STURAA TEST

7 YEAR

200,000 MILE BUS

from

DIAMOND COACH CORPORATION

MODEL VIP 2200

JULY 2010

PTI-BT-R1005

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 20
1.2 SERVICING, PREVENTATIVE MAINTENANCE, AND REPAIR AND MAINTENANCE DURING TESTING 23
1.3 REPLACEMENT AND/OR REPAIR OF SELECTED SUBSYSTEMS 27

2. RELIABILITY - DOCUMENTATION OF BREAKDOWN AND REPAIR TIMES DURING TESTING 31

3. SAFETY - A DOUBLE-LANE CHANGE (OBSTACLE AVOIDANCE TEST) 34

4. PERFORMANCE TESTS

4.1 PERFORMANCE - AN ACCELERATION, GRADEABILITY, AND TOP SPEED TEST 37

4.2 PERFORMANCE – BUS BRAKING PERFORMANCE TEST…….…. 41

5. STRUCTURAL INTEGRITY

5.1 STRUCTURAL STRENGTH AND DISTORTION TESTS - STRUCTURAL SHAKEDOWN TEST 46
5.2 STRUCTURAL STRENGTH AND DISTORTION TESTS - STRUCTURAL DISTORTION 50
5.3 STRUCTURAL STRENGTH AND DISTORTION TESTS - STATIC TOWING TEST 62
5.4 STRUCTURAL STRENGTH AND DISTORTION TESTS - DYNAMIC TOWING TEST 63
5.5 STRUCTURAL STRENGTH AND DISTORTION TESTS - JACKING TEST 66
5.6 STRUCTURAL STRENGTH AND DISTORTION TESTS - HOISTING TEST 68
5.7 STRUCTURAL DURABILITY TEST 70

6. FUEL ECONOMY TEST - A FUEL CONSUMPTION TEST USING AN APPROPRIATE OPERATING CYCLE 78

7. NOISE

7.1 INTERIOR NOISE AND VIBRATION TESTS 93
7.2 EXTERIOR NOISE TESTS 98

8. EMISSIONS – DYNAMOMETER-BASED EMISSIONS TEST USING TRANSIT DRIVING CYCLES.....105

EXECUTIVE SUMMARY

Diamond Coach Corporation submitted a model VIP 2200, gasoline-powered 15 seat (including the driver) 23-foot bus, for a 7 yr/200,000 mile STURAA test. The bus is built on a Ford Motor Co. E 450 Super Duty chassis. The odometer reading at the time of delivery was 1,220 miles. Testing started on April 8, 2010 and was completed on July 21, 2010. 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 April 19, 2010 and was completed on June 30, 2010.

The interior of the bus is configured with seating for 15 passengers including the driver. Free floor space will accommodate 6 standing passengers resulting in a potential load of 21 persons. At 150 lbs per person, this load results in a measured gross vehicle weight of 13,410 lbs. The first segment of the Structural Durability Test was performed with the bus loaded to a GVW of 13,410 lbs. **Note: at Gross Vehicle Load (GVL) the weight of the rear axle is 150 lbs over the rear GAWR.** The middle segment was performed at a seated load weight of 12,530 lbs and the final segment was performed at a curb weight of 9,440 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.

Effective January 1, 2010 the Federal Transit Administration determined that the total number of simulated passengers used for loading all test vehicles will be based on the full complement of seats and free-floor space available for standing passengers (150 lbs per passenger). The passenger loading used for dynamic testing will not be reduced in order to comply with Gross Axle Weight Ratings (GAWR's) or the Gross Vehicle Weight Ratings (GVWR's) declared by the manufacturer. Cases where the loading exceeds the GAWR and/or the GVWR will be noted accordingly. During the testing program, all test vehicles transported or operated over public roadways will be loaded to comply with the GAWR and GVWR specified by the manufacturer.

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 bus encountered no Class 1. Of the seven reported failures, six were Class 3 and one was a Class 2.

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 20.38 seconds. The Stopping Distance phase of the Brake Test was completed with the following results; for the Uniform High Friction Test average stopping distances were 24.25' at 20 mph, 51.71' at 30 mph, 84.40' at 40 mph and 106.38' at 45 mph. The average stopping distance for the Uniform Low Friction Test was 26.20'. There was no deviation from the test lane during the performance of the Stopping Distance phase. During the Stability phase of Brake Testing the test bus experienced no deviation from the test lane but did experience pull to the left during both approaches to the Split Friction Road surface. The Parking Brake phase was completed with the test bus maintaining the parked position for the full five minute period with no slip or roll observed in both the uphill and downhill positions.

The Shakedown Test produced a maximum final loaded deflection of 0.237 inches with a permanent set ranging between -0.005 to 0.004 inches under a distributed static load of 8,325 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 bus 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 7.3 inches.

A Fuel Economy Test was run on simulated central business district, arterial, and commuter courses. The results were 6.89 mpg, 7.13 mpg, and 11.41 mpg respectively; with an overall average of 7.86 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 a Diamond Coach Corp., model VIP 2200. The test bus is built on a Ford Motor Co. E 450 Super Duty chassis. The bus has an O.E.M driver's door rear of the front axle. The passenger entrance is rear of the front axle and the dedicated handicap entrance is equipped with a Braun Corp. model NCL919F1B-2 hydraulic platform lift and is located rear of the rear axle. Power is provided by a gasoline-fueled, Ford Motor Co. model 6.8 L engine coupled to a Ford Motor Co. model Torq Shift transmission.

The measured curb weight is 3,250 lbs for the front axle and 6,190 lbs for the rear axle. These combined weights provide a total measured curb weight of 9,440 lbs. There are 15 seats including the driver and room for 6 standing passengers bringing the total passenger capacity to 21. Two rear passenger seats fold away creating 2 wheelchair positions. Gross load is 150 lb x 13 = 1,950 lbs + 1,200 lbs (2 wheelchair positions) = 3,150 lbs. At full capacity, the measured gross vehicle weight is 13,410 lbs. **Note;** at GVL the load is 150 lbs over the rear GAWR.

VEHICLE DATA FORM

Bus Number: 1005	Arrival Date: 4/8/10
Bus Manufacturer: Diamond Coach Corp.	Vehicle Identification Number (VIN): 1FDFE45S49DA19908
Model Number: VIP 2200	Date: 4/8/10
Personnel: S.C.	Chassis: Ford Motor Co. / E 450 Super duty

WEIGHT:

Individual Wheel Reactions:

Weights (lb)	Front Axle		Middle Axle		Rear Axle	
	Right	Left	Right	Left	Right	Left
CW	1,700	1,550	N/A	N/A	3,290	2,900
SLW	1,780	1,690	N/A	N/A	4,630	4,430
GVW	1,930	1,830	N/A	N/A	4,930	4,720

Total Weight Details:

Weight (lb)	CW	SLW	GVW	GAWR
Front Axle	3,250	3,470	3,760	5,000
Middle Axle	N/A	N/A	N/A	N/A
Rear Axle	6,190	9,060	9,650	9,500
Total	9,440	12,530	13,410	GVWR: 14,500

Dimensions:

Length (ft/in)	23.0 / 2.5
Width (in)	97.0
Height (in)	113.75
Front Overhang (in)	35.5
Rear Overhang (in)	84.5
Wheel Base (in)	158.5
Wheel Track (in)	Front: 68.2
	Rear: 78.8

Bus Number: 1005	Date: 4/8/10

CLEARANCES:

Lowest Point Outside Front Axle	Location: Steering stabilizer Clearance(in): 12.4
Lowest Point Outside Rear Axle	Location: Fuel tank Clearance(in): 12.3
Lowest Point between Axles	Location: Step well Clearance(in): 9.7
Ground Clearance at the center (in)	14.2
Front Approach Angle (deg)	20.7
Rear Approach Angle (deg)	10.9
Ramp Clearance Angle (deg)	10.2
Aisle Width (in)	15.8
Inside Standing Height at Center Aisle (in)	73.6

