 6.5 |
| | Tire Mfr./ Model No. | Yokohama / 225/65 R16 100S |

BRAKES

| | | | |
|---|---|---|---|
| Front Axle Brakes Type | □ Cam | ■ Disc | □ Other (explain) |
| Mfr. / Model No. | TRW / O.E.M. | | |
| Middle Axle Brakes Type | □ Cam | □ Disc | □ Other (explain) |
| Mfr. / Model No. | N/A | | |
| Rear Axle Brakes Type | □ Cam | ■ Disc | □ Other (explain) |
| Mfr. / Model No. | Daimler Chrysler / O.E.M. | | |
| Retarder Type | N/A | | |
| Mfr. / Model No. | N/A | | |

HVAC

| | | | |
|---|---|---|---|
| Heating System Type | □ Air | ■ Water | □ Other |
| Capacity (Btu/hr) | 18,500 | | |
| Mfr. / Model No. | Daimler Chrysler / O.E.M. | | |
| Air Conditioner | ■ Yes | □ No | |
| Location | Front | | |
| Capacity (Btu/hr) | 18,500 | | |
| A/C Compressor Mfr. / Model No. | Design Press / BJ 24823 | | |

STEERING

| | |
|---|---|
| Steering Gear Box Type | Rack& pinion |
| Mfr. / Model No. | Daimler Chrysler / O.E.M. |
| Steering Wheel Diameter | 15.3 |
| Number of turns (lock to lock) | 3.0 |

| | |
|---|---|
| Bus Number: 0809 | Date: 6-18-08 |

OTHERS

| | | |
|---|---|---|
| Wheel Chair Ramps | Location: Middle right | Type: Fold-out |
| Wheel Chair Lifts | Location: N/A | Type: N/A |
| Mfr. / Model No. | ElDorado National / 0032621 Manual ramp Pro Fab | |
| Emergency Exit | Location: Doors<br>Rear hatch | Number: 4<br>1 |

CAPACITIES

| | |
|---|---|
| Fuel Tank Capacity (units) | 20 gals |
| Engine Crankcase Capacity (quarts) | 5.0 |
| Transmission Capacity (quarts) | 9.0 (total) |
| Differential Capacity (gallons) | N/A |
| Cooling System Capacity (quarts) | 13.4 |
| Power Steering Fluid Capacity (pints) | 2.5 |

**VEHICLE DATA FORM**

| | |
|---|---|
| Bus Number: 0809 | Date: 6-18-08 |

**List all spare parts, tools and manuals delivered with the bus.**

| Part Number | Description | Qty. |
|---|---|---|
| N/A | N/A | N/A |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

## COMPONENT/SUBSYSTEM INSPECTION FORM

| Bus Number: 0809 | Date: 6-18-08 |
|---|---|

| Subsystem | Checked | Comments |
|---|---|---|
| Air Conditioning Heating and Ventilation | ✓ | |
| Body and Sheet Metal | ✓ | |
| Frame | ✓ | |
| Steering | ✓ | |
| Suspension | ✓ | |
| Interior/Seating | ✓ | |
| Axles | ✓ | |
| Brakes | ✓ | |
| Tires/Wheels | ✓ | |
| Exhaust | ✓ | |
| Fuel System | ✓ | |
| Power Plant | ✓ | |
| Accessories | ✓ | |
| Lift System | ✓ | |
| Interior Fasteners | ✓ | |
| Batteries | ✓ | |

# CHECK - IN

## ELDORADO NATIONAL (KANSAS) INC.
## MODEL AMERIVAN

## AMERIVAN EQUIPPED WITH AN ELDORADO NATIONAL PRO FAB MODEL HANDICAP RAMP

# CHECK - IN CONT.

## FRONT INTERIOR

## REAR INTERIOR

# CHECK - IN CONT.

## DRIVER'S STATION

# 1. MAINTAINABILITY

## 1.1 ACCESSIBILITY OF COMPONENTS AND SUBSYSTEMS

### 1.1-I. TEST OBJECTIVE

The objective of this test is to check the accessibility of components and subsystems.

### 1.1-II. TEST DESCRIPTION

Accessibility of components and subsystems is checked, and where accessibility is restricted the subsystem is noted along with the reason for the restriction.

### 1.1-III. DISCUSSION

Accessibility, in general, was adequate. Components covered in Section 1.3 (repair and/or replacement of selected subsystems), along with all other components encountered during testing, were found to be readily accessible and no restrictions were noted.

# ACCESSIBILITY DATA FORM

| Bus Number: 0809 | Date: 9-24-08 |
|---|---|

| Component | Checked | Comments |
|---|---|---|
| **ENGINE :** | | |
| Oil Dipstick | ✓ | |
| Oil Filler Hole | ✓ | |
| Oil Drain Plug | ✓ | |
| Oil Filter | ✓ | |
| Fuel Filter | ✓ | |
| Air Filter | ✓ | |
| Belts | ✓ | |
| Coolant Level | ✓ | |
| Coolant Filler Hole | ✓ | |
| Coolant Drain | ✓ | |
| Spark / Glow Plugs | ✓ | |
| Alternator | ✓ | |
| Diagnostic Interface Connector | ✓ | |
| **TRANSMISSION :** | | |
| Fluid Dip-Stick | ✓ | |
| Filler Hole | ✓ | |
| Drain Plug | ✓ | |
| **SUSPENSION :** | | |
| Bushings | ✓ | |
| Shock Absorbers | ✓ | |
| Air Springs | ✓ | |
| Leveling Valves | ✓ | |
| Grease Fittings | ✓ | |

# ACCESSIBILITY DATA FORM

| Bus Number: 0809 | Date: 9-24-08 |
|---|---|

| Component | Checked | Comments |
|---|---|---|
| **HVAC :** | | |
| A/C Compressor | ✓ | |
| Filters | ✓ | |
| Fans | ✓ | |
| **ELECTRICAL SYSTEM :** | | |
| Fuses | ✓ | |
| Batteries | ✓ | |
| Voltage regulator | ✓ | |
| Voltage Converters | ✓ | |
| Lighting | ✓ | |
| **MISCELLANEOUS :** | | |
| Brakes | ✓ | |
| Handicap Lifts/Ramps | ✓ | |
| Instruments | ✓ | |
| Axles | ✓ | |
| Exhaust | ✓ | |
| Fuel System | ✓ | |
| **OTHERS :** | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

# 1.2 SERVICING, PREVENTIVE MAINTENANCE, AND REPAIR AND MAINTENANCE DURING TESTING

## 1.2-I. TEST OBJECTIVE

The objective of this test is to collect maintenance data about the servicing, preventive maintenance, and repair.

## 1.2.-II. TEST DESCRIPTION

The test will be conducted by operating the NBM and collecting the following data on work order forms and a driver log.

1. Unscheduled Maintenance
    a. Bus number
    b. Date
    c. Mileage
    d. Description of malfunction
    e. Location of malfunction (e.g., in service or undergoing inspection)
    f. Repair action and parts used
    g. Man-hours required

2. Scheduled Maintenance
    a. Bus number
    b. Date
    c. Mileage
    d. Engine running time (if available)
    e. Results of scheduled inspections
    f. Description of malfunction (if any)
    g. Repair action and parts used (if any)
    h. Man-hours required

The buses will be operated in accelerated durability service. While typical items are given below, the specific service schedule will be that specified by the manufacturer.

A. Service
    1. Fueling
    2. Consumable checks
    3. Interior cleaning

B. Preventive Maintenance
    4. Brake adjustments
    5. Lubrication
    6. 3,000 mi (or equivalent) inspection

7. Oil and filter change inspection
8. Major inspection
9. Tune-up

C. Periodic Repairs
1. Brake reline
2. Transmission change
3. Engine change
4. Windshield wiper motor change
5. Stoplight bulb change
6. Towing operations
7. Hoisting operations

## 1.2-III. DISCUSSION

Servicing and preventive maintenance were performed at manufacturer-specified intervals. The following Scheduled Maintenance Form lists the mileage, items serviced, the service interval, and amount of time required to perform the maintenance. Table 1 is a list of the lubricating products used in servicing. Finally, the Unscheduled Maintenance List along with Unscheduled Maintenance-related photographs is included in Section 5.7, Structural Durability. This list supplies information related to failures that occurred during the durability portion of testing. The Unscheduled Maintenance List includes the date and mileage at which the malfunction occurred, a description of the malfunction and repair, and the time required to perform the repair.

**SCHEDULED MAINTENANCE**

ElDorado National #0809

| DATE | TEST MILES | SERVICE | ACTIVITY | DOWN TIME | HOURS |
|---|---|---|---|---|---|
| 07-29-08 | 694 | P.M. / Inspection | Linkage, tie rods, universals/u-joints all lubed; all fluids checked. | 4.00 | 4.00 |
| 08-07-08 | 1,695 | P.M. / Inspection | Linkage, tie rods, universals/u-joints all lubed; all fluids checked. | 4.00 | 4.00 |
| 08-13-08 | 2,150 | P.M. / Inspection | Linkage, tie rods, universals/u-joints all lubed; all fluids checked. | 4.00 | 4.00 |
| 08-21-08 | 2,780 | P.M. / Inspection | Linkage, tie rods, universals/u-joints all lubed; all fluids checked. | 4.00 | 4.00 |
| 09-17-08 | 3,751 | P.M. / Inspection<br>Fuel Economy Prep | Linkage, tie rods, universals/u-joints all lubed. Oil changed. Oil, fuel, and air filters changed. Transmission oil and filter changed. | 8.00 | 8.00 |

**Table 1. STANDARD LUBRICANTS**

The following is a list of Texaco lubricant products used in bus testing conducted by the Penn State University Altoona Bus Testing Center:

| ITEM | PRODUCT CODE | TEXACO DESCRIPTION |
|---|---|---|
| Engine oil | #2112 | URSA Super Plus SAE 30 |
| Transmission oil | #1866 | Automatic Trans Fluid<br>Mercon/Dexron II<br>Multipurpose |
| Gear oil | #2316 | Multigear Lubricant<br>EP SAE 80W90 |
| Wheel bearing &<br>Chassis grease | #1935 | Starplex II |

# 1.3 REPLACEMENT AND/OR REPAIR OF SELECTED SUBSYSTEMS

## 1.3-I. TEST OBJECTIVE

The objective of this test is to establish the time required to replace and/or repair selected subsystems.

## 1.3-II. TEST DESCRIPTION

The test will involve components that may be expected to fail or require replacement during the service life of the bus. In addition, any component that fails during the NBM testing is added to this list. Components to be included are:

1. Transmission
2. Alternator
3. Starter
4. Batteries
5. Windshield wiper motor

## 1.3-III. DISCUSSION

During the test, several additional components were removed for repair or replacement. Following is a list of components and total repair/replacement time.

| | MAN HOURS |
|---|---|
| Both rear air struts. | 4.00 |
| Air compressor. | 4.00 |
| Right rear “ABS” sensor. | 2.00 |

At the end of the test, the remaining items on the list were removed and replaced. The transmission assembly took 12.0 man-hours (two men 6.0 hrs) to remove and replace. The time required for repair/replacement of the four remaining components is given on the following Repair and/or Replacement Form.

## REPLACEMENT AND/OR REPAIR FORM

| Subsystem | Replacement Time |
|---|---|
| Transmission | 12.0 man hours |
| Wiper Motor | 0.25 man hours |
| Starter | 0.75 man hours |
| Alternator | 0.50 man hours |
| Batteries | 0.25 man hours |

# 1.3 REPLACEMENT AND/OR REPAIR OF SELECTED SUBSYSTEMS

## TRANSMISSION REMOVAL AND REPLACEMENT (12.0 MAN HOURS)

## WIPER MOTOR REMOVAL AND REPLACEMENT (0.25 MAN HOURS)

# 1.3 REPLACEMENT AND/OR REPAIR OF SELECTED SUBSYSTEMS CONT.

**STARTER REMOVAL AND REPLACEMENT (0.75 MAN HOURS)**

**ALTERNATOR REMOVAL AND REPLACEMENT (0.50 MAN HOURS)**

# 2. RELIABILITY - DOCUMENTATION OF BREAKDOWN AND REPAIR TIMES DURING TESTING

## 2-I. TEST OBJECTIVE

The objective of this test is to document unscheduled breakdowns, repairs, down time, and repair time that occur during testing.

## 2-II. TEST DESCRIPTION

Using the driver log and unscheduled work order forms, all significant breakdowns, repairs, man-hours to repair, and hours out of service are recorded on the Reliability Data Form.

### CLASS OF FAILURES

Classes of failures are described below:

(a) Class 1: Physical Safety. A failure that could lead directly to passenger or driver injury and represents a severe crash situation.

(b) Class 2: Road Call. A failure resulting in an en route interruption of revenue service. Service is discontinued until the bus is replaced or repaired at the point of failure.

(c) Class 3: Bus Change. A failure that requires removal of the bus from service during its assignments. The bus is operable to a rendezvous point with a replacement bus.

(d) Class 4: Bad Order. A failure that does not require removal of the bus from service during its assignments but does degrade coach operation. The failure shall be reported by driver, inspector, or hostler.

## 2-III. DISCUSSION

A listing of breakdowns and unscheduled repairs is accumulated during the Structural Durability Test. The following Reliability Data Form lists all unscheduled repairs under classes as defined above. These classifications are somewhat subjective as the test is performed on a test track with careful inspections every two hours. However, even on the road, there is considerable latitude on deciding how to handle many failures.

The Unscheduled Repair List is also attached to provide a reference for the repairs that are included in the Reliability Data Forms.

The classification of repairs according to subsystem is intended to emphasize those systems which had persistent minor or more serious problems. There were no Class 1 or 2 failures. Of the eleven Class 3 failures, eight involved the suspension system and one each with the brakes, exhaust system and tires. These, and the one remaining Class 4 failures are available for review in the Unscheduled Maintenance List, located in Section 5.7 Structural Durability.

## RELIABILITY DATA FORMS

| Bus Number: 0809 | Date: 09-17-08 |
|---|---|
| Personnel: Bob Reifsteck | |

| | Failure Type | | | | | |
|---|---|---|---|---|---|---|
| | Class 4 Bad Order | Class 3 Bus Change | Class 2 Road Call | Class 1 Physical Safety | | |
| Subsystems | Mileage | Mileage | Mileage | Mileage | Man Hours | Down Time |
| Suspension | | 101 | | | 12.00 | 208.00 |
| | | 224 | | | 8.00 | 138.00 |
| | 299 | | | | 4.00 | 12.00 |
| | | 452 | | | 8.00 | 128.00 |
| | | 694 | | | 4.00 | 2.00 |
| | | 897 | | | 3.00 | 4.00 |
| | | 2,045 | | | 2.00 | 1.00 |
| | | 2,150 | | | 2.00 | 10.00 |
| | | 2,581 | | | 2.00 | 32.00 |
| Brakes | | 2,045 | | | 2.00 | 13.00 |
| Exhaust System | | 694 | | | 3.00 | 1.50 |
| Wheels/Tires | | 1,401 | | | 1.00 | 10.00 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

# 3. SAFETY - A DOUBLE-LANE CHANGE (OBSTACLE AVOIDANCE)

## 3-I. TEST OBJECTIVE

The objective of this test is to determine handling and stability of the bus by measuring speed through a double lane change test.

## 3-II. TEST DESCRIPTION

The Safety Test is a vehicle handling and stability test. The bus will be operated at SLW on a smooth and level test track. The bus will be driven through a double lane change course at increasing speed until the test is considered unsafe or a speed of 45 mph is reached. The lane change course will be set up using pylons to mark off two 12 foot center to center lanes with two 100 foot lane change areas 100 feet apart. The bus will begin in one lane, change to the other lane in a 100 foot span, travel 100 feet, and return to the original lane in another 100 foot span. This procedure will be repeated, starting first in the right-hand and then in the left-hand lane.

## 3-III. DISCUSSION

The double-lane change was performed in both right-hand and left-hand directions. The bus was able to safely negotiate the test course in both the right-hand and left-hand directions up to the maximum test speed of 45 mph.

# SAFETY DATA FORM

| | |
|---|---|
| Bus Number: 0809 | Date: 9-5-08 |
| Personnel: S.C. | |

| | |
|---|---|
| Temperature (°F): 84 | Humidity (%): 31 |
| Wind Direction: S | Wind Speed (mph): 10 |
| Barometric Pressure (in.Hg): 29.99 | |

| SAFETY TEST: DOUBLE LANE CHANGE | |
|---|---|
| Maximum safe speed tested for double-lane change to left | 45 mph |
| Maximum safe speed tested for double-lane change to right | 45 mph |
| **Comments of the position of the bus during the lane change:** A safe profile was maintained through all portions of testing. | |
| | |
| | |
| **Comments of the tire/ground contact patch:** Tire/ground contact was maintained through all portions of testing. | |
| | |
| | |

# 3. SAFETY

## RIGHT - HAND APPROACH

## LEFT - HAND APPROACH

# 4. PERFORMANCE - AN ACCELERATION, GRADEABILITY, AND TOP SPEED TEST

## 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 the skid pad at the PSBRTF. The bus will be accelerated at full throttle from a standstill to a maximum "geared" or "safe" speed as determined by the test driver. The vehicle speed is measured using a Correvit non-contacting speed sensor. The times to reach speed between ten mile per hour increments are measured and recorded using a stopwatch with a lap timer. The time to speed data will be recorded on the Performance Data Form and later used to generate a speed vs. time plot and gradeability calculations.

## 4-III. DISCUSSION

This test consists of three runs in both the clockwise and counterclockwise directions on the Test Track. Velocity versus time data is obtained for each run and results are averaged together to minimize any test variability which might be introduced by wind or other external factors. The test was performed up to a maximum speed of 50 mph. The fitted curve of velocity vs. time is attached, followed by the calculated gradeability results. The average time to obtain 50 mph was 11.93 seconds.

# PERFORMANCE DATA FORM

| | |
|---|---|
| Bus Number: 0809 | Date: 9-5-08 |
| Personnel: T.S., T.W. M.R. | |

| | |
|---|---|
| Temperature (°F): 84 | Humidity (%): 31 |
| Wind Direction: S | Wind Speed (mph): 10 |
| Barometric Pressure (in.Hg): 29.99 | |

| | |
|---|---|
| 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 | 2.37 | 2.35 | 2.25 |
| 20 mph | 3.84 | 3.35 | 3.57 |
| 30 mph | 5.69 | 6.27 | 5.92 |
| 40 mph | 8.26 | 8.54 | 8.57 |
| Top Test Speed(mph) 50 | 11.76 | 12.04 | 12.04 |

Clockwise Recorded Interval Times

| Speed | Run 1 | Run 2 | Run 3 |
|---|---|---|---|
| 10 mph | 2.16 | 2.25 | 2.00 |
| 20 mph | 3.94 | 3.72 | 3.72 |
| 30 mph | 6.23 | 5.98 | 5.98 |
| 40 mph | 8.30 | 8.33 | 8.33 |
| Top Test Speed(mph) 50 | 12.23 | 11.61 | 11.92 |

PERFORMANCE SUMMARY SHEET

BUS MANUFACTURER :Eldorado National
BUS MODEL :Amerivan

BUS NUMBER :0809
TEST DATE :9/05/08

TEST CONDITIONS :

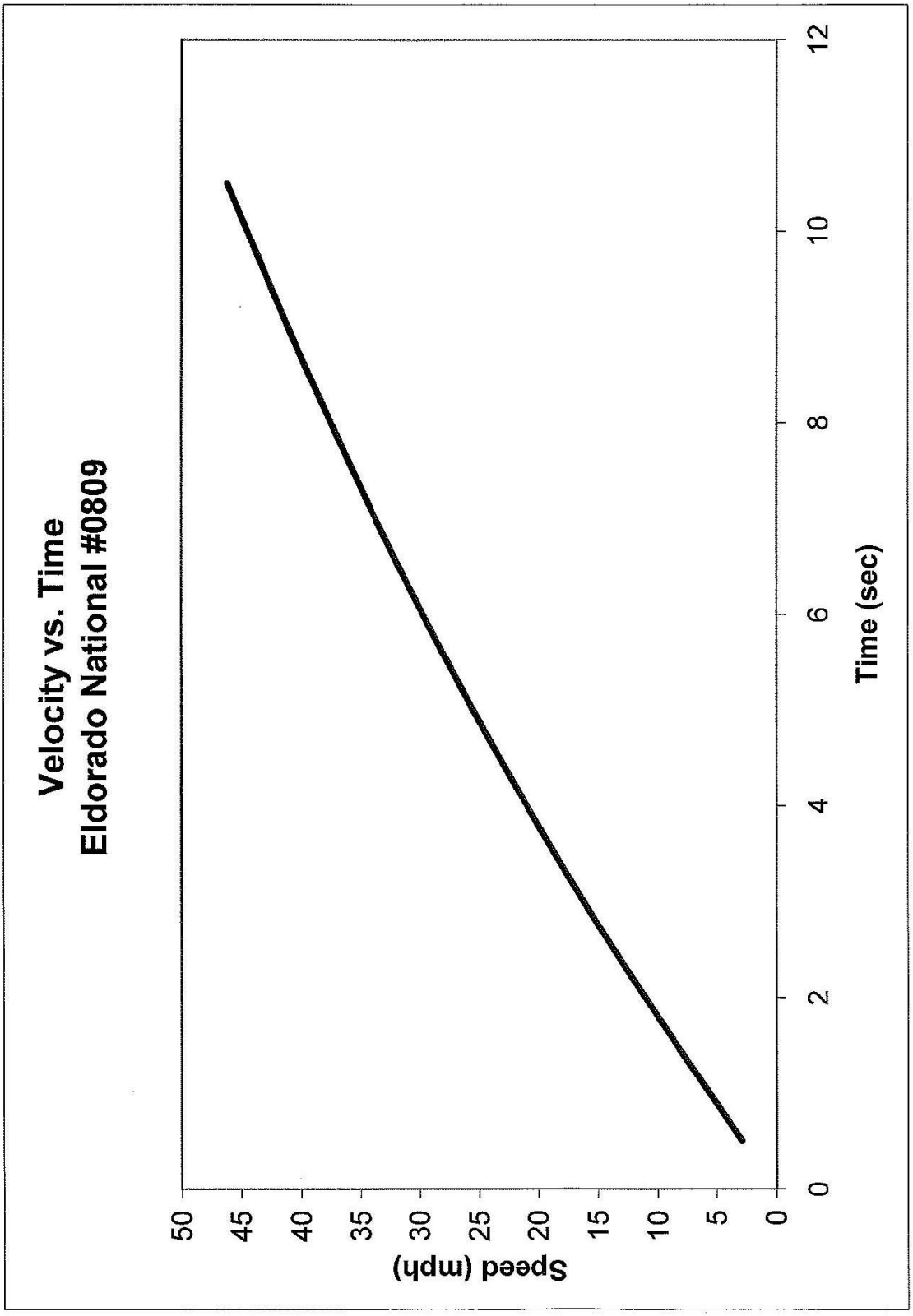
TEMPERATURE (DEG F ) : 84.0
WIND DIRECTION : S
WIND SPEED (MPH) : 10.0
HUMIDITY (%) : 31
BAROMETRIC PRESSURE (IN. HG) : 30.0

| VEHICLE SPEED | AVERAGE TIME (SEC) | | |
|---|---|---|---|
| (MPH) | CCW DIRECTION | CW DIRECTION | TOTAL |
| 10.0 | 2.32 | 2.14 | 2.23 |
| 20.0 | 3.59 | 3.79 | 3.69 |
| 30.0 | 5.96 | 6.06 | 6.01 |
| 40.0 | 8.46 | 8.32 | 8.39 |
| 50.0 | 11.95 | 11.92 | 11.93 |

TEST SUMMARY :

| VEHICLE SPEED (MPH) | TIME (SEC) | ACCELERATION (FT/SEC^2) | MAX. GRADE (%) |
|---|---|---|---|
| 1.0 | .17 | 8.5 | 27.5 |
| 5.0 | .87 | 8.2 | 26.4 |
| 10.0 | 1.79 | 7.8 | 24.8 |
| 15.0 | 2.76 | 7.3 | 23.3 |
| 20.0 | 3.79 | 6.9 | 21.9 |
| 25.0 | 4.90 | 6.5 | 20.4 |
| 30.0 | 6.07 | 6.0 | 19.1 |
| 35.0 | 7.33 | 5.6 | 17.7 |
| 40.0 | 8.69 | 5.2 | 16.4 |
| 45.0 | 10.15 | 4.8 | 15.1 |
| 50.0 | 11.74 | 4.4 | 13.9 |

NOTE : Gradeability results were calculated from performance test data. Actual sustained gradeability performance for vehicles equipped with auto transmission may be lower than the values indicated here.


Velocity vs. Time
Eldorado National #0809
Speed (mph)
50
45
40
35
30
25
20
15
10
5
0
0
2
4
6
8
10
12
Time (sec)

# 5. STRUCTURAL INTEGRITY

## 5.1 STRUCTURAL STRENGTH AND DISTORTION TESTS - STRUCTURAL SHAKEDOWN TEST

### 5.1-I. DISCUSSION

The objective of this test is to determine certain static characteristics (e.g., bus floor 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 blocking the vehicle under the suspension points. The bus will then be loaded and unloaded up to a maximum of three times with a distributed load equal to 2.5 times gross load. Gross load is 150 lb for every designed passenger seating position, for the driver, and for each 1.5 sq ft 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 sq ft of free floor space. The first loading and unloading sequence will "settle" the structure. Bus deflection will be measured at several locations during the loading sequences.

### 5.1-III. DISCUSSION

This test was performed based on a maximum passenger capacity of 5 people including the driver and 1 wheelchair position. The resulting test load is (5 x 375 lb) = 1,875 lbs = 600 lbs (1 wheelchair position) = 2,475 lbs. The load is distributed evenly over the passenger space. Deflection data before and after each loading and unloading sequence is provided on the Structural Shakedown Data Form.

The unloaded height after each test becomes the original height for the next test. Some initial settling is expected due to undercoat compression, etc. After each loading cycle, the deflection of each reference point is determined. The bus is then unloaded and the residual (permanent) deflection is recorded. On the final test, the maximum loaded deflection was 0.053 inches at reference point 7. The maximum permanent deflection after the final loading sequence ranged from -0.006 inches at reference point 4 to 0. 006 inches at reference point 8.