BODY DETAILS:

Body Structural Type	Integral		
Frame Material	Steel		
Body Material	Steel & composite		
Floor Material	Plywood		
Roof Material	Composite		
Windows Type	☐ Fixed	■ Movable	
Window Mfg./Model No.	KTG AS3 M3 / DOT 620		
Number of Doors	_1_ Front	_1_ Rear	_1_ Driver's
Mfr. / Model No.	A & M Systems Inc. / 213381A6C1		
Dimension of Each Door (in)	Front- 32.5 x 79.5	Rear – 43.3 x 70.0	Driver's – 31.5 x 53.6
Passenger Seat Type	☐ Cantilever	■ Pedestal	☐ Other (explain)
Mfr. / Model No.	Freedman Seating Co. / Feather Weight Mid Hi		
Driver Seat Type	☐ Air	☐ Spring	■ Other (Cushion)
Mfr. / Model No.	Freedman Seating Co. / FSC		
Number of Seats (including Driver)	15 (2 rear seats fold away for 2 wheelchair positions)		

Bus Number: 1005	Date: 4/8/10

BODY DETAILS (Cont'd.)

Free Floor Space (ft^2)	10.4			
Height of Each Step at Normal Position (in)	Front	1. 12.3	2. 7.3	3. 7.3	4. 6.8
	Middle	1. N/A	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.	Ford Motor Co. / 6.8 L		
Location	■ Front	☐ Rear	☐ Other (explain)
Fuel Type	■ Gasoline	☐ CNG	☐ Methanol
	☐ Diesel	☐ LNG	☐ Other (explain)
Fuel Tank Capacity (indicate units)	55 gals		
Fuel Induction Type	■ Injected	☐ Carburetion	
Fuel Injector Mfr. / Model No.	Ford Motor co. / 6.8 L		
Carburetor Mfr. / Model No.	N/A		
Fuel Pump Mfr. / Model No.	Ford Motor Co. / 6.8 L		
Alternator (Generator) Mfr. / Model No.	Ford O.E.M. / 225 amp		
Maximum Rated Output (Volts / Amps)	12 / 225		
Air Compressor Mfr. / Model No.	N/A		
Maximum Capacity (ft^3 / min)	N/A		
Starter Type	■ Electrical	☐ Pneumatic	☐ Other (explain)
Starter Mfr. / Model No.	Ford / O.E.M.		

Bus Number: 1005	Date: 4/8/10

TRANSMISSION

Transmission Type	☐ Manual	■ Automatic	
Mfr. / Model No.	Ford Motor Co. / Torque Shift		
Control Type	■ Mechanical	☐ Electrical	☐ Other
Torque Converter Mfr. / Model No.	Ford Motor Co. / Torque Shift		
Integral Retarder Mfr. / Model No.	N/A		

SUSPENSION

Number of Axles	2		
Front Axle Type	■ Independent	☐ Beam Axle	
Mfr. / Model No.	Ford Motor Co. / Twin I-Beam		
Axle Ratio (if driven)	N/A		
Suspension Type	☐ Air	■ Spring	☐ Other (explain)
No. of Shock Absorbers	2		
Mfr. / Model No.	Motorcraft / C283B1		
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.	Dana / M70HD		
Axle Ratio (if driven)	4.56		
Suspension Type	☐ Air	■ Spring	☐ Other (explain)
No. of Shock Absorbers	2		
Mfr. / Model No.	Motorcraft / C283B1		

Bus Number: 1005	Date: 4-8-10

WHEELS & TIRES

Front	Wheel Mfr./ Model No.	Fumagalli / 16 x 6
	Tire Mfr./ Model No.	Michelin LTX / LT225/75R 15
Rear	Wheel Mfr./ Model No.	Fumagalli / 16 x 6
	Tire Mfr./ Model No.	Michelin LTX / LT225/75R 16

BRAKES

Front Axle Brakes Type	☐ Cam	■ Disc	☐ Other (explain)
Mfr. / Model No.	Ford Motor Co. / 5000#		
Middle Axle Brakes Type	☐ Cam	☐ Disc	☐ Other (explain)
Mfr. / Model No.	N/A		
Rear Axle Brakes Type	☐ Cam	■ Disc	☐ Other (explain)
Mfr. / Model No.	Ford Motor Co. / 9500#		
Retarder Type	N/A		
Mfr. / Model No.	N/A		

HVAC

Heating System Type	☐ Air	■ Water	☐ Other
Capacity (Btu/hr)	45,000		
Mfr. / Model No.	Ford Motor Co. & Carrier Corp.		
Air Conditioner	■ Yes	☐ No	
Location	Dash & interior rear ceiling mount		
Capacity (Btu/hr)	53,000		
A/C Compressor Mfr. / Model No.	Ford / O.E.M.		

STEERING

Steering Gear Box Type	Hydraulic gear
Mfr. / Model No.	Ford / O.E.M.
Steering Wheel Diameter	15.5
Number of turns (lock to lock)	4.0

Bus Number: 1005	Date: 4/8/10

OTHERS

Wheel Chair Ramps	Location: N/A	Type: N/A
Wheel Chair Lifts	Location: Right rear	Type: Hydraulic platform
Mfr. / Model No.	The Braun Corp. / NCL919F1B-2	
Emergency Exit	Location: Windows Doors Roof hatch	Number: 2 1 1

CAPACITIES

Fuel Tank Capacity (units)	55 gals
Engine Crankcase Capacity (gallons)	1.5
Transmission Capacity (gallons)	4.7
Differential Capacity (gallons)	1.0
Cooling System Capacity (quarts)	8.15 (engine only)
Power Steering Fluid Capacity (quarts)	Fill to line.

VEHICLE DATA FORM

Bus Number: 1005	Date: 4/8/10

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

Part Number	Description	Qty.
Michelin LTX LT225/75 R16	Tires, mounted	6
FL-820S	Oil filters	2
FA-1632	Air filters	1
7709	Manual packet	1

COMPONENT/SUBSYSTEM INSPECTION FORM

Bus Number: 1005	Date: 4-8-10

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

DIAMOND COACH CORP.
MODEL VIP 2200

CHECK - IN CONT.

DIAMOND COACH CORP.
MODEL VIP 2200 EQUIPPED WITH A BRAUN MODEL NCL919F1B-2 HYDRAULIC PLATFORM LIFT

CHECK - IN CONT.

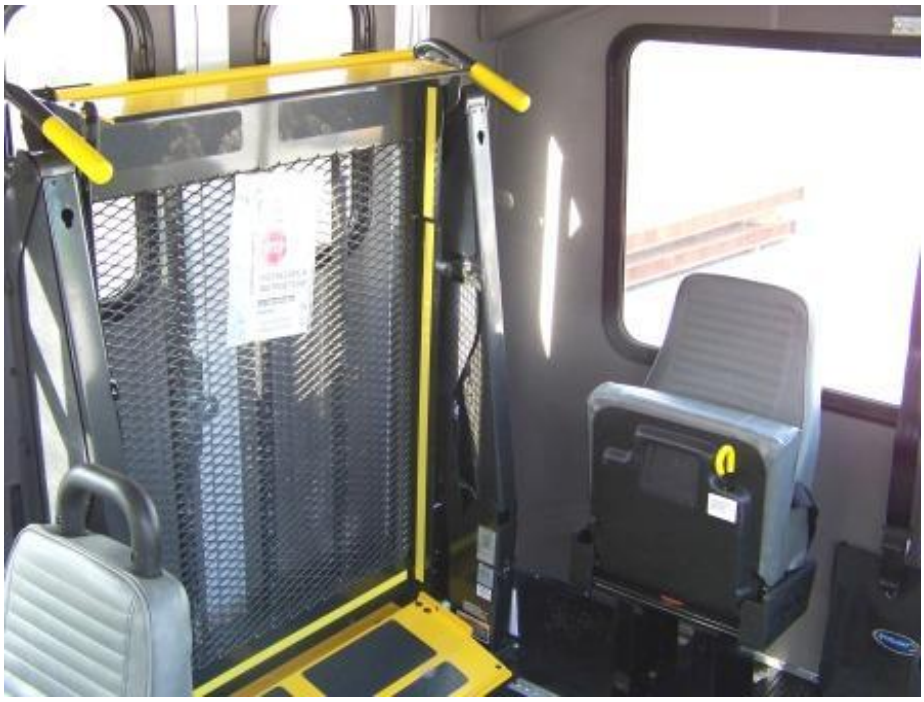
OPERATOR'S AREA

ENGINE COMPARTMENT

CHECK - IN CONT.

INTERIOR

CHECK - IN CONT.



HANDICAP LIFT (INTERIOR)

2 REAR SEATS FOLD AWAY FOR 2 WHEELCHAIR POSITIONS

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: 1005	Date: 7-19-10

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	**N/A**	
Leveling Valves	**N/A**	
Grease Fittings	✓	

ACCESSIBILITY DATA FORM

Bus Number: 1005	Date: 7-19-10

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

Diamond #1005

DATE	TEST MILES	SERVICE	ACTIVITY	DOWN TIME	HOURS
04/22/10	517	P.M. / Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
04/28/10	835	P.M. / Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
05/06/10	1,506	P.M. / Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
05/14/10	3,284	P.M. / Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
05/19/10	4,291	P.M. / Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
05/26/10	5,747	P.M. / Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
06/03/10	6,470	P.M. / Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
06/08/10	6,796	P.M. / Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00

SCHEDULED MAINTENANCE

Diamond #1005

DATE	TEST MILES	SERVICE	ACTIVITY	DOWN TIME	HOURS
06/30/10	7,502	P.M. / Inspection 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 Mercon/Dexron II Multipurpose
Gear oil	#2316	Multigear Lubricant EP SAE 80W90
Wheel bearing & 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
Tail pipe hanger.	1.0
Left rear spring.	4.0
Right rear load spring.	3.0
Right side hood hinge.	0.5
Left side hood hinge.	1.0

At the end of the test, the remaining items on the list were removed and replaced. The transmission assembly took 8.0 man-hours (two men 4.0 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	8.0 man hours
Wiper Motor	0.75 man hours
Starter	0.75 man hours
Alternator	1.0 man hours
Batteries	0.75 man hours

1.3 REPLACEMENT AND/OR REPAIR OF SELECTED SUBSYSTEMS

TRANSMISSION REMOVAL AND REPLACEMENT (8.0 MAN HOURS)

WIPER MOTOR REMOVAL AND REPLACEMENT (0.75 MAN HOURS)

1.3 REPLACEMENT AND/OR REPAIR OF SELECTED SUBSYSTEMS CONT.

STARTER REMOVAL AND REPLACEMENT (0.75 MAN HOURS)

ALTERNATOR REMOVAL AND REPLACEMENT (1.0 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 failures. Of the six Class 3 failures, 3 involved the suspension system and one occurred with the exhaust. One class 2 failure involved the handicap device. These, and the remaining two Class 3 failures are available for review in the Unscheduled Maintenance List, located in Section 5.7 Structural Durability.

RELIABILITY DATA FORMS

Bus Number: 1005	Date: 06-30-10
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		3,073			4.00	6.00
		5,426			3.00	1.00
		5,687			4.00	4.00
Compartments		5,426			0.50	0.50
		6,875			1.00	16.00
Exhaust		1,650			1.00	9.00
Handicap Device			6,796		2.00	21.00

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: 1005	Date: 6-23-10
Personnel: M.R., T.S. & S.C.	

Temperature (°F): 89	Humidity (%): 45
Wind Direction: WSW	Wind Speed (mph): 8
Barometric Pressure (in.Hg): 30.03	

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

4.0 PERFORMANCE

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

4.1-I. TEST OBJECTIVE

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

4.1-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.

4.1-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 20.38 seconds.

PERFORMANCE DATA FORM

Bus Number: 1005	Date: 6/24/10
Personnel: M.R., T.S. & S.C.	

Temperature (°F): 82	Humidity (%): 63
Wind Direction: WSW	Wind Speed (mph): 12
Barometric Pressure (in.Hg): 29.88	

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	2.23	2.14	2.51
20 mph	5.04	4.70	4.76
30 mph	8.89	9.39	8.88
40 mph	13.51	14.42	13.58
Top Test Speed(mph) 50	19.64	19.86	19.04

Clockwise Recorded Interval Times

Speed	Run 1	Run 2	Run 3
10 mph	2.33	2.48	2.32
20 mph	5.08	5.39	4.89
30 mph	9.01	9.30	8.98
40 mph	15.05	11.83	14.64
Top Test Speed(mph) 50	21.25	21.98	20.48

1005.ACC

PERFORMANCE SUMMARY SHEET

BUS MANUFACTURER :Diamond
BUS MODEL :VIP 2200
BUS NUMBER :1005
TEST DATE :06/24/10

TEST CONDITIONS :

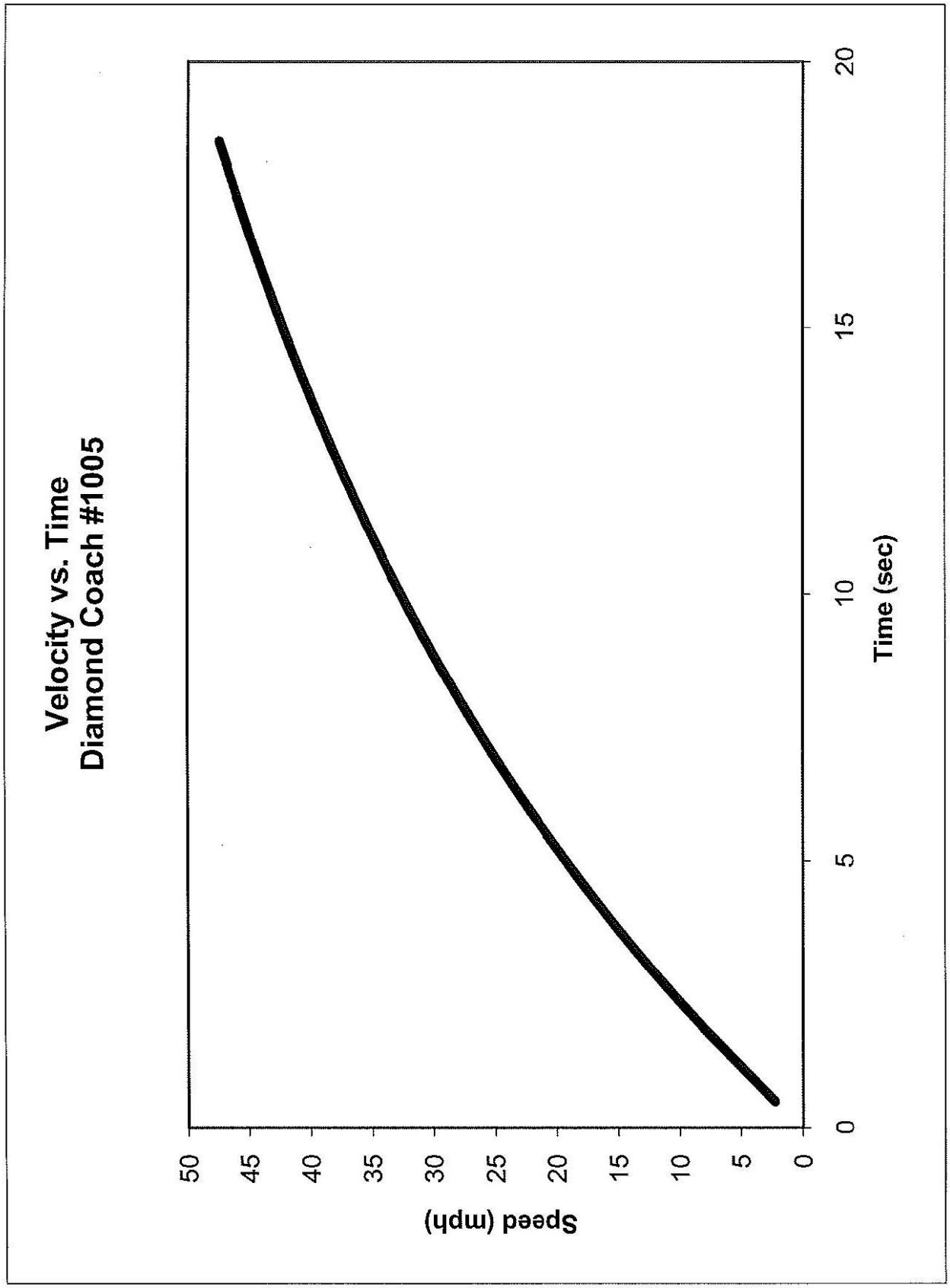
TEMPERATURE (DEG F) : 82.0
WIND DIRECTION : WSW
WIND SPEED (MPH) : 12.0
HUMIDITY (%) : 63
BAROMETRIC PRESSURE (IN. HG) : 29.9