## STRUCTURAL SHAKEDOWN DATA FORM

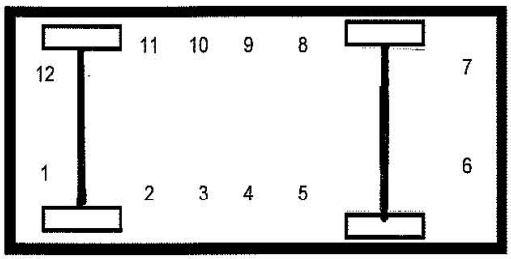
| | |
|---|---|
| Bus Number: 0809 | Date: 6-23-08 |
| Personnel: T.S., P.S. & E.D. | Temperature (°F): 74 |
| Loading Sequence: ■ 1 □ 2 □ 3 (check one)<br>Test Load (lbs): 3,450 | |

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 | B-A (in) Loaded Deflection | C (in) Unloaded Height | C-A (in) Permanent Deflection |
|---|---|---|---|---|---|
| 1 | 0 | -.047 | -.047 | -.005 | -.005 |
| 2 | 0 | .022 | .022 | .012 | .012 |
| 3 | 0 | .011 | .011 | .012 | .012 |
| 4 | 0 | .007 | .007 | -.006 | -.006 |
| 5 | 0 | -.009 | -.009 | -.005 | -.005 |
| 6 | 0 | .068 | .068 | .017 | .017 |
| 7 | 0 | .095 | .095 | .040 | .040 |
| 8 | 0 | .078 | .078 | .068 | .068 |
| 9 | 0 | .049 | .049 | .035 | .035 |
| 10 | 0 | .026 | .026 | .007 | .007 |
| 11 | 0 | .007 | .007 | -.001 | -.001 |
| 12 | 0 | -.042 | -.042 | -.002 | -.002 |

## STRUCTURAL SHAKEDOWN DATA FORM

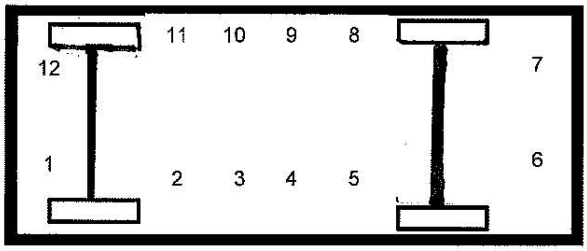
| | |
|---|---|
| Bus Number: 0809 | Date: 6-23-08 |
| Personnel: T.S., P.S. & E.D. | Temperature (°F): 74 |
| Loading Sequence: □ 1 ■ 2 □ 3 (check one)<br>Test Load (lbs): 3,450 | |

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 | B-A (in) Loaded Deflection | C (in) Unloaded Height | C-A (in) Permanent Deflection |
|---|---|---|---|---|---|
| 1 | -.005 | -.045 | -.040 | -.003 | -.002 |
| 2 | .012 | .036 | .024 | .018 | .002 |
| 3 | .012 | .029 | .017 | .012 | .000 |
| 4 | -.006 | .008 | -.014 | .000 | -.006 |
| 5 | -.005 | -.016 | -.011 | -.010 | -.005 |
| 6 | .017 | .066 | .049 | .013 | .004 |
| 7 | .040 | .093 | .053 | .035 | .005 |
| 8 | .068 | .081 | .013 | .062 | .006 |
| 9 | .035 | .059 | .024 | .037 | .002 |
| 10 | .007 | .024 | .017 | .010 | .003 |
| 11 | -.001 | .006 | -.005 | .000 | -.001 |
| 12 | -.002 | -.042 | -.040 | -.002 | .000 |

## 5.1 STRUCTURAL SHAKEDOWN TEST

**DIAL INDICATORS IN POSITION**

**BUS LOADED TO 2.5 TIMES GVL (2,475 LBS)**

# 5.2 STRUCTURAL STRENGTH AND DISTORTION TESTS - STRUCTURAL DISTORTION

## 5.2-I. TEST OBJECTIVE

The objective of this test is to observe the operation of the bus subsystems when the bus is placed in a longitudinal twist simulating operation over a curb or through a pothole.

## 5.2-II. TEST DESCRIPTION

With the bus loaded to GVWR, each wheel of the bus will be raised (one at a time) to simulate operation over a curb and the following will be inspected:

1. Body
2. Windows
3. Doors
4. Roof vents
5. Special seating
6. Undercarriage
7. Engine
8. Service doors
9. Escape hatches
10. Steering mechanism

Each wheel will then be lowered (one at a time) to simulate operation through a pothole and the same items inspected.

## 5.2-III. DISCUSSION

The test sequence was repeated ten times. The first and last test is with all wheels level. The other eight tests are with each wheel 6 inches higher and 6 inches lower than the other three wheels.

All doors, windows, escape mechanisms, engine, steering and handicapped devices operated normally throughout the test. The undercarriage and body indicated no deficiencies. No water leakage was observed during the test. The results of this test are indicated on the following data forms.

**DISTORTION TEST INSPECTION FORM**
(Note: Ten copies of this data sheet are required)

| | |
|---|---|
| Bus Number: 0809 | Date: 6-23-08 |
| Personnel: T.S., S.C., E.D. & P.S. | Temperature(°F): 78 |

| Wheel Position : (check one) | | |
|---|---|---|
| All wheels level | ■ before | □ after |
| Left front | □ 6 in higher | □ 6 in lower |
| Right front | □ 6 in higher | □ 6 in lower |
| Right rear | □ 6 in higher | □ 6 in lower |
| Left rear | □ 6 in higher | □ 6 in lower |
| Right center | □ 6 in higher | □ 6 in lower |
| Left center | □ 6 in higher | □ 6 in lower |

| | Comments |
|---|---|
| ■ Windows | No deficiencies. |
| ■ Front Doors | No deficiencies. |
| ■ Rear Doors | No deficiencies. |
| ■ Escape Mechanisms/ Roof Vents | No deficiencies. |
| ■ Engine | No deficiencies. |
| ■ Handicapped Device/ Special Seating | No deficiencies. |
| ■ Undercarriage | No deficiencies. |
| ■ Service Doors | No deficiencies. |
| ■ Body | No deficiencies. |
| ■ Windows/ Body Leakage | No deficiencies. |
| ■ Steering Mechanism | No deficiencies. |

**DISTORTION TEST INSPECTION FORM**
(Note: Ten copies of this data sheet are required)

| | |
|---|---|
| Bus Number: 0809 | Date: 6-23-08 |
| Personnel: T.S., S.C., E.D. & P.S. | Temperature(°F): 78 |

| Wheel Position : (check one) | | |
|---|---|---|
| All wheels level | □ before | □ after |
| Left front | ■ 6 in higher | □ 6 in lower |
| Right front | □ 6 in higher | □ 6 in lower |
| Right rear | □ 6 in higher | □ 6 in lower |
| Left rear | □ 6 in higher | □ 6 in lower |
| Right center | □ 6 in higher | □ 6 in lower |
| Left center | □ 6 in higher | □ 6 in lower |

| | Comments |
|---|---|
| ■ Windows | No deficiencies. |
| ■ Front Doors | No deficiencies. |
| ■ Rear Doors | No deficiencies. |
| ■ Escape Mechanisms/ Roof Vents | No deficiencies. |
| ■ Engine | No deficiencies. |
| ■ Handicapped Device/ Special Seating | No deficiencies. |
| ■ Undercarriage | No deficiencies. |
| ■ Service Doors | No deficiencies. |
| ■ Body | No deficiencies. |
| ■ Windows/ Body Leakage | No deficiencies. |
| ■ Steering Mechanism | No deficiencies. |

**DISTORTION TEST INSPECTION FORM**
(Note: Ten copies of this data sheet are required)

| | |
|---|---|
| Bus Number: 0809 | Date: 6-23-08 |
| Personnel: T.S., S.C., E.D. & P.S. | Temperature(°F): 78 |

| Wheel Position : (check one) | | |
|---|---|---|
| All wheels level | □ before | □ after |
| Left front | □ 6 in higher | □ 6 in lower |
| Right front | ■ 6 in higher | □ 6 in lower |
| Right rear | □ 6 in higher | □ 6 in lower |
| Left rear | □ 6 in higher | □ 6 in lower |
| Right center | □ 6 in higher | □ 6 in lower |
| Left center | □ 6 in higher | □ 6 in lower |

| | Comments |
|---|---|
| ■ Windows | No deficiencies. |
| ■ Front Doors | No deficiencies. |
| ■ Rear Doors | No deficiencies. |
| ■ Escape Mechanisms/ Roof Vents | No deficiencies. |
| ■ Engine | No deficiencies. |
| ■ Handicapped Device/ Special Seating | No deficiencies. |
| ■ Undercarriage | No deficiencies. |
| ■ Service Doors | No deficiencies. |
| ■ Body | No deficiencies. |
| ■ Windows/ Body Leakage | No deficiencies. |
| ■ Steering Mechanism | No deficiencies. |

**DISTORTION TEST INSPECTION FORM**
(Note: Ten copies of this data sheet are required)

| | |
|---|---|
| Bus Number: 0809 | Date: 6-23-08 |
| Personnel: T.S., S.C., E.D. & P.S. | Temperature(°F): 78 |

| Wheel Position : (check one) | | |
|---|---|---|
| All wheels level | □ before | □ after |
| Left front | □ 6 in higher | □ 6 in lower |
| Right front | □ 6 in higher | □ 6 in lower |
| Right rear | ■ 6 in higher | □ 6 in lower |
| Left rear | □ 6 in higher | □ 6 in lower |
| Right center | □ 6 in higher | □ 6 in lower |
| Left center | □ 6 in higher | □ 6 in lower |

| | Comments |
|---|---|
| ■ Windows | No deficiencies. |
| ■ Front Doors | No deficiencies. |
| ■ Rear Doors | No deficiencies. |
| ■ Escape Mechanisms/ Roof Vents | No deficiencies. |
| ■ Engine | No deficiencies. |
| ■ Handicapped Device/ Special Seating | No deficiencies. |
| ■ Undercarriage | No deficiencies. |
| ■ Service Doors | No deficiencies. |
| ■ Body | No deficiencies. |
| ■ Windows/ Body Leakage | No deficiencies. |
| ■ Steering Mechanism | No deficiencies. |

**DISTORTION TEST INSPECTION FORM**
(Note: Ten copies of this data sheet are required)

| | |
|---|---|
| Bus Number: 0809 | Date: 6-23-08 |
| Personnel: T.S., S.C., E.D. & P.S. | Temperature(°F): 78 |

| Wheel Position : (check one) | | |
|---|---|---|
| All wheels level | □ before | □ after |
| Left front | □ 6 in higher | □ 6 in lower |
| Right front | □ 6 in higher | □ 6 in lower |
| Right rear | □ 6 in higher | □ 6 in lower |
| Left rear | ■ 6 in higher | □ 6 in lower |
| Right center | □ 6 in higher | □ 6 in lower |
| Left center | □ 6 in higher | □ 6 in lower |

| | Comments |
|---|---|
| ■ Windows | No deficiencies. |
| ■ Front Doors | No deficiencies. |
| ■ Rear Doors | No deficiencies. |
| ■ Escape Mechanisms/ Roof Vents | No deficiencies. |
| ■ Engine | No deficiencies. |
| ■ Handicapped Device/ Special Seating | No deficiencies. |
| ■ Undercarriage | No deficiencies. |
| ■ Service Doors | No deficiencies. |
| ■ Body | No deficiencies. |
| ■ Windows/ Body Leakage | No deficiencies. |
| ■ Steering Mechanism | No deficiencies. |

**DISTORTION TEST INSPECTION FORM**
(Note: Ten copies of this data sheet are required)

| | |
|---|---|
| Bus Number: 0809 | Date: 6-23-08 |
| Personnel: T.S., S.C., E.D. & P.S. | Temperature(°F): 78 |

| Wheel Position : (check one) | | |
|---|---|---|
| All wheels level | □ before | □ after |
| Left front | □ 6 in higher | □ 6 in lower |
| Right front | □ 6 in higher | □ 6 in lower |
| Right rear | □ 6 in higher | □ 6 in lower |
| Left rear | □ 6 in higher | ■ 6 in lower |
| Right center | □ 6 in higher | □ 6 in lower |
| Left center | □ 6 in higher | □ 6 in lower |

| | Comments |
|---|---|
| ■ Windows | No deficiencies. |
| ■ Front Doors | No deficiencies. |
| ■ Rear Doors | No deficiencies. |
| ■ Escape Mechanisms/ Roof Vents | No deficiencies. |
| ■ Engine | No deficiencies. |
| ■ Handicapped Device/ Special Seating | No deficiencies. |
| ■ Undercarriage | No deficiencies. |
| ■ Service Doors | No deficiencies. |
| ■ Body | No deficiencies. |
| ■ Windows/ Body Leakage | No deficiencies. |
| ■ Steering Mechanism | No deficiencies. |

**DISTORTION TEST INSPECTION FORM**
(Note: Ten copies of this data sheet are required)

| | |
|---|---|
| Bus Number: 0809 | Date: 6-23-08 |
| Personnel: T.S., S.C., E.D. & P.S. | Temperature(°F): 78 |

| Wheel Position : (check one) | | |
|---|---|---|
| All wheels level | □ before | □ after |
| Left front | □ 6 in higher | □ 6 in lower |
| Right front | □ 6 in higher | □ 6 in lower |
| Right rear | □ 6 in higher | ■ 6 in lower |
| Left rear | □ 6 in higher | □ 6 in lower |
| Right center | □ 6 in higher | □ 6 in lower |
| Left center | □ 6 in higher | □ 6 in lower |

| | Comments |
|---|---|
| ■ Windows | No deficiencies. |
| ■ Front Doors | No deficiencies. |
| ■ Rear Doors | No deficiencies. |
| ■ Escape Mechanisms/ Roof Vents | No deficiencies. |
| ■ Engine | No deficiencies. |
| ■ Handicapped Device/ Special Seating | No deficiencies. |
| ■ Undercarriage | No deficiencies. |
| ■ Service Doors | No deficiencies. |
| ■ Body | No deficiencies. |
| ■ Windows/ Body Leakage | No deficiencies. |
| ■ Steering Mechanism | No deficiencies. |