VEHICLE SPEED	AVERAGE TIME (SEC)		
(MPH)	CCW DIRECTION	CW DIRECTION	TOTAL
10.0	2.29	2.38	2.34
20.0	4.83	5.12	4.98
30.0	9.05	9.10	9.08
40.0	13.84	13.84	13.84
50.0	19.51	21.24	20.38

TEST SUMMARY :

VEHICLE SPEED (MPH)	TIME (SEC)	ACCELERATION (FT/SEC^2)	MAX. GRADE (%)
1.0	.22	6.7	21.3
5.0	1.12	6.2	19.8
10.0	2.36	5.7	17.9
15.0	3.72	5.1	16.1
20.0	5.24	4.6	14.3
25.0	6.95	4.0	12.6
30.0	8.89	3.5	11.0
35.0	11.12	3.1	9.5
40.0	13.72	2.6	8.1
45.0	16.79	2.2	6.8
50.0	20.48	1.8	5.6

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
Diamond Coach #1005
Speed (mph)
50
45
40
35
30
25
20
15
10
5
0
0
5
10
15
20
Time (sec)

4.0 PERFORMANCE

4.2 Performance - Bus Braking

4.2 I. TEST OBJECTIVE

The objective of this test is to provide, for comparison purposes, braking performance data on transit buses produced by different manufacturers.

4.2 II. TEST DESCRIPTION

The testing will be conducted at the PTI Test Track skid pad area. Brake tests will be conducted after completion of the GVW portion of the vehicle durability test. At this point in testing the brakes have been subjected to a large number of braking snubs and will be considered well burnished. Testing will be performed when the bus is fully loaded at its GVW. All tires on each bus must be representative of the tires on the production model vehicle

The brake testing procedure comprises three phases:

1. Stopping distance tests

    i. Dry surface (high-friction, Skid Number within the range of 70-76)
    ii. Wet surface (low-friction, Skid Number within the range of 30-36)

2. Stability tests
3. Parking brake test

Stopping Distance Tests

The stopping distance phase will evaluate service brake stops. All stopping distance tests on dry surface will be performed in a straight line and at the speeds of 20, 30, 40 and 45 mph. All stopping distance tests on wet surface will be performed in straight line at speed of 20 mph.

The tests will be conducted as follows:

1. **Uniform High Friction Tests:** Four maximum deceleration straight-line brake applications each at 20, 30, 40 and 45 mph, to a full stop on a uniform high-friction surface in a 3.66-m (12-ft) wide lane.

2. **Uniform Low Friction Tests:** Four maximum deceleration straight-line brake applications from 20 mph on a uniform low friction surface in a 3.66-m (12-ft) wide lane.

When performing service brake stops for both cases, the test vehicle is accelerated on the bus test lane to the speed specified in the test procedure and this speed is maintained into the skid pad area. Upon entry of the appropriate lane of the skid pad area, the vehicle's service brake is applied to stop the vehicle as quickly as possible. The stopping distance is measured and recorded for both cases on the test data form. Stopping distance results on dry and wet surfaces will be recorded and the

average of the four measured stopping distances will be considered as the measured stopping distance. Any deviation from the test lane will be recorded.

Stability Tests

This test will be conducted in both directions on the test track. The test consists of four maximum deceleration, straight-line brake applications on a surface with split coefficients of friction (i.e., the wheels on one side run on high-friction SN 70-76 or more and the other side on low-friction [where the lower coefficient of friction should be less than half of the high one] at initial speed of 30 mph).

(I) The performance of the vehicle will be evaluated to determine if it is possible to keep the vehicle within a 3.66m (12 ft) wide lane, with the dividing line between the two surfaces in the lane's center. The steering wheel input angle required to keep the vehicle in the lane during the maneuver will be reported.

Parking Brake Test

The parking brake phase utilizes the brake slope, which has a 20% grade. The test vehicle, at its GVW, is driven onto the brake slope and stopped. With the transmission in neutral, the parking brake is applied and the service brake is released. The test vehicle is required to remain stationary for five minutes. The parking brake test is performed with the vehicle facing uphill and downhill.

4.2-III. DISCUSSION

The Stopping Distance phase of the Brake Test was completed with the following results; for the Uniform High Friction Test average stopping distances were 24.25' at 20 mph, 51.71' at 30 mph, 84.40' at 40 mph and 106.38' at 45 mph. The average stopping distance for the Uniform Low Friction Test was 26.20'. There was no deviation from the test lane during the performance of the Stopping Distance phase.

During the Stability phase of Brake Testing the test bus experienced no deviation from the test lane but did experience pull to the left during both approaches to the Split Friction Road surface.

The Parking Brake phase was completed with the test bus maintaining the parked position for the full five minute period with no slip or roll observed in both the uphill and downhill positions.

Table 4.2-6. Braking Test Data Forms

Bus Number: 1005	Date: 7-7-10
Personnel: M.R., S.C., T.S. & A.H.	
Ambient Temperature (^{o}F): 81	Wind Speed (mph): 3
Wind Direction: SE	Pavement Temp. F° Start: 104 End: 125 88 118

TIRE INFLATION PRESSURE (psi): 80 Tire Type: Front: Michelin XLT M/S Rear: Michelin LTX M/S				
	Left Tire(s)		Right Tire(s)	
Front	80 psi		80 psi	
	Inner	Outer	Inner	Outer
Rear	80 psi	80 psi	80psi	80psi
Rear	N/A	N/A	N/A	N/A

AXLE LOADS (lb)		
	Left	Right
Front	1,830	1,930
Rear	4,720	4,930

FINAL INSPECTION	
Bus Number: 1005	Date: 7/7/10
Personnel: S.C.	

Table 4.2-7. Record of All Braking System Faults/Repairs.

Date	Personnel	Fault/Repair	Description
7/6/10	G.F., S.C. and A.H.		None noted.

Table 4.2-8.1. Stopping Distance Test Results Form

Stopping Distance (ft)					
Vehicle Direction	CW	CW	CCW	CCW	
Speed (mph)	**Stop 1**	**Stop 2**	**Stop 3**	**Stop 4**	**Average**
20 (dry)	24.76	24.29	24.88	23.04	24.25
30 (dry)	51.67	53.06	56.55	50.54	51.71
40 (dry)	90.17	80.94	82.14	84.33	84.40
45 (dry)	102.30	107.67	105.77	109.75	106.38
20 (wet)	28.47	24.86	26.36	25.09	26.20

Table 4.2-8.2. Stability Test Results Form

Stability Test Results (Split Friction Road surface)			30 mph
Vehicle Direction	Attempt	Did bus stay in 12' lane (Yes/No).	Comments
CW	1	Yes	None noted.
	2	Yes	None noted.
CCW	1	Yes	None noted.
	2	Yes	None noted.

Table 4.2-8.3. Parking Brake Test Form

PARKING BRAKE (Fully Loaded) - GRADE HOLDING						
Vehicle Direction	Attempt	Hold Time (min)	Slide (in)	Roll (in)	Did Hold	No Hold
Front up	1	5 min.			✓	
	2					
	3					
Front down	1	5 min.			✓	
	2					
	3					

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 19 people including the driver plus 2 wheelchair positions. The resulting test load is (19 x 375 lb) = 7,125 lbs. + 1,200 lbs (2 wheelchair positions) = 8,235 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 0.237 inches at reference points 5 & 8. The maximum permanent deflection after the final loading sequence ranged from -0.005 inches at reference point 5 to 0.004 inches at reference point 3.

STRUCTURAL SHAKEDOWN DATA FORM

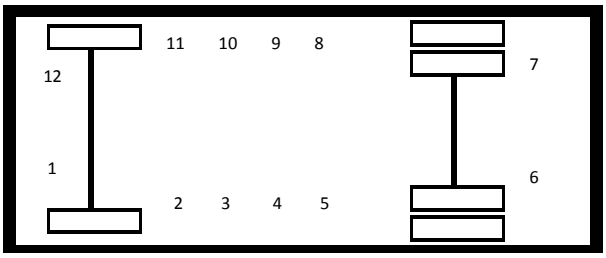
Bus Number: 1005	Date: 4-13-10
Personnel: E.D., E.L., B.L. & P.D.	Temperature (°F): 62
Loading Sequence: ■ 1 ☐ 2 ☐ 3 (check one) Test Load (lbs): 8,325	

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	-.107	-.107	-.014	-.014
2	0	.100	.100	.018	.018
3	0	.171	.171	.024	.024
4	0	.251	.251	.041	.041
5	0	.295	.295	.047	.047
6	0	.002	.002	.007	.007
7	0	-.024	-.024	-.008	-.008
8	0	.285	.285	.038	.038
9	0	.254	.254	.032	.032
10	0	.180	.180	.022	.022
11	0	.099	.099	.013	.013
12	0	-.145	-.145	-.021	-.021

STRUCTURAL SHAKEDOWN DATA FORM

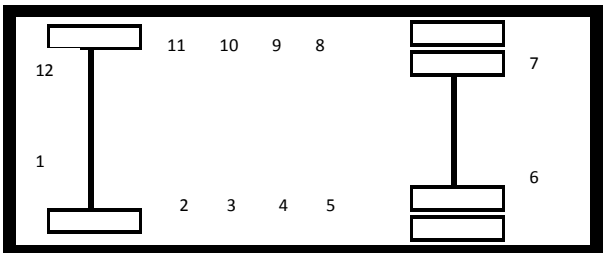
Bus Number: 1005	Date: 4/13/10
Personnel: E.D., E.L., B.L. & P.D.	Temperature (°F):
Loading Sequence: ☐ 1 ■ 2 ☐ 3 (check one) Test Load (lbs): 8,325	

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	-.014	-.096	-.082	-.018	-.004
2	.018	.098	.080	.020	.002
3	.024	.167	.143	.028	.004
4	.041	.244	.203	.043	.002
5	.047	.284	.237	.048	.001
6	.007	.001	-.006	.006	-.001
7	-.008	-.068	-.060	-.007	.001
8	.038	.275	.237	.039	.001
9	.032	.246	.214	.033	.001
10	.022	.177	.155	.024	.002
11	.013	.198	.185	.013	.000
12	-.021	-.142	-.121	-.026	-.005

5.1 STRUCTURAL SHAKEDOWN TEST

DIAL INDICATORS IN POSITION

BUS LOADED TO 2.5 TIMES GVL (8,325 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: 1005	Date: 4-15-10
Personnel: E.D., E.L. & P.D.	Temperature(°F): 64

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

	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: 1005	Date: 4-15-10
Personnel: E.D., E.L. & P.D.	Temperature(°F): 64

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

	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: 1005	Date: 4-15-10
Personnel: E.D., E.L. & P.D.	Temperature(°F): 64

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

	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: 1005	Date: 4-15-10
Personnel: E.D., E.L. & P.D.	Temperature(°F): 64

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

	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: 1005	Date: 4-15-10
Personnel: E.D., E.L. & P.D.	Temperature(°F): 64

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

	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: 1005	Date: 4-15-10
Personnel: E.D., E.L. & P.D.	Temperature(°F): 64

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

	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: 1005	Date: 4-15-10
Personnel: E.D., E.L. & P.D.	Temperature(°F): 64

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

	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: 1005	Date: 4-15-10
Personnel: E.D., E.L. & P.D.	Temperature(°F): 64

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

	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: 1005	Date: 4-15-10
Personnel: E.D., E.L. & P.D.	Temperature(°F): 64

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

	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: 1005	Date: 4-15-10
Personnel: E.D., E.L. & P.D.	Temperature(°F): 64

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

	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 HIGHER

LEFT REAR 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: 1005	Date: 7/16/10
Personnel: T.S.	

Temperature (°F): 84	Humidity (%): 59
Wind Direction: W	Wind Speed (mph): 12
Barometric Pressure (in.Hg): 29.99	

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 toe 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 during the test.

5.4 DYNAMIC TOWING TEST

TOWING INTERFACE

TEST BUS IN TOW

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 7.3 inches to 16.3 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	11.8”
Rear axle – one tire flat	15.1”
Rear axle – two tires flat	13.0”

JACKING TEST DATA FORM

Bus Number: 1005	Date: 4/9/10
Personnel: T.S., E.D. & P.D.	Temperature (°F): 65

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	13.7 “ I 11.9 “ D	9.5 “ I 7.3 “ D	None noted.
Left front	13.6 “ I 11.8 “ D	9.5 “ I 7.4 “ D	“
Right rear—outside	15.6 “ I 15.1 “ D	10.5 “ I 10.1 “ D	“
Right rear—both	15.6 “ I 13.0 “ D	10.5 “ I 8.5 “ D	“
Left rear—outside	16.8 “ I 16.3 “ D	10.7 “ I 10.3 “ D	“
Left rear—both	16.8 “ I 14.8 “ D	10.7 “ I 9.0 “ D	“

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: 1005	Date: 4/9/10
Personnel: T.S., E.D. & P.D.	Temperature (°F): 65

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 7,500 miles; approximately 5,000 miles on the PSBRTF Durability Test Track and approximately 2,500 miscellaneous other miles. The test will be conducted with the bus operated under three different loading conditions. The first segment will consist of approximately 3,000 miles with the bus operated at GVW. The second segment will consist of approximately 1,500 miles with the bus operated at SLW. The remainder of the test, approximately 3,000 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 April 19, 2010 and was conducted until June 30, 2010. The first 3,000 miles were performed at a GVW of 13,410 lbs. and completed on May 17, 2010. **Note; at GVL the load is 150 lbs over the rear GAWR.** The next 1,500 mile SLW segment was performed at 12,530 lbs and completed on May 24, 2010, and the final 3,000 mile segment was performed at a CW of 9,440 lbs and completed on June 30, 2010.