**DISTORTION TEST INSPECTION FORM**
(Note: Ten copies of this data sheet are required)

| | |
|---|---|
| Bus Number: 0809 | Date: 6-23-08 |
| Personnel: T.S., S.C., E.D. & P.S. | Temperature(°F): 78 |

| Wheel Position : (check one) | | |
|---|---|---|
| All wheels level | □ before | □ after |
| Left front | □ 6 in higher | □ 6 in lower |
| Right front | □ 6 in higher | ■ 6 in lower |
| Right rear | □ 6 in higher | □ 6 in lower |
| Left rear | □ 6 in higher | □ 6 in lower |
| Right center | □ 6 in higher | □ 6 in lower |
| Left center | □ 6 in higher | □ 6 in lower |

| | Comments |
|---|---|
| ■ Windows | No deficiencies. |
| ■ Front Doors | No deficiencies. |
| ■ Rear Doors | No deficiencies. |
| ■ Escape Mechanisms/ Roof Vents | No deficiencies. |
| ■ Engine | No deficiencies. |
| ■ Handicapped Device/ Special Seating | No deficiencies. |
| ■ Undercarriage | No deficiencies. |
| ■ Service Doors | No deficiencies. |
| ■ Body | No deficiencies. |
| ■ Windows/ Body Leakage | No deficiencies. |
| ■ Steering Mechanism | No deficiencies. |

**DISTORTION TEST INSPECTION FORM**
(Note: Ten copies of this data sheet are required)

| | |
|---|---|
| Bus Number: 0809 | Date: 6-23-08 |
| Personnel: T.S., S.C., E.D. & P.S. | Temperature(°F): 78 |

| Wheel Position : (check one) | | |
|---|---|---|
| All wheels level | □ before | □ after |
| Left front | □ 6 in higher | ■ 6 in lower |
| Right front | □ 6 in higher | □ 6 in lower |
| Right rear | □ 6 in higher | □ 6 in lower |
| Left rear | □ 6 in higher | □ 6 in lower |
| Right center | □ 6 in higher | □ 6 in lower |
| Left center | □ 6 in higher | □ 6 in lower |

| | Comments |
|---|---|
| ■ Windows | No deficiencies. |
| ■ Front Doors | No deficiencies. |
| ■ Rear Doors | No deficiencies. |
| ■ Escape Mechanisms/ Roof Vents | No deficiencies. |
| ■ Engine | No deficiencies. |
| ■ Handicapped Device/ Special Seating | No deficiencies. |
| ■ Undercarriage | No deficiencies. |
| ■ Service Doors | No deficiencies. |
| ■ Body | No deficiencies. |
| ■ Windows/ Body Leakage | No deficiencies. |
| ■ Steering Mechanism | No deficiencies. |

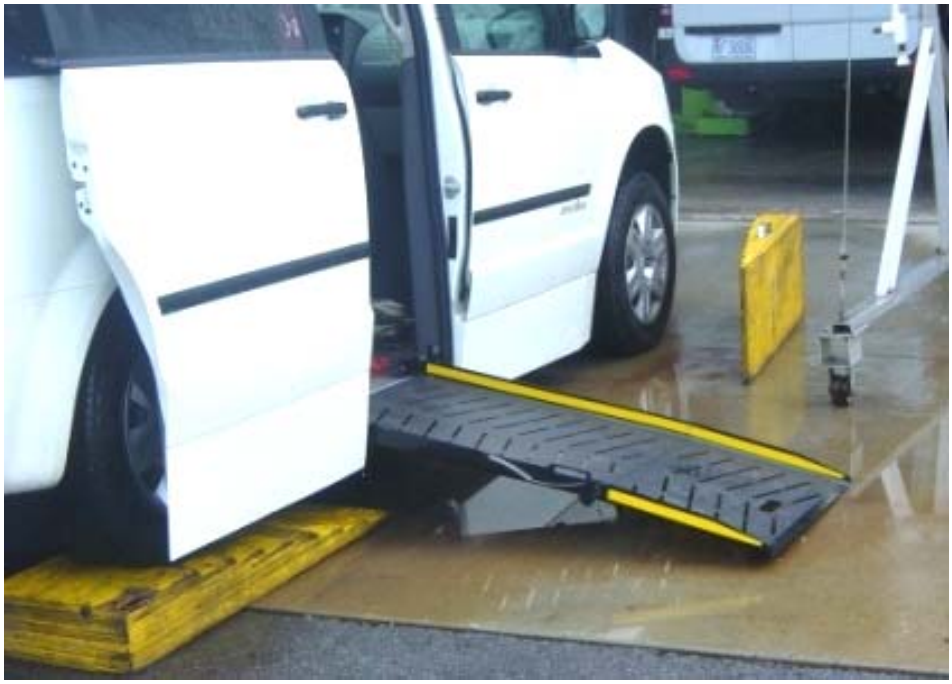
**DISTORTION TEST INSPECTION FORM**
(Note: Ten copies of this data sheet are required)

| | |
|---|---|
| Bus Number: 0809 | Date: 6-23-08 |
| Personnel: T.S., S.C., E.D. & P.S. | Temperature(°F): 78 |

| Wheel Position : (check one) | | |
|---|---|---|
| All wheels level | □ before | ■ after |
| Left front | □ 6 in higher | □ 6 in lower |
| Right front | □ 6 in higher | □ 6 in lower |
| Right rear | □ 6 in higher | □ 6 in lower |
| Left rear | □ 6 in higher | □ 6 in lower |
| Right center | □ 6 in higher | □ 6 in lower |
| Left center | □ 6 in higher | □ 6 in lower |

| | Comments |
|---|---|
| ■ Windows | No deficiencies. |
| ■ Front Doors | No deficiencies. |
| ■ Rear Doors | No deficiencies. |
| ■ Escape Mechanisms/ Roof Vents | No deficiencies. |
| ■ Engine | No deficiencies. |
| ■ Handicapped Device/ Special Seating | No deficiencies. |
| ■ Undercarriage | No deficiencies |
| ■ Service Doors | No deficiencies. |
| ■ Body | No deficiencies. |
| ■ Windows/ Body Leakage | No deficiencies. |
| ■ Steering Mechanism | No deficiencies. |

## 5.2 STRUCTURAL DISTORTION TEST



**RIGHT FRONT WHEEL SIX INCHES LOWER**

**LEFT FRONT WHEEL SIX INCHES LOWER**

# 5.3 STRUCTURAL STRENGTH AND DISTORTION TESTS - STATIC TOWING TEST

## 5.3-I. TEST OBJECTIVE

The objective of this test is to determine the characteristics of the bus towing mechanisms under static loading conditions.

## 5.3-II. TEST DESCRIPTION

Utilizing a load-distributing yoke, a hydraulic cylinder is used to apply a static tension load equal to 1.2 times the bus curb weight. The load will be applied to both the front and rear, if applicable, towing fixtures at an angle of 20 degrees with the longitudinal axis of the bus, first to one side then the other in the horizontal plane, and then upward and downward in the vertical plane. Any permanent deformation or damage to the tow eyes or adjoining structure will be recorded.

## 5.3-III. DISCUSSION

The test bus submitted for testing was not equipped with any type of tow eyes or tow hooks, therefore, the Static Towing Test was not performed.

# 5.4 STRUCTURAL STRENGTH AND DISTORTION TESTS - DYNAMIC TOWING TEST

## 5.4-I. TEST OBJECTIVE

The objective of this test is to verify the integrity of the towing fixtures and determine the feasibility of towing the bus under manufacturer specified procedures.

## 5.4-II. TEST DESCRIPTION

This test requires the bus be towed at curb weight using the specified equipment and instructions provided by the manufacturer and a heavy-duty wrecker. The bus will be towed for 5 miles at a speed of 20 mph for each recommended towing configuration. After releasing the bus from the wrecker, the bus will be visually inspected for any structural damage or permanent deformation. All doors, windows and passenger escape mechanisms will be inspected for proper operation.

## 5.4-III. DISCUSSION

The bus was towed using a heavy-duty wrecker. The towing interface was accomplished by incorporating a hydraulic under lift. A front lift tow was performed. Rear towing is not recommended. No problems, deformation, or damage was noted during testing.

# DYNAMIC TOWING TEST DATA FORM

| | |
|---|---|
| Bus Number: 0809 | Date: 9-19-08 |
| Personnel: S.C. | |

| | |
|---|---|
| Temperature (°F): 59 | Humidity (%): 75 |
| Wind Direction: Calm | Wind Speed (mph): Calm |
| Barometric Pressure (in.Hg): 30.11 | |

| |
|---|
| **Inspect tow equipment-bus interface.** |
| **Comments:** A safe and adequate connection was made between the tow equipment and the bus. |
| **Inspect tow equipment-wrecker interface.** |
| **Comments:** A safe and adequate connection was made between the tow equipment and the wrecker. |
| **Towing Comments:** A front lift tow was performed incorporating a hydraulic under lift wrecker. |
| |
| |
| **Description and location of any structural damage:** No damage or deformation was observed. |
| **General Comments:** No problems with the tow or towing interface were encountered. |
| |
| |

## 5.4 DYNAMIC TOWING TEST

**TOWING INTERFACE**

# 5.5 STRUCTURAL STRENGTH AND DISTORTION TESTS – JACKING TEST

## 5.5-I. TEST OBJECTIVE

The objective of this test is to inspect for damage due to the deflated tire, and determine the feasibility of jacking the bus with a portable hydraulic jack to a height sufficient to replace a deflated tire.

## 5.5-II. TEST DESCRIPTION

With the bus at curb weight, the tire(s) at one corner of the bus are replaced with deflated tire(s) of the appropriate type. A portable hydraulic floor jack is then positioned in a manner and location specified by the manufacturer and used to raise the bus to a height sufficient to provide 3-in clearance between the floor and an inflated tire. The deflated tire(s) are replaced with the original tire(s) and the hack is lowered. Any structural damage or permanent deformation is recorded on the test data sheet. This procedure is repeated for each corner of the bus.

## 5.5-III. DISCUSSION

The jack used for this test has a minimum height of 8.75 inches. During the deflated portion of the test, the jacking point clearances ranged from 3.0 inches to 4.5 inches. No deformation or damage was observed during testing. A complete listing of jacking point clearances is provided in the Jacking Test Data Form.

**JACKING CLEARANCE SUMMARY**

| Condition | Frame Point Clearance |
|---|---|
| Front axle – one tire flat | 3.0” |
| Rear axle – one tire flat | 4.3” |
| Rear axle – two tires flat | NA |

# JACKING TEST DATA FORM

| | |
|---|---|
| Bus Number: 0809 | Date: 6-23-08 |
| Personnel: T.S & P.S. | Temperature (°F): 70 |

Record any permanent deformation or damage to bus as well as any difficulty encountered during jacking procedure.

| Deflated Tire | Jacking Pad Clearance Body/Frame (in) | Jacking Pad Clearance Axle/Suspension (in) | Comments |
|---|---|---|---|
| Right front | 5.4 " I<br>3.0 " D | 7.1 " I<br>4.5 " D | |
| Left front | 5.4 " I<br>3.0 " D | 7.1 " I<br>4.5 " D | |
| Right rear—outside | 6.7 " I<br>4.3 " D | 5.8 " I<br>3.1 " D | |
| Right rear—both | NA | NA | |
| Left rear—outside | 6.7 " I<br>4.3 " D | 5.8 " I<br>3.1 " D | |
| Left rear—both | NA | NA | |
| Right middle or tag—outside | NA | NA | |
| Right middle or tag—both | NA | NA | |
| Left middle or tag—outside | NA | NA | |
| Left middle or tag—both | NA | NA | |

**Additional comments of any deformation or difficulty during jacking**:

None noted.

# 5.6 STRUCTURAL STRENGTH AND DISTORTION TESTS - HOISTING TEST

## 5.6-I. TEST OBJECTIVE

The objective of this test is to determine possible damage or deformation caused by the jack/stands.

## 5.6-II. TEST DESCRIPTION

With the bus at curb weight, the front end of the bus is raised to a height sufficient to allow manufacturer-specified placement of jack stands under the axles or jacking pads independent of the hoist system. The bus will be checked for stability on the jack stands and for any damage to the jacking pads or bulkheads. The procedure is repeated for the rear end of the bus. The procedure is then repeated for the front and rear simultaneously.

## 5.6-III. DISCUSSION

The test was conducted using four posts of a six-post electric lift and standard 19 inch jack stands. The bus was hoisted from the front wheel, rear wheel, and then the front and rear wheels simultaneously and placed on jack stands.

The bus easily accommodated the placement of the vehicle lifts and jack stands and the procedure was performed without any instability noted.

# HOISTING TEST DATA FORM

| | |
|---|---|
| Bus Number: 0809 | Date: 6-23-08 |
| Personnel: T.S. & P.S. | Temperature (°F): 70 |

| |
|---|
| **Comments of any structural damage to the jacking pads or axles while both the front wheels are supported by the jack stands:** |
| None noted. |
| |
| |
| |
| |
| **Comments of any structural damage to the jacking pads or axles while both the rear wheels are supported by the jack stands:** |
| None noted. |
| |
| |
| |
| |
| **Comments of any structural damage to the jacking pads or axles while both the front and rear wheels are supported by the jack stands:** |
| None noted. |
| |
| |
| |
| |
| |
| |

# 5.7 STRUCTURAL DURABILITY TEST

## 5.7-I. TEST OBJECTIVE

The objective of this test is to perform an accelerated durability test that approximates up to 25 percent of the service life of the vehicle.