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.

DIAMOND- TEST BUS #1005

MILEAGE DRIVEN/RECORDED FROM DRIVER'S LOGS

DATE	TOTAL DURABILITY TRACK	TOTAL OTHER MILES	TOTAL
04/19/10 TO 04/25/10	641.00	80.00	721.00
04/26/10 TO 05/02/10	170.00	9.00	179.00
05/3/10 TO 05/09/10	708.00	32.00	740.00
05/10/10 TO 05/16/10	339.00	1452.00	1791.00
5/17/10 TO 05/23/10	1132.00	514.00	1646.00
05/24/10 TO 05/30/10	1032.00	147.00	1179.00
5/31/10 TO 06/06/10	481.00	23.00	504.00
6/7/10 TO 06/13/10	434.00	21.00	455.00
6/14/10 TO 06/20/10	63.00	111.00	174.00
6/21/10 TO 06/27/10	0.00	20.00	20.00
6/28/10 TO 07/04/10	0.00	93.00	93.00
TOTAL	5000.00	2502.00	7502.00

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

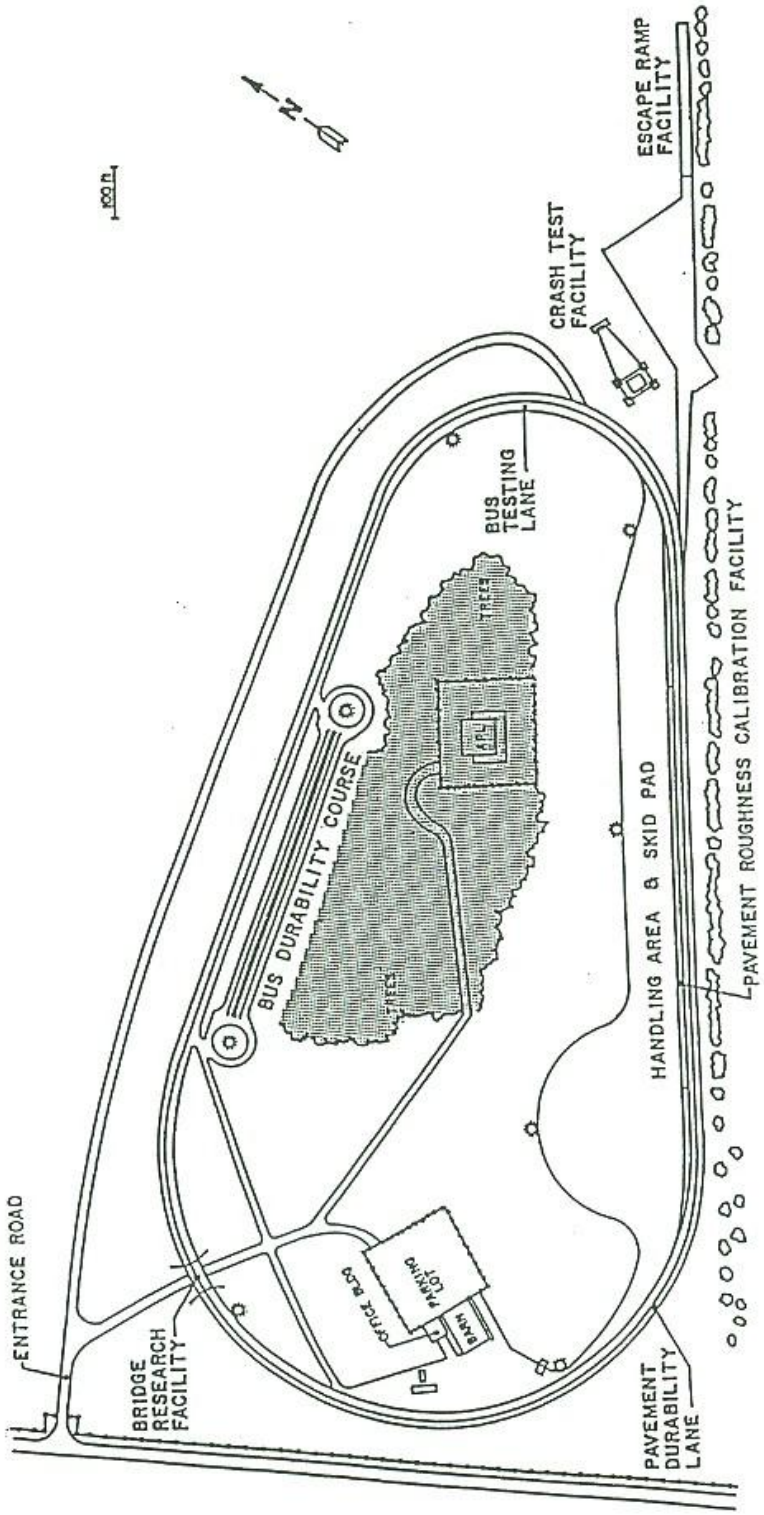
STANDARD OPERATING SCHEDULE

Monday through Friday

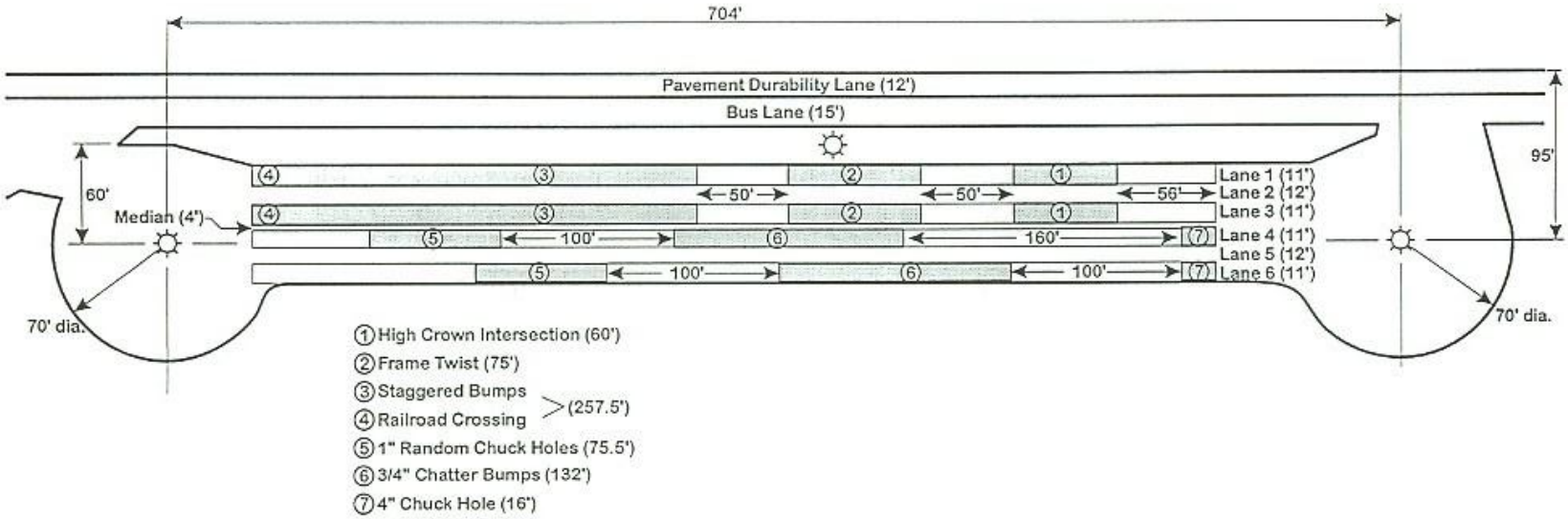
	HOUR	ACTION
Shift 1	midnight	D
	1:40 am	C
	1:50 am	B
	2:00 am	D
	3:35 am	C
	3:45 am	B
	4:05 am	D
	5:40 am	C
	5:50 am	B
	6:00 am	D
	7:40 am	C
	7:50 am	F
Shift 2	8:00 am	D
	9:40 am	C
	9:50 am	B
	10:00 am	D
	11:35 am	C
	11:45 am	B
	12:05 pm	D
	1:40 pm	C
	1:50 pm	B
	2:00 pm	D
	3:40 pm	C
	3:50 pm	F
Shift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



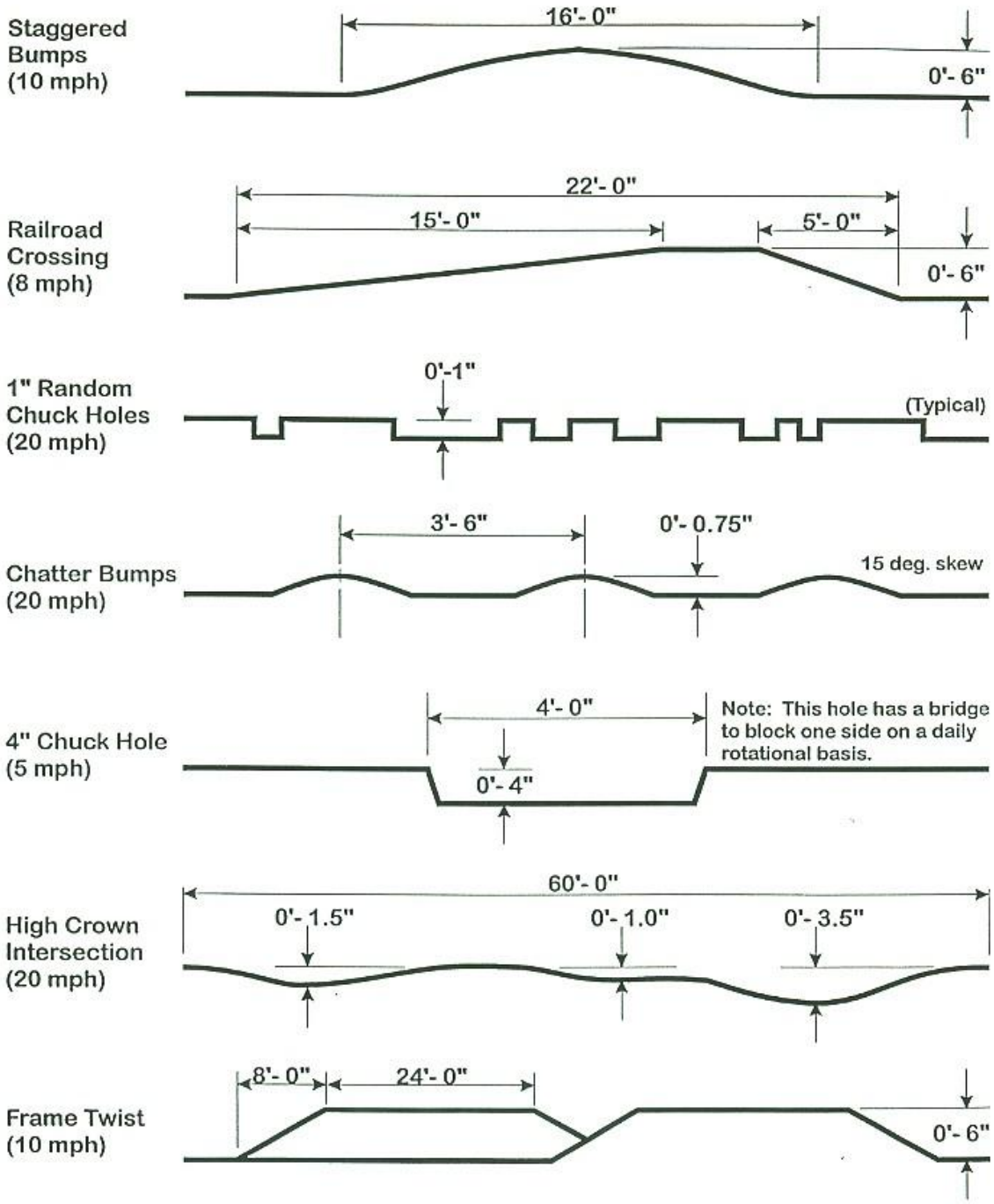
BUS TESTING AND RESEARCH TEST TRACK
UNIVERSITY PARK, PA



Plan View

Vehicle Durability Test Track

The Pennsylvania Transportation Institute
Penn State



Durability Element Profiles

The Pennsylvania Transportation Institute
Penn State

(Page 1 of 1)

UNSCHEDULED MAINTENANCE

Diamond #1005

DATE	TEST MILES	SERVICE	ACTIVITY	MAN HOURS	DOWN TIME
05-10-10	1,650	The tailpipe hanger is broken.	Tailpipe hanger replaced.	1.00	9.00
05-13-10	3,073	The lower spring ply is broken on the left rear spring.	Left rear spring replaced.	4.00	6.00
05-25-10	5,426	Both spring plies are broken on the right rear load spring.	Right rear load spring replaced.	3.00	1.00
05-25-10	5,426	The right side hood hinge is broken.	Right side hood hinge replaced.	.50	.50
05-26-10	5,687	The center bolt is missing from the right rear load spring.	New center bolt installed.	4.00	4.00
06-08-10	6,796	The wheelchair lift will deploy but will not lower.	Proximity switch mounting rivets and bracket are broken, proximity switch out of position. Rivets and broken bracket replaced.	2.00	21.00
06-10-10	6,875	The left side hood hinge is broken.	Left side hood hinge replaced.	1.00	16.00

UNSCHEDULED MAINTENANCE

LEFT REAR SPRING: BROKEN LOWER SPRING PLY (3,073 TEST MILES)

BROKEN RIGHT REAR LOAD SPRING (5,426 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

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

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.

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

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/BTUx10^6.

Eq = Energy equivalent of converting mpg to mile/BTUx10^6.

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

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/BTUx10^6) 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/BTUx10^6) 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/BTUx10^6
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 – 6.89 mpg, ART – 7.13 mpg, and COM – 11.41 mpg. Average fuel consumption at idle was 0.66 gph.

FUEL ECONOMY PRE-TEST MAINTENANCE FORM

Bus Number: 1005	Date: 6/25/10	SLW (lbs): 12,530
Personnel: T.S., G.F. & J.P.		

FUEL SYSTEM	OK	Date	Initials
Install fuel measurement system	✓	6/25/10	T.S.
Replace fuel filter	✓	6/25/10	T.S.
Check for fuel leaks	✓	6/25/10	T.S.
Specify fuel type (refer to fuel analysis)	Gasoline		
Remarks: None noted.			
BRAKES/TIRES	OK	Date	Initials
Inspect hoses	✓	6/25/10	T.S.
Inspect brakes	✓	6/25/10	T.S.
Relube wheel bearings	✓	6/25/10	G.F.
Check tire inflation pressures (mfg. specs.)	✓	6/25/10	T.S.
Remarks: None noted.			
COOLING SYSTEM	OK	Date	Initials
Check hoses and connections	✓	6/25/10	T.S.
Check system for coolant leaks	✓	6/25/10	T.S.
Remarks: None noted.			