## 5.7-II. TEST DESCRIPTION

The test vehicle is driven a total of 3,800 miles; approximately 2,500 miles on the PSBRTF Durability Test Track and approximately 1,300 miscellaneous other miles. The test will be conducted with the bus operated under three different loading conditions. The first segment will consist of approximately 1,500 miles with the bus operated at GVW. The second segment will consist of approximately 800 miles with the bus operated at SLW. The remainder of the test, approximately 1,500 miles, will be conducted with the bus loaded to CW. If GVW exceeds the axle design weights, then the load will be adjusted to the axle design weights and the change will be recorded. All subsystems are run during these tests in their normal operating modes. All recommended manufacturers servicing is to be followed and noted on the vehicle maintainability log. Servicing items accelerated by the durability tests will be compressed by 10:1; all others will be done on a 1:1 mi/mi basis. Unscheduled breakdowns and repairs are recorded on the same log as are any unusual occurrences as noted by the driver. Once a week the test vehicle shall be washed down and thoroughly inspected for any signs of failure.

## 5.7-III. DISCUSSION

The Structural Durability Test was started on June 24, 2008 and was conducted until August 25, 2008. The first 1,500 miles were performed at a GVW of 5,990 lbs. and completed on August 1, 2008. The next 800 mile SLW segment was performed at the same 5,990 lbs and completed on August 11, 2008, and the final 1,500 mile segment was performed at a CW of 4,550 lbs and completed on August 25, 2008.

The following mileage summary presents the accumulation of miles during the Structural Durability Test. The driving schedule is included, showing the operating duty cycle. A detailed plan view of the Test Track Facility and Durability Test Track are attached for reference. Also, a durability element profile detail shows all the measurements of the different conditions. Finally, photographs illustrating some of the failures that were encountered during the Structural Durability Test are included.

**ELDORADO - TEST BUS #0809**

MILEAGE DRIVEN/RECORDED FROM DRIVER'S LOGS

| DATE | TOTAL DURABILITY TRACK | TOTAL OTHER MILES | TOTAL |
|---|---|---|---|
| 06/23/08 TO 06/29/08 | 0.00 | 101.00 | 101.00 |
| 06/30/08 TO 07/06/08 | 0.00 | 0.00 | 0.00 |
| 07/07/08 TO 07/13/08 | 72.00 | 51.00 | 123.00 |
| 07/14/08 TO 07/20/08 | 170.00 | 8.00 | 178.00 |
| 07/21/08 TO 07/27/08 | 0.00 | 0.00 | 0.00 |
| 07/28/08 TO 08/03/08 | 789.00 | 210.00 | 999.00 |
| 08/04/08 TO 08/10/08 | 444.00 | 22.00 | 466.00 |
| 08/11/08 TO 08/17/08 | 618.00 | 29.00 | 647.00 |
| 08/18/08 TO 08/24/08 | 411.00 | 736.00 | 1147.00 |
| 08/25/08 TO 08/31/08 | 0.00 | 90.00 | 90.00 |
| | | | |
| TOTAL | 2504.00 | 1247.00 | 3751.00 |

Table 4. Driving Schedule for Bus Operation on the Durability Test Track.

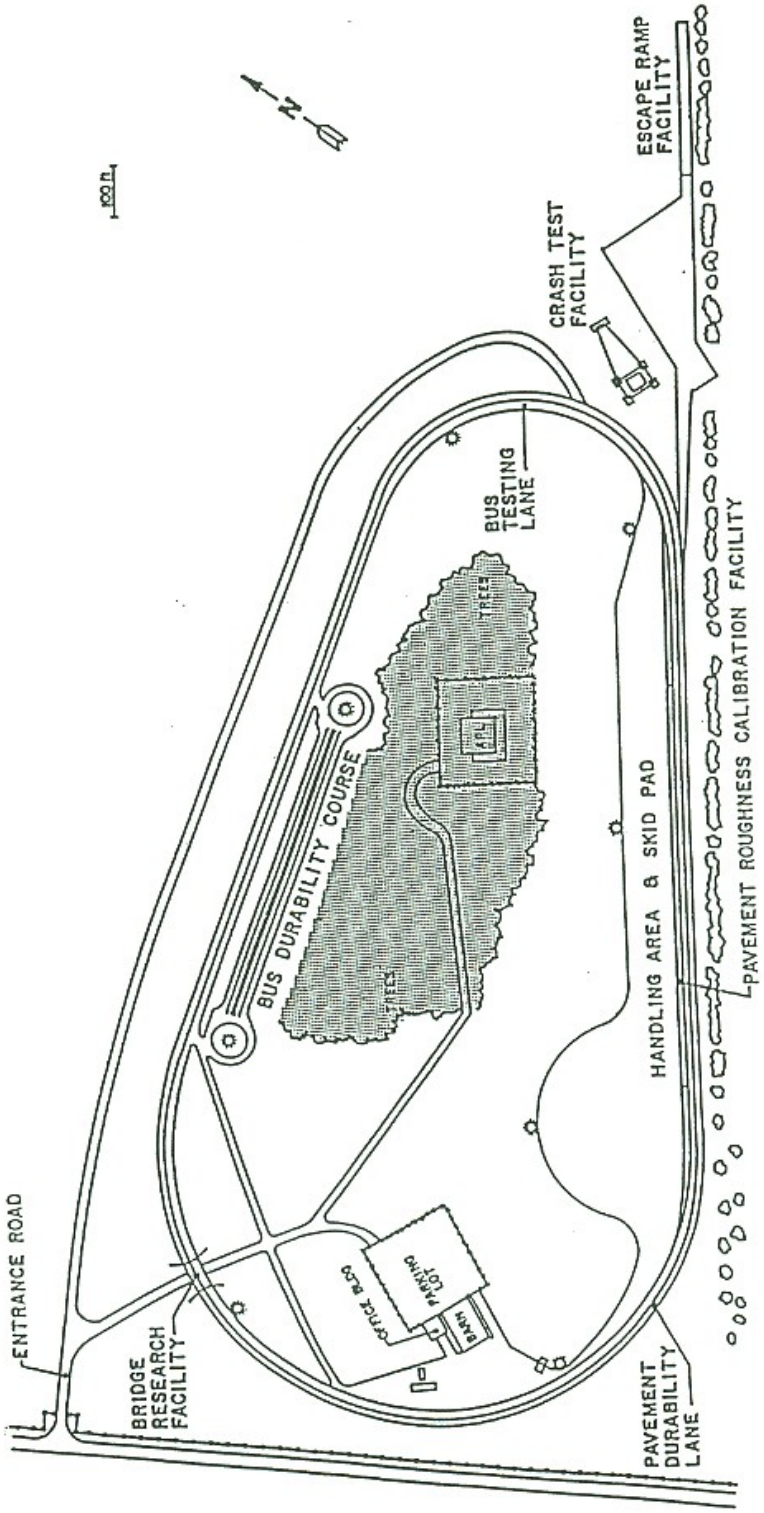
STANDARD OPERATING SCHEDULE

Monday through Friday

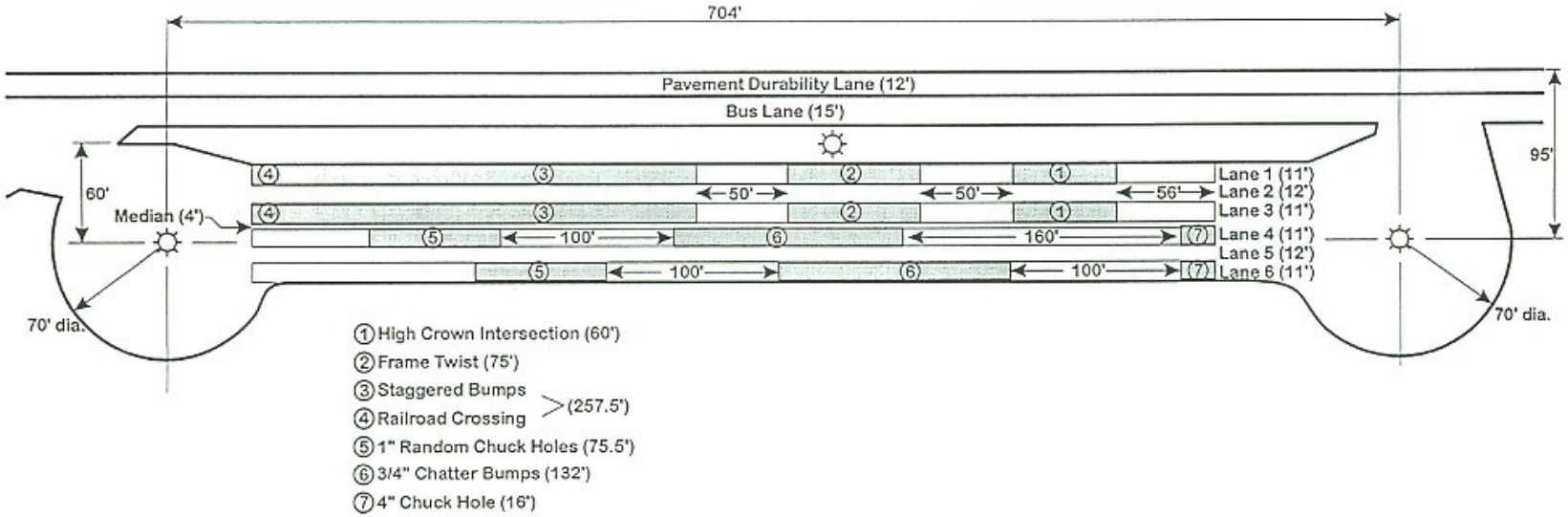
| | HOUR | ACTION |
|---|---|---|
| Shift 1 | midnight | D |
| | 1:40 am | C |
| | 1:50 am | B |
| | 2:00 am | D |
| | 3:35 am | C |
| | 3:45 am | B |
| | 4:05 am | D |
| | 5:40 am | C |
| | 5:50 am | B |
| | 6:00 am | D |
| | 7:40 am | C |
| | 7:50 am | F |
| Shift 2 | 8:00 am | D |
| | 9:40 am | C |
| | 9:50 am | B |
| | 10:00 am | D |
| | 11:35 am | C |
| | 11:45 am | B |
| | 12:05 pm | D |
| | 1:40 pm | C |
| | 1:50 pm | B |
| | 2:00 pm | D |
| | 3:40 pm | C |
| | 3:50 pm | F |
| Shift 3 | 4:00 pm | D |
| | 5:40 pm | C |
| | 5:50 pm | B |
| | 6:00 pm | D |
| | 7:40 pm | C |
| | 7:50 pm | B |
| | 8:05 pm | D |
| | 9:40 pm | C |
| | 9:50 pm | B |
| | 10:00 pm | D |
| | 11:40 pm | C |
| | 11:50 pm | F |

B----Break
C----Cycle all systems five times, visual inspection, driver's log entries
D----Drive bus as specified by procedure
F----Fuel bus, complete driver's log shift entries

# "PLAN VIEW OF PENN STATE BUS TESTING AND RESEARCH FACILITY"



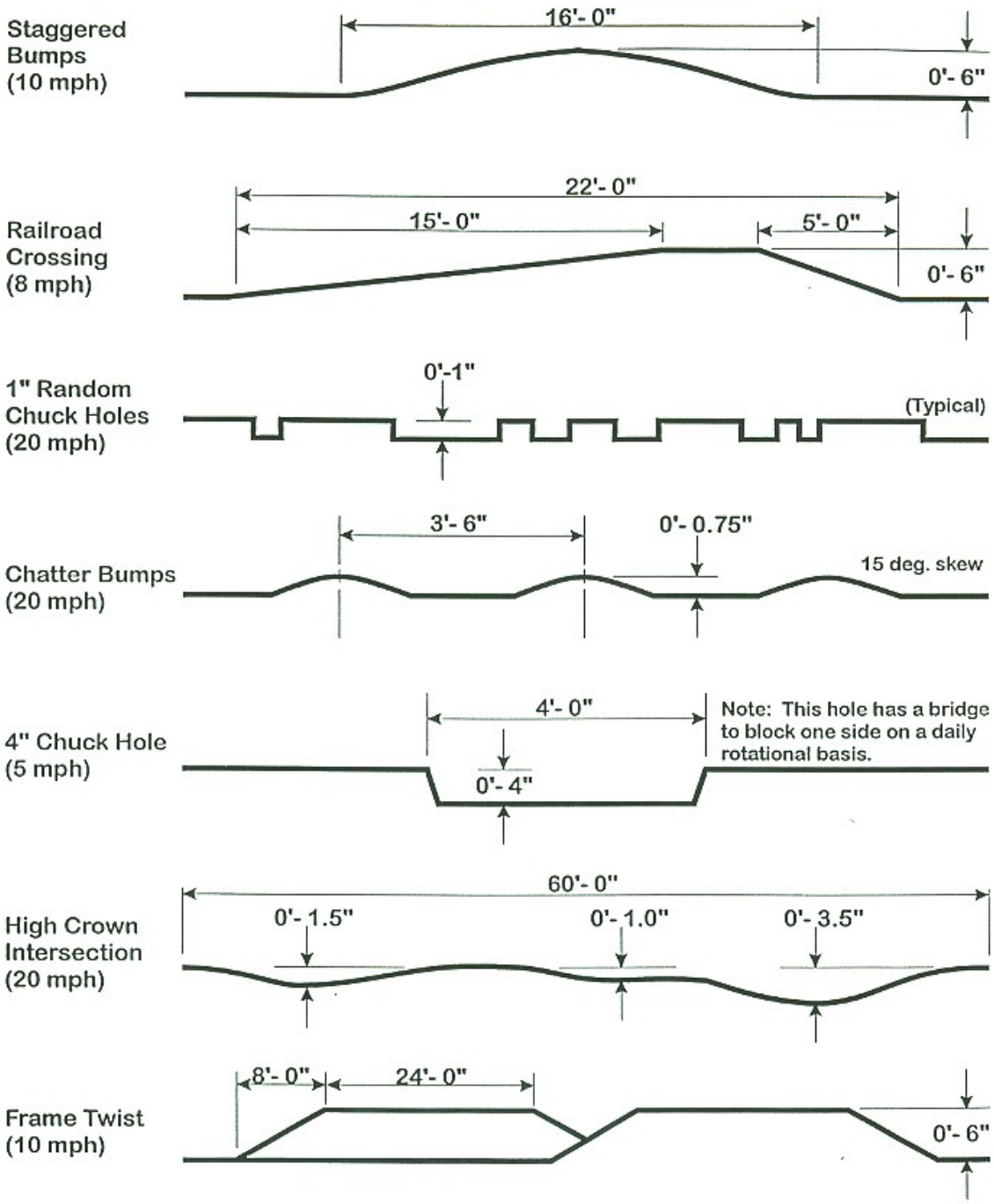

BUS TESTING AND RESEARCH TEST TRACK
UNIVERSITY PARK, PA




Plan View

# Vehicle Durability Test Track

The Pennsylvania Transportation Institute
Penn State




# Durability Element Profiles

The Pennsylvania Transportation Institute
Penn State

**UNSCHEDULED MAINTENANCE**

ElDorado Bus #0809

| DATE | TEST MILES | SERVICE | ACTIVITY | MAN HOURS | DOWN TIME |
|---|---|---|---|---|---|
| 07-07-08 | 101 | Test vehicle is bottoming out on the durability track. | Increased strut spacers to raise test vehicle. | 12.00 | 208.00 |
| 07-14-08 | 224 | The rear suspension will not fill with air. The right rear strut air bag has a hole chaffed due to interference from trailing arm gusset. | Replaced both rear air struts and ground off 0.10" radius rod bolt. | 8.00 | 138.00 |
| 07-18-08 | 299 | Assist manufacturer's rep with following rear air strut modifications. | Replace rear air struts with base mounted lower. Replace the upper radius arm bolts that were ground with machined bolts to prevent contact. | 4.00 | 12.00 |
| 07-28-08 | 452 | The track bar is hitting the rear air struts. | Manufacturer sent in Air Lift suspension techs for modifications. Tech cut the wheel well area and installed mounting brackets for the rear struts approximately 2" inboard of the original mounts. Struts and air compressor replaced. | 8.00 | 128.00 |
| 07-29-08 | 694 | The right rear air strut is blistering. | Replaced right rear air strut. | 4.00 | 2.00 |
| 07-29-08 | 694 | The exhaust pipe is hitting on the Test Track. | Welded/installed rub guard to prevent exhaust pipe from hitting the track. | 3.00 | 1.50 |

**UNSCHEDULED MAINTENANCE**

ElDorado Bus #0809

| DATE | TEST MILES | SERVICE | ACTIVITY | MAN HOURS | DOWN TIME |
|---|---|---|---|---|---|
| 07-30-08 | 897 | The right rear air strut is leaking air at the top of the bellows. | Replaced right rear air strut. | 3.00 | 4.00 |
| 08-04-08 | 1,401 | The left front tire is flat. | Plugged left front tire. | 1.00 | 10.00 |
| 08-12-08 | 2,045 | The "ABS", "ESC" and "BAS" lights are on. | Replaced right rear broken "ABS" wheel sensor. (Broken wire). | 2.00 | 13.00 |
| 08-12-08 | 2,045 | The right rear air strut is leaking at the upper bellows crimp. | Replaced right rear air strut. | 2.00 | 1.00 |
| 08-13-08 | 2,150 | The left rear air strut is leaking at the upper bellows crimp. | Replaced left rear air strut. | 2.00 | 10.00 |
| 08-20-08 | 2,581 | The right rear air strut is leaking at the upper crimp. | Replaced right rear air strut. | 2.00 | 32.00 |

## UNSCHEDULED MAINTENANCE CONT.

## TEST VEHICLE BOTTOMING OUT ON TEST TRACK ELEMENTS (101 TEST MILES)

## UNSCHEDULED MAINTENANCE CONT.

**RIGHT REAR STRUT AIR BAG CHAFFED DO TO INTERFERENCE WITH TRAILING ARM (224 TEST MILES)**

**AIR COMPRESSOR REPLACED (452 TEST MILES)**

# UNSCHEDULED MAINTENANCE CONT.

**RIGHT REAR AIR STRUT IS BLISTERING**
**(897 TEST MILES)**

**FAILED “ABS” SENSOR**
**(2,045 TEST MILES)**

# 6. FUEL ECONOMY TEST - A FUEL CONSUMPTION TEST USING AN APPROPRIATE OPERATING CYCLE

## 6-I. TEST OBJECTIVE

The objective of this test is to provide accurate comparable fuel consumption data on transit buses produced by different manufacturers. This fuel economy test bears no relation to the calculations done by the Environmental Protection Agency (EPA) to determine levels for the Corporate Average Fuel Economy Program. EPA's calculations are based on tests conducted under laboratory conditions intended to simulate city and highway driving. This fuel economy test, as designated here, is a measurement of the fuel expended by a vehicle traveling a specified test loop under specified operating conditions. The results of this test will not represent actual mileage but will provide data that can be used by recipients to compare buses tested by this procedure.

## 6-II. TEST DESCRIPTION

This test requires operation of the bus over a course based on the Transit Coach Operating Duty Cycle (ADB Cycle) at seated load weight using a procedure based on the Fuel Economy Measurement Test (Engineering Type) For Trucks and Buses: SAE 1376 July 82. The procedure has been modified by elimination of the control vehicle and by modifications as described below. The inherent uncertainty and expense of utilizing a control vehicle over the operating life of the facility is impractical.

The fuel economy test will be performed as soon as possible (weather permitting) after the completion of the GVW portion of the structural durability test. It will be conducted on the bus test lane at the Penn State Test Facility. Signs are erected at carefully measured points which delineate the test course. A test run will comprise 3 CBD phases, 2 Arterial phases, and 1 Commuter phase. An electronic fuel measuring system will indicate the amount of fuel consumed during each phase of the test. The test runs will be repeated until there are at least two runs in both the clockwise and counterclockwise directions in which the fuel consumed for each run is within ± 4 percent of the average total fuel used over the 4 runs. A 20-minute idle consumption test is performed just prior to and immediately after the driven portion of the fuel economy test. The amount of fuel consumed while operating at normal/low idle is recorded on the Fuel Economy Data Form. This set of four valid runs along with idle consumption data comprise a valid test.

The test procedure is the ADB cycle with the following four modifications:

1. The ADB cycle is structured as a set number of miles in a fixed time in the following order: CBD, Arterial, CBD, Arterial, CBD, and Commuter. A separate idle fuel consumption measurement is performed at the beginning and end of the fuel economy test. This phase sequence permits the reporting of fuel consumption for each of these phases separately, making the data more useful to bus manufacturers and transit properties.

2. The operating profile for testing purposes shall consist of simulated transit type service at seated load weight. The three test phases (figure 6-1) are: a central business district (CBD) phase of 2 miles with 7 stops per mile and a top speed of 20 mph; an arterial phase of 2 miles with 2 stops per mile and a top speed of 40 mph; and a commuter phase of 4 miles with 1 stop and a maximum speed of 40 mph. At each designated stop the bus will remain stationary for seven seconds. During this time, the passenger doors shall be opened and closed.

3. The individual ADB phases remain unaltered with the exception that 1 mile has been changed to 1 lap on the Penn State Test Track. One lap is equal to 5,042 feet. This change is accommodated by adjusting the cruise distance and time.

4. The acceleration profile, for practical purposes and to achieve better repeatability, has been changed to "full throttle acceleration to cruise speed".

Several changes were made to the Fuel Economy Measurement Test (Engineering Type) For Trucks and Buses: SAE 1376 July 82:

1. Sections 1.1, and 1.2 only apply to diesel, gasoline, methanol, and any other fuel in the liquid state (excluding cryogenic fuels).

1.1 SAE 1376 July 82 requires the use of at least a 16-gal fuel tank. Such a fuel tank when full would weigh approximately 160 lb. It is judged that a 12-gal tank weighing approximately 120 lb will be sufficient for this test and much easier for the technician and test personnel to handle.

1.2 SAE 1376 July 82 mentions the use of a mechanical scale or a flowmeter system. This test procedure uses a load cell readout combination that provides an accuracy of 0.5 percent in weight and permits on-board weighing of the gravimetric tanks at the end of each phase. This modification permits the determination of a fuel economy value for each phase as well as the overall cycle.

2. Section 2.1 applies to compressed natural gas (CNG), liquefied natural gas (LNG), cryogenic fuels, and other fuels in the vapor state.

2.1 A laminar type flowmeter will be used to determine the fuel consumption. The pressure and temperature across the flow element will be monitored by the flow computer. The flow computer will use this data to calculate the gas flow rate. The flow computer will also display the flow rate (scfm) as well as the total fuel used (scf). The total fuel used (scf) for each phase will be recorded on the Fuel Economy Data Form.

3. Use both Sections 1 and 2 for dual fuel systems.

## FUEL ECONOMY CALCULATION PROCEDURE

### A. For diesel, gasoline, methanol and fuels in the liquid state.

The reported fuel economy is based on the following: measured test quantities--distance traveled (miles) and fuel consumed (pounds); standard reference values--density of water at 60EF (8.3373 lbs/gal) and volumetric heating value of standard fuel; and test fuel specific gravity (unitless) and volumetric heating value (BTU/gal). These combine to give a fuel economy in miles per gallon (mpg) which is corrected to a standard gallon of fuel referenced to water at 60EF. This eliminates fluctuations in fuel economy due to fluctuations in fuel quality. This calculation has been programmed into a computer and the data processing is performed automatically.

The fuel economy correction consists of three steps:

1.) Divide the number of miles of the phase by the number of pounds of fuel consumed

| phase | miles per phase | total miles per run |
|---|---|---|
| CBD | 1.9097 | 5.7291 |
| ART | 1.9097 | 3.8193 |
| COM | 3.8193 | 3.8193 |

$$\mathbf{FEo_{mi/lb}} = \text{Observed fuel economy} = \frac{\text{miles}}{\text{lb of fuel}}$$

2.) Convert the observed fuel economy to miles per gallon [mpg] by multiplying by the specific gravity of the test fuel Gs (referred to water) at 60°F and multiply by the density of water at 60°F

$$\mathbf{FEo_{mpg}} = \mathbf{FEc_{mi/lb}} \times Gs \times Gw$$

where **Gs** = Specific gravity of test fuel at 60°F (referred to water)
**Gw** = 8.3373 lb/gal

3.) Correct to a standard gallon of fuel by dividing by the volumetric heating value of the test fuel (H) and multiplying by the volumetric heating value of standard reference fuel (Q). Both heating values must have the same units.

$$\mathbf{FEc} = \mathbf{FEo_{mpg}} \times \frac{Q}{H}$$

where

**H** = Volumetric heating value of test fuel [BTU/gal]
**Q** = Volumetric heating value of standard reference fuel

Combining steps 1-3 yields

$$\Longrightarrow \quad FEc = \frac{\text{miles}}{\text{lbs}} \times (Gs \times Gw) \times \frac{Q}{H}$$

4.) Covert the fuel economy from mpg to an energy equivalent of miles per BTU. Since the number would be extremely small in magnitude, the energy equivalent will be represented as miles/BTUx$10^6$.

Eq = Energy equivalent of converting mpg to mile/BTUx$10^6$.

$$Eq = ((mpg)/(H))\times 10^6$$

**B. CNG, LNG, cryogenic and other fuels in the vapor state.**

The reported fuel economy is based on the following: measured test quantities--distance traveled (miles) and fuel consumed (scf); density of test fuel, and volumetric heating value (BTU/lb) of test fuel at standard conditions (P=14.73 psia and T=60°F). These combine to give a fuel economy in miles per lb. The energy equivalent

(mile/BTUx$10^6$) will also be provided so that the results can be compared to buses that use other fuels.

1.) Divide the number of miles of the phase by the number of standard cubic feet (scf) of fuel consumed.

| phase | miles per phase | total miles per run |
|---|---|---|
| CBD | 1.9097 | 5.7291 |
| ART | 1.9097 | 3.8193 |
| COM | 3.8193 | 3.8193 |

$$\mathbf{FEo_{mi/scf}} = \text{Observed fuel economy} = \frac{\text{miles}}{\text{scf of fuel}}$$

2.) Convert the observed fuel economy to miles per lb by dividing FEo by the density of the test fuel at standard conditions (Lb/$ft^3$).

**Note: The density of test fuel must be determined at standard conditions as described above. If the density is not defined at the above standard conditions, then a correction will be needed before the fuel economy can be calculated.**

$$\mathbf{FEo_{mi/lb}} = FEo / Gm$$

where Gm = Density of test fuel at standard conditions

3.) Convert the observed fuel economy (FEomi/lb) to an energy equivalent of (miles/BTUx$10^6$) by dividing the observed fuel economy (FEomi/lb) by the heating value of the test fuel at standard conditions.

$$Eq = ((FEomi/lb)/H)x10^6$$

where

Eq = Energy equivalent of miles/lb to mile/BTUx$10^6$
H = Volumetric heating value of test fuel at standard conditions

## 6-III. DISCUSSION

This is a comparative test of fuel economy using gasoline fuel with a heating value of 20,025.0 btu/lb. The driving cycle consists of Central Business District (CBD), Arterial (ART), and Commuter (COM) phases as described in 6-II. The fuel consumption for each driving cycle and for idle is measured separately. The results are corrected to a reference fuel with a volumetric heating value of 127,700.0 btu/gal.

An extensive pretest maintenance check is made including the replacement of all lubrication fluids. The details of the pretest maintenance are given in the first three Pretest Maintenance Forms. The fourth sheet shows the Pretest Inspection. The next sheet shows the correction calculation for the test fuel. The next four Fuel Economy Forms provide the data from the four test runs. Finally, the summary sheet provides the average fuel consumption. The overall average is based on total fuel and total mileage for each phase. The overall average fuel consumption values were; CBD – 14.76 mpg, ART – 16.29 mpg, and COM – 13.79 mpg. Average fuel consumption at idle was 0.36 gal/hr.

# FUEL ECONOMY PRE-TEST MAINTENANCE FORM

| | | |
|---|---|---|
| Bus Number: 0809 | Date: 9-15-08 | SLW (lbs): 5,990 |
| Personnel: S.C. & P.D. | | |

| FUEL SYSTEM | OK | Date | Initials |
|---|---|---|---|
| Install fuel measurement system | ✓ | 9/15/08 | S.C. |
| Replace fuel filter | ✓ | 9/15/08 | S.C. |
| Check for fuel leaks | ✓ | 9/15/08 | S.C. |
| Specify fuel type (refer to fuel analysis) | Gasoline | | |
| Remarks: None noted. | | | |
| | | | |
| BRAKES/TIRES | OK | Date | Initials |
| Inspect hoses | ✓ | 9/15/08 | S.C. |
| Inspect brakes | ✓ | 9/15/08 | S.C. |
| Relube wheel bearings | ✓ | 9/15/08 | S.C. |
| Check tire inflation pressures (mfg. specs.) | ✓ | 9/15/08 | S.C. |
| Remarks: None noted. | | | |
| | | | |
| COOLING SYSTEM | OK | Date | Initials |
| Check hoses and connections | ✓ | 9/15/08 | S.C. |
| Check system for coolant leaks | ✓ | 9/15/08 | S.C. |
| Remarks: None noted. | | | |
| | | | |

# FUEL ECONOMY PRE-TEST MAINTENANCE FORM (page 2)

| | |
|---|---|
| Bus Number: 0809 | Date: 9-15-08 |
| Personnel: S.C. & P.D. | |

| ELECTRICAL SYSTEMS | OK | Date | Initials |
|---|---|---|---|
| Check battery | ✓ | 9/15/08 | S.C. |
| Inspect wiring | ✓ | 9/15/08 | S.C. |
| Inspect terminals | ✓ | 9/15/08 | S.C. |
| Check lighting | ✓ | 9/15/08 | S.C. |
| Remarks: None noted. | | | |
| | | | |
| DRIVE SYSTEM | OK | Date | Initials |
| Drain transmission fluid | ✓ | 9/15/08 | P.D. |
| Replace filter/gasket | ✓ | 9/15/08 | P.D. |
| Check hoses and connections | ✓ | 9/15/08 | P.D. |
| Replace transmission fluid | ✓ | 9/15/08 | P.D. |
| Check for fluid leaks | ✓ | 9/15/08 | P.D. |
| Remarks: None noted. | | | |
| | | | |
| LUBRICATION | OK | Date | Initials |
| Drain crankcase oil | ✓ | 9/15/08 | P.D. |
| Replace filters | ✓ | 9/15/08 | P.D. |
| Replace crankcase oil | ✓ | 9/15/08 | P.D. |
| Check for oil leaks | ✓ | 9/15/08 | P.D. |
| Check oil level | ✓ | 9/15/08 | P.D. |
| Lube all chassis grease fittings | ✓ | 9/15/08 | P.D. |
| Lube universal joints | ✓ | 9/15/08 | P.D. |
| Replace differential lube including axles | ✓ | 9/15/08 | P.D. |
| Remarks: None noted. | | | |
| | | | |

## FUEL ECONOMY PRE-TEST MAINTENANCE FORM (page 3)

| | |
|---|---|
| Bus Number: 0809 | Date: 9-15-08 |
| Personnel: S.C. & P.D. | |

| EXHAUST/EMISSION SYSTEM | OK | Date | Initials |
|---|---|---|---|
| Check for exhaust leaks | ✓ | 9/15/08 | S.C. |
| Remarks: None noted. | | | |
| | | | |

| ENGINE | OK | Date | Initials |
|---|---|---|---|
| Replace air filter | ✓ | 9/15/08 | S.C. |
| Inspect air compressor and air system | ✓ | 9/15/08 | S.C. |
| Inspect vacuum system, if applicable | ✓ | 9/15/08 | S.C. |
| Check and adjust all drive belts | ✓ | 9/15/08 | S.C. |
| Check cold start assist, if applicable | ✓ | 9/15/08 | S.C. |
| Remarks: None noted. | | | |
| | | | |

| STEERING SYSTEM | OK | Date | Initials |
|---|---|---|---|
| Check power steering hoses and connectors | ✓ | 9/15/08 | S.C. |
| Service fluid level | ✓ | 9/15/08 | S.C. |
| Check power steering operation | ✓ | 9/15/08 | S.C. |
| Remarks: None noted. | | | |
| | | | |

| | OK | Date | Initials |
|---|---|---|---|
| Ballast bus to seated load weight | ✓ | 9/15/08 | S.C. |
| | | | |

| TEST DRIVE | OK | Date | Initials |
|---|---|---|---|
| Check brake operation | ✓ | 9/15/08 | S.C. |
| Check transmission operation | ✓ | 9/15/08 | S.C. |
| Remarks: None noted. | | | |
| | | | |

## FUEL ECONOMY PRE-TEST INSPECTION FORM

| | |
|---|---|
| Bus Number: 0809 | Date: 9-15-08 |
| Personnel: S.C. | |

| PRE WARM-UP | If OK, Initial |
|---|---|
| Fuel Economy Pre-Test Maintenance Form is complete | S.C. |
| Cold tire pressure (psi): Front 35 Middle N/A Rear 35 | S.C. |
| Tire wear: | S.C. |
| Engine oil level | S.C. |
| Engine coolant level | S.C. |
| Interior and exterior lights on, evaporator fan on | S.C. |
| Fuel economy instrumentation installed and working properly. | S.C. |
| Fuel line -- no leaks or kinks | S.C. |
| Speed measuring system installed on bus. Speed indicator installed in front of bus and accessible to TECH and Driver. | S.C. |
| Bus is loaded to SLW | S.C. |
| **WARM-UP** | **If OK, Initial** |
| Bus driven for at least one hour warm-up | S.C. |
| No extensive or black smoke from exhaust | S.C. |
| **POST WARM-UP** | **If OK, Initial** |
| Warm tire pressure (psi): Front 37 Middle N/A Rear 36 | S.C. |
| Environmental conditions<br>Average wind speed <12 mph and maximum gusts <15 mph<br>Ambient temperature between 30°F(-1C°) and 90°F(32°C)<br>Track surface is dry<br>Track is free of extraneous material and clear of interfering traffic | S.C. |

# FUEL ECONOMY DATA FORM (Liquid Fuels)

| | | |
|---|---|---|
| Bus Number: 0809 | Manufacturer: ElDorado National | Date: 9-16-08 |
| Run Number: 1 | Personnel: B.S. & S.C. | |
| Test Direction: ▫CW or ▪CCW | Temperature (°F): 69 | Humidity (%): 59 |
| SLW (lbs): 5,990 | Wind Speed (mph) & Direction: 5 / NE | Barometric Pressure (in.Hg): 30.08 |

| Cycle Type | Time (min:sec) | | Cycle Time (min:sec) | Fuel Temperature (°C) | Load Cell Reading (lb) | | Fuel Used (lbs) |
|---|---|---|---|---|---|---|---|
| | Start | Finish | | Start | Start | Finish | |
| CBD #1 | 0 | 8:31 | 8:31 | 24.4 | 0 | .136 | .136 |
| ART #1 | 0 | 3:55 | 3:55 | 25.3 | 0 | .119 | .119 |
| CBD #2 | 0 | 8:44 | 8:44 | 26.1 | 0 | .137 | .137 |
| ART #2 | 0 | 3:57 | 3:57 | 26.4 | 0 | .118 | .118 |
| CBD #3 | 0 | 8:35 | 8:35 | 25.7 | 0 | .136 | .136 |
| COMMUTER | 0 | 6:04 | 6:04 | 25.1 | 0 | .291 | .291 |
| | | | | | | Total Fuel = .937 gals | |

20 minute idle : Total Fuel Used = .120 gals

Heating Value = 20,025.0 BTU/LB

Comments: None noted.

# FUEL ECONOMY DATA FORM (Liquid Fuels)

| | | |
|---|---|---|
| Bus Number: 0809 | Manufacturer: ElDorado National | Date: 9-16-08 |
| Run Number: 2 | Personnel: B.S. & S.C. | |
| Test Direction: ■CW or □CCW | Temperature (°F): 67 | Humidity (%): 55 |
| SLW (lbs): 5,990 | Wind Speed (mph) & Direction: 7 / NE | Barometric Pressure (in.Hg): 30.11 |

| Cycle Type | Time (min:sec) | | Cycle Time (min:sec) | Fuel Temperature (°C) | Load Cell Reading (lb) | | Fuel Used (lbs) |
|---|---|---|---|---|---|---|---|
| | Start | Finish | | Start | Start | Finish | |
| CBD #1 | 0 | 8:42 | 8:42 | 22.4 | 0 | .132 | .132 |
| ART #1 | 0 | 3:58 | 3:58 | 22.1 | 0 | .119 | .119 |
| CBD #2 | 0 | 8:24 | 8:24 | 21.8 | 0 | .126 | .126 |
| ART #2 | 0 | 3:52 | 3:52 | 21.5 | 0 | .121 | .121 |
| CBD #3 | 0 | 8:45 | 8:45 | 21.1 | 0 | .129 | .129 |
| COMMUTER | 0 | 5:55 | 5:55 | 20.8 | 0 | .280 | .280 |
| | | | | | | | Total Fuel = .907 gals |

20 minute idle : Total Fuel Used = N/A gals

Heating Value = 20,025.0 BTU/LB

Comments: None noted.

# FUEL ECONOMY DATA FORM (Liquid Fuels)

| | | |
|---|---|---|
| Bus Number: 0809 | Manufacturer: ElDorado National | Date: 9-17-08 |
| Run Number: 3 | Personnel: B.S. & S.C. | |
| Test Direction: ▫CW or ▪CCW | Temperature (°F): 55 | Humidity (%): 80 |
| SLW (lbs): 5,990 | Wind Speed (mph) & Direction: 2/WNW | Barometric Pressure (in.Hg): 30.12 |

| Cycle Type | Time (min:sec) | | Cycle Time (min:sec) | Fuel Temperature (°C) | Load Cell Reading (lb) | | Fuel Used (lbs) |
|---|---|---|---|---|---|---|---|
| | Start | Finish | | Start | Start | Finish | |
| CBD #1 | 0 | 8:28 | 8:28 | 25.1 | 0 | .134 | .134 |
| ART #1 | 0 | 3:54 | 3:54 | 25.8 | 0 | .121 | .121 |
| CBD #2 | 0 | 8:34 | 8:34 | 24.1 | 0 | .136 | .136 |
| ART #2 | 0 | 4:04 | 4:04 | 23.8 | 0 | .122 | .122 |
| CBD #3 | 0 | 8:29 | 8:29 | 23.3 | 0 | .131 | .131 |
| COMMUTER | 0 | 5:30 | 5:30 | 22.6 | 0 | .287 | .287 |
| | | | | | | | Total Fuel = .931 gals |

20 minute idle : Total Fuel Used = N/A gals

Heating Value = 20,025.0 BTU/LB

Comments: None noted.

# FUEL ECONOMY DATA FORM (Liquid Fuels)

| | | |
|---|---|---|
| Bus Number: 0809 | Manufacturer: ElDorado National | Date: 9-17-08 |
| Run Number: 4 | Personnel: B.S. & S.C. | |
| Test Direction: ■CW or □CCW | Temperature (°F): 59 | Humidity (%): 76 |
| SLW (lbs): 5,990 | Wind Speed (mph) & Direction: 5/WNW | Barometric Pressure (in.Hg): 30.12 |

| Cycle Type | Time (min:sec) | | Cycle Time (min:sec) | Fuel Temperature (°C) | Load Cell Reading (lb) | | Fuel Used (lbs) |
|---|---|---|---|---|---|---|---|
| | Start | Finish | | Start | Start | Finish | |
| CBD #1 | 0 | 8:31 | 8:31 | 22.6 | 0 | .132 | .132 |
| ART #1 | 0 | 3:55 | 3:55 | 22.6 | 0 | .122 | .122 |
| CBD #2 | 0 | 8:37 | 8:37 | 22.9 | 0 | .131 | .131 |
| ART #2 | 0 | 4:01 | 4:01 | 22.8 | 0 | .120 | .120 |
| CBD #3 | 0 | 8:34 | 8:34 | 23.2 | 0 | .133 | .133 |
| COMMUTER | 0 | 5:55 | 5:55 | 23.3 | 0 | .279 | .279 |
| | | | | | | | Total Fuel = .917 gals |

20 minute idle : Total Fuel Used = .118 gals

Heating Value = 20,025.0 BTU/LB

Comments: None noted.

FUEL ECONOMY SUMMARY SHEET

BUS MANUFACTURER :ElDorado National  BUS NUMBER :0809
BUS MODEL :Amerivan  TEST DATE :09/17/08

FUEL TYPE : GASOLINE
SP. GRAVITY : .7400
HEATING VALUE : 20025.00 BTU/Lb
FUEL TEMPERATURE : 60.00 deg F
Standard Conditions : 60 deg F and 14.7 psi
Density of Water : 8.3373 lb/gallon at 60 deg F

| CYCLE | TOTAL FUEL USED(GAL) | TOTAL MILES | FUEL ECONOMY MPG(Measured) | FUEL ECONOMY MPG (Corrected) |
|---|---|---|---|---|
| Run # :1, CCW | | | | |
| CBD | .409 | 5.73 | 14.010 | 14.37 |
| ART | .237 | 3.82 | 16.118 | 16.53 |
| COM | .291 | 3.82 | 13.127 | 13.46 |
| TOTAL | .937 | 13.37 | 14.269 | 14.63 |
| Run # :2, CW | | | | |
| CBD | .387 | 5.73 | 14.806 | 15.18 |
| ART | .240 | 3.82 | 15.917 | 16.32 |
| COM | .280 | 3.82 | 13.643 | 13.99 |
| TOTAL | .907 | 13.37 | 14.741 | 15.12 |
| Run # :3, CCW | | | | |
| CBD | .401 | 5.73 | 14.289 | 14.65 |
| ART | .243 | 3.82 | 15.720 | 16.12 |
| COM | .287 | 3.82 | 13.310 | 13.65 |
| TOTAL | .931 | 13.37 | 14.361 | 14.73 |
| Run # :4, CW | | | | |
| CBD | .396 | 5.73 | 14.470 | 14.84 |
| ART | .242 | 3.82 | 15.785 | 16.19 |
| COM | .279 | 3.82 | 13.692 | 14.04 |
| TOTAL | .917 | 13.37 | 14.580 | 14.95 |

IDLE CONSUMPTION (MEASURED)

First 20 Minutes Data : .12GAL  Last 20 Minutes Data : .12GAL
Average Idle Consumption : .36GAL/Hr

RUN CONSISTENCY: % Difference from overall average of total fuel used

Run 1 : -1.5  Run 2 : 1.7  Run 3 : -.9  Run 4 : .7

SUMMARY (CORRECTED VALUES)

Average Idle Consumption : .35 G/Hr
Average CBD Phase Consumption : 14.76 MPG
Average Arterial Phase Consumption : 16.29 MPG
Average Commuter Phase Consumption : 13.79 MPG
Overall Average Fuel Consumption : 14.86 MPG
Overall Average Fuel Consumption :120.26 Miles/ Million BTU

# 7. NOISE

## 7.1 INTERIOR NOISE AND VIBRATION TESTS

### 7.1-I. TEST OBJECTIVE

The objective of these tests is to measure and record interior noise levels and check for audible vibration under various operating conditions.

### 7.1-II. TEST DESCRIPTION

During this series of tests, the interior noise level will be measured at several locations with the bus operating under the following three conditions:

1. With the bus stationary, a white noise generating system shall provide a uniform sound pressure level equal to 80 dB(A) on the left, exterior side of the bus. The engine and all accessories will be switched off and all openings including doors and windows will be closed. This test will be performed at the ABTC.

2. The bus accelerating at full throttle from a standing start to 35 mph on a level pavement. All openings will be closed and all accessories will be operating during the test. This test will be performed on the track at the Test Track Facility.

3. The bus will be operated at various speeds from 0 to 55 mph with and without the air conditioning and accessories on. Any audible vibration or rattles will be noted. This test will be performed on the test segment between the Test Track and the Bus Testing Center.

All tests will be performed in an area free from extraneous sound-making sources or reflecting surfaces. The ambient sound level as well as the surrounding weather conditions will be recorded in the test data.

### 7.1-III. DISCUSSION

This test is performed in three parts. The first part exposes the exterior of the vehicle to 80.0 dB(A) on the left side of the bus and the noise transmitted to the interior is measured. The overall average of the six measurements was 46.1 dB(A); ranging from 44.2 dB(A) at the driver's seat to 48.2 dB(A) at the rear speaker. The interior ambient noise level for this test was < 34.0 dB(A).

The second test measures interior noise during acceleration from 0 to 35 mph. This noise level ranged from 70.0 dB(A) at the drive's seat to 72.1 dB(A) at the middle passenger seats. The overall average was 71.1 dB(A). The interior ambient noise level for this test was < 34.0 dB(A).

The third part of the test is to listen for resonant vibrations, rattles, and other noise sources while operating over the road. No vibrations or rattles were noted.

## INTERIOR NOISE TEST DATA FORM
## Test Condition 1: 80 dB(A) Stationary White Noise

| | |
|---|---|
| Bus Number: 0809 | Date: 6-17-08 |
| Personnel: S.C. & E.D. | |
| Temperature (°F): 65 | Humidity (%): 49 |
| Wind Speed (mph): 4 | Wind Direction: West |
| Barometric Pressure (in.Hg): 29.87 | |
| Initial Sound Level Meter Calibration: ■ checked by: S.C. | |
| Interior Ambient<br>Noise Level dB(A): < 34.0 | Exterior Ambient<br>Noise Level dB(A): 52.1 |
| Microphone Height During Testing (in): 48 | |

| Measurement Location | Measured Sound Level dB(A) |
|---|---|
| Driver's Seat | 44.2 |
| Front Passenger Seats | 46.8 |
| In Line with Front Speaker | 46.2 |
| In Line with Middle Speaker | 45.0 |
| In Line with Rear Speaker | 46.1 |
| Rear Passenger Seats | 48.2 |

Final Sound Level Meter Calibration: ■ checked by: S.C.

**Comments:** All readings taken in the center aisle.

## INTERIOR NOISE TEST DATA FORM
## Test Condition 2: 0 to 35 mph Acceleration Test

| | |
|---|---|
| Bus Number: 0809 | Date: 9-5-08 |
| Personnel: T.S., T.W. & M.R. | |
| Temperature (°F): 84 | Humidity (%): 31 |
| Wind Speed (mph): 10 | Wind Direction: S |
| Barometric Pressure (in.Hg): 29.99 | |
| Initial Sound Level Meter Calibration: ■ checked by: S.C. | |
| Interior Ambient<br>Noise Level dB(A): < 34.0 | Exterior Ambient<br>Noise Level dB(A): 46.2 |
| Microphone Height During Testing (in): 48.0 | |

| Measurement Location | Measured Sound Level dB(A) |
|---|---|
| Driver's Seat | 70.0 |
| Front Passenger Seats | 71.3 |
| Middle Passenger Seats | 72.1 |
| Rear Passenger Seats | 70.9 |

Final Sound Level Meter Calibration: ■ checked by: S.C.

**Comments:** All readings taken in the center aisle.

## INTERIOR NOISE TEST DATA FORM
## Test Condition 3: Audible Vibration Test

| | |
|---|---|
| Bus Number: 0809 | Date: 9-5-08 |
| Personnel: T.S. & M.R. | |
| Temperature (°F): 84 | Humidity (%): 31 |
| Wind Speed (mph): 10 | Wind Direction: S |
| Barometric Pressure (in.Hg): 29.99 | |

Describe the following possible sources of noise and give the relative location on the bus.

| Source of Noise | Location |
|---|---|
| Engine and Accessories | None noted. |
| Windows and Doors | None noted. |
| Seats and Wheel Chair lifts | None noted. |

| |
|---|
| **Comment on any other vibration or noise source which may have occurred** |
| **that is not described above:** None noted. |
| |
| |
| |
| |

# 7.1 INTERIOR NOISE TEST

**TEST BUS SET-UP FOR 80 dB(A)**
**INTERIOR NOISE TEST**

# 7.2 EXTERIOR NOISE TESTS

## 7.2-I. TEST OBJECTIVE

The objective of this test is to record exterior noise levels when a bus is operated under various conditions.

## 7.2-II. TEST DESCRIPTION

In the exterior noise tests, the bus will be operated at a SLW in three different conditions using a smooth, straight and level roadway:

1. Accelerating at full throttle from a constant speed at or below 35 mph and just prior to transmission up shift.
2. Accelerating at full throttle from standstill.
3. Stationary, with the engine at low idle, high idle, and wide open throttle.

In addition, the buses will be tested with and without the air conditioning and all accessories operating. The exterior noise levels will be recorded.

The test site is at the PSBRTF and the test procedures will be in accordance with SAE Standards SAE J366b, Exterior Sound Level for Heavy Trucks and Buses. The test site is an open space free of large reflecting surfaces. A noise meter placed at a specified location outside the bus will measure the noise level.

During the test, special attention should be paid to:

1. The test site characteristics regarding parked vehicles, signboards, buildings, or other sound-reflecting surfaces
2. Proper usage of all test equipment including set-up and calibration
3. The ambient sound level

## 7.2-III. DISCUSSION

The Exterior Noise Test determines the noise level generated by the vehicle under different driving conditions and at stationary low and high idle, with and without air conditioning and accessories operating. The test site is a large, level, bituminous paved area with no reflecting surfaces nearby.

With an exterior ambient noise level of 46.5 dB(A), the average test result obtained while accelerating from a constant speed was 66.0 dB(A) on the right side and 64.9 dB(A) on the left side.

When accelerating from a standstill with an exterior ambient noise level of 46.5 dB(A), the average of the results obtained were 64.3 dB(A) on the right side and 64.0 dB(A) on the left side.

With the vehicle stationary and the engine, accessories, and air conditioning on, the measurements averaged 47.9 dB(A) at low idle and 64.1 dB(A) at wide open throttle. With the accessories and air conditioning off, the readings averaged 0.5 dB(A) lower at low idle and 0.8 dB(A) lower at wide open throttle. The exterior ambient noise level measured during this test was 46.5 dB(A). Note; the test bus was not equipped with a high idle mode, therefore, data for that condition is not available.

## EXTERIOR NOISE TEST DATA FORM
## Accelerating from Constant Speed

| | |
|---|---|
| Bus Number: 0809 | Date: 9-5-08 |
| Personnel: T.S., T.W. & M.R. | |
| Temperature (°F): 84 | Humidity (%): 31 |
| Wind Speed (mph): 10 | Wind Direction: S |
| Barometric Pressure (in.Hg): 29.99 | |
| Verify that microphone height is 4 feet, wind speed is less than 12 mph and ambient temperature is between 30°F and 90°F: ■ checked by: S.C. | |
| Initial Sound Level Meter Calibration: ■ checked by: S.C. | |
| Exterior Ambient Noise Level dB(A): 46.5 | |

| Accelerating from Constant Speed Curb (Right) Side | | Accelerating from Constant Speed Street (Left) Side | |
|---|---|---|---|
| Run # | Measured Noise Level dB(A) | Run # | Measured Noise Level dB(A) |
| 1 | 61.9 | 1 | 63.1 |
| 2 | 63.4 | 2 | 61.9 |
| 3 | 65.0 | 3 | 64.2 |
| 4 | 65.5 | 4 | 64.9 |
| 5 | 66.4 | 5 | 64.8 |
| Average of two highest actual noise levels = 66.0 dB(A) | | Average of two highest actual noise levels = 64.9 dB(A) | |

| |
|---|
| Final Sound Level Meter Calibration Check: ■ checked by: S.C. |
| Comments: None noted. |
| |
| |

## EXTERIOR NOISE TEST DATA FORM
## Accelerating from Standstill

| | |
|---|---|
| Bus Number: 0809 | Date: 9-5-08 |
| Personnel: T.S., T.W. & M.R. | |
| Temperature (°F): 84 | Humidity (%): 31 |
| Wind Speed (mph): 10 | Wind Direction: S |
| Barometric Pressure (in.Hg): 29.99 | |
| Verify that microphone height is 4 feet, wind speed is less than 12 mph and ambient temperature is between 30°F and 90°F: ■ checked by: S.C. | |
| Initial Sound Level Meter Calibration: ■ checked by: S.C. | |
| Exterior Ambient Noise Level dB(A): 46.5 | |

| Accelerating from Standstill Curb (Right) Side | | Accelerating from Standstill Street (Left) Side | |
|---|---|---|---|
| Run # | Measured Noise Level dB(A) | Run # | Measured Noise Level dB(A) |
| 1 | 61.9 | 1 | 63.1 |
| 2 | 63.4 | 2 | 61.9 |
| 3 | 65.0 | 3 | 64.2 |
| 4 | 65.5 | 4 | 64.9 |
| 5 | 66.4 | 5 | 64.8 |
| Average of two highest actual noise levels = 66.0 dB(A) | | Average of two highest actual noise levels = 64.9 dB(A) | |

| |
|---|
| Final Sound Level Meter Calibration Check: ■ checked by: S.C. |

| |
|---|
| Comments: None noted. |
| |
| |

# EXTERIOR NOISE TEST DATA FORM
## Stationary

| | |
|---|---|
| Bus Number: 0809 | Date: 9-5-08 |
| Personnel: T.S., T.W. & M.R. | |
| Temperature (°F): 84 | Humidity (%): 31 |
| Wind Speed (mph): 10 | Wind Direction: 5 |
| Barometric Pressure (in.Hg): 29.99 | |
| Verify that microphone height is 4 feet, wind speed is less than 12 mph and ambient temperature is between 30°F and 90°F: ■ checked by: S.C. | |
| Initial Sound Level Meter Calibration: ■ checked by: S.C. | |
| Exterior Ambient Noise Level dB(A): 46.5 | |

Accessories and Air Conditioning ON

| Throttle Position | Engine RPM | Curb (Right) Side dB(A) | Street (Left) Side db(A) |
|---|---|---|---|
| | | Measured | Measured |
| Low Idle | 755 | 48.8 | 46.9 |
| High Idle | N/A | N/A | N/A |
| Wide Open Throttle | 3,595 | 65.3 | 62.9 |

Accessories and Air Conditioning OFF

| Throttle Position | Engine RPM | Curb (Right) Side dB(A) | Street (Left) Side db(A) |
|---|---|---|---|
| | | Measured | Measured |
| Low Idle | 771 | 47.6 | 47.1 |
| High Idle | N/A | N/A | N/A |
| Wide Open Throttle | 3,601 | 63.2 | 63.4 |

Final Sound Level Meter Calibration Check: ■ checked by: S.C.

Comments: None noted.

## 7.2 EXTERIOR NOISE TESTS

**TEST VEHICLE UNDERGOING EXTERIOR NOISE TESTING**