FUEL ECONOMY PRE-TEST MAINTENANCE FORM (page 2)

Bus Number: 1005	Date: 6/25/10
Personnel: T.S.	

ELECTRICAL SYSTEMS	OK	Date	Initials
Check battery	✓	6/25/10	T.S.
Inspect wiring	✓	6/25/10	T.S.
Inspect terminals	✓	6/25/10	T.S.
Check lighting	✓	6/25/10	T.S.
Remarks: None noted.			
DRIVE SYSTEM	OK	Date	Initials
Drain transmission fluid	✓	6/25/10	J.P.
Replace filter/gasket	✓	6/25/10	J.P.
Check hoses and connections	✓	6/25/10	J.P.
Replace transmission fluid	✓	6/25/10	J.P.
Check for fluid leaks	✓	6/25/10	J.P.
Remarks: None noted.			
LUBRICATION	OK	Date	Initials
Drain crankcase oil	✓	6/25/10	G.F.
Replace filters	✓	6/25/10	G.F.
Replace crankcase oil	✓	6/25/10	G.F.
Check for oil leaks	✓	6/25/10	G.F.
Check oil level	✓	6/25/10	G.F.
Lube all chassis grease fittings	✓	6/25/10	G.F.
Lube universal joints	✓	6/25/10	G.F.
Replace differential lube including axles	✓	6/25/10	G.F.
Remarks: None noted.			

FUEL ECONOMY PRE-TEST MAINTENANCE FORM (page 3)

Bus Number: 1005	Date: 6/25/10
Personnel: T.S.	

EXHAUST/EMISSION SYSTEM	OK	Date	Initials
Check for exhaust leaks	✓	6/25/10	T.S.
Remarks: None noted.			
ENGINE	OK	Date	Initials
Replace air filter	✓	6/25/10	T.S.
Inspect air compressor and air system	✓	6/25/10	T.S.
Inspect vacuum system, if applicable	✓	6/25/10	T.S.
Check and adjust all drive belts	✓	6/25/10	T.S.
Check cold start assist, if applicable	✓	6/25/10	T.S.
Remarks: None noted.			
STEERING SYSTEM	OK	Date	Initials
Check power steering hoses and connectors	✓	6/25/10	T.S.
Service fluid level	✓	6/25/10	T.S.
Check power steering operation	✓	6/25/10	T.S.
Remarks: None noted.			
	OK	Date	Initials
Ballast bus to seated load weight	✓	6/25/10	T.S.
TEST DRIVE	OK	Date	Initials
Check brake operation	✓	6/25/10	T.S.
Check transmission operation	✓	6/25/10	T.S.
Remarks: None noted.			

FUEL ECONOMY PRE-TEST INSPECTION FORM

Bus Number: 1005	Date: 6/30/10
Personnel: S.C.	

PRE WARM-UP	If OK, Initial
Fuel Economy Pre-Test Maintenance Form is complete	S.C.
Cold tire pressure (psi): Front 80 Middle N/A Rear 80	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 84 Middle N/A Rear 86	S.C.
Environmental conditions Average wind speed <12 mph and maximum gusts <15 mph Ambient temperature between 30°F(-1C°) and 90°F(32°C) Track surface is dry Track is free of extraneous material and clear of interfering traffic	S.C.

FUEL ECONOMY DATA FORM (Liquid Fuels)

Bus Number: 1005	Manufacturer: Diamond	Date: 6/30/10
Run Number: 1	Personnel: M.R., T.S. & B.L.	
Test Direction: □CW or ■CCW	Temperature (°F): 61	Humidity (%): 53
SLW (lbs): 12,530	Wind Speed (mph) & Direction: 3 / NW	Barometric Pressure (in.Hg): 30.17

Cycle Type	Time (min:sec)		Cycle Time (min:sec)	Fuel Temperature (°C)	Flow Meter Reading (gals)		Fuel Used (gals)
	Start	Finish		Start	Start	Finish	
CBD #1	0	8:36	8:36	24.6	0	.2937	.2937
ART #1	0	3:51	3:51	21.6	0	.2792	.2792
CBD #2	0	8:10	8:10	20.2	0	.2843	.2843
ART #2	0	3:51	3:51	20.2	0	.2731	.2731
CBD #3	0	8:06	8:06	22.4	0	.2858	.2858
COMMUTER	0	5:55	5:55	20.4	0	.3430	.3430
							Total Fuel = 1.7591 gals

20 minute idle : Total Fuel Used = 0.2207 gals

Heating Value = 20,025.0 BTU/LB

Comments: None noted.

FUEL ECONOMY DATA FORM (Liquid Fuels)

Bus Number: 1005	Manufacturer: Diamond	Date: 6/30/10
Run Number: 2	Personnel: M.R. & B.L.	
Test Direction: ■CW or □CCW	Temperature (°F): 67	Humidity (%): 53
SLW (lbs): 12,530	Wind Speed (mph) & Direction: 3 / NW	Barometric Pressure (in.Hg): 30.17

Cycle Type	Time (min:sec)		Cycle Time (min:sec)	Fuel Temperature (°C)	Flow Meter Reading (gals)		Fuel Used (gals)
	Start	Finish		Start	Start	Finish	
CBD #1	0	8:21	8:21	22.4	0	.2858	.2858
ART #1	0	3:49	3:49	22.6	0	.2747	.2747
CBD #2	0	8:17	8:17	23.0	0	.2788	.2788
ART #2	0	3:54	3:54	22.4	0	.2728	.2728
CBD #3	0	8:09	8:09	23.2	0	.2868	.2868
COMMUTER	0	5:59	5:59	23.0	0	.3454	.3454
							Total Fuel = 1.7443 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: 1005	Manufacturer: Diamond	Date: 6/30/10
Run Number: 3	Personnel: M.R., T.S. & S.C.	
Test Direction: □CW or ■CCW	Temperature (°F): 71	Humidity (%): 40
SLW (lbs): 12,530	Wind Speed (mph) & Direction: 7/WNW	Barometric Pressure (in.Hg): 30.15

Cycle Type	Time (min:sec)		Cycle Time (min:sec)	Fuel Temperature (°C)	Flow Meter Reading (gals)		Fuel Used (gals)
	Start	Finish		Start	Start	Finish	
CBD #1	0	8:37	8:37	27.8	0	.2887	.2887
ART #1	0	3:55	3:55	26.2	0	.2763	.2763
CBD #2	0	8:14	8:14	27.8	0	.2788	.2788
ART #2	0	3:53	3:53	27.4	0	.2777	.2777
CBD #3	0	8:10	8:10	26.2	0	.2832	.2832
COMMUTER	0	5:54	5:54	25.6	0	.3404	.3404
							Total Fuel = 1.7451 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: 1005	Manufacturer: Diamond	Date: 6/30/10
Run Number: 4	Personnel: M.R., T.S. & S.C.	
Test Direction: ■CW or □CCW	Temperature (°F): 73	Humidity (%): 40
SLW (lbs): 12,530	Wind Speed (mph) & Direction: 9/WNW	Barometric Pressure (in.Hg): 30.15

Cycle Type	Time (min:sec)		Cycle Time (min:sec)	Fuel Temperature (°C)	Flow Meter Reading (gals)		Fuel Used (gals)
	Start	Finish		Start	Start	Finish	
CBD #1	0	8:22	8:22	25.4	0	.2846	.2846
ART #1	0	3:52	3:52	25.2	0	.2716	.2716
CBD #2	0	8:16	8:16	24.4	0	.2802	.2802
ART #2	0	3:52	3:52	24.6	0	.2712	.2712
CBD #3	0	8:15	8:15	24.8	0	.2811	.2811
COMMUTER	0	5:55	5:55	24.8	0	.3444	.3444
							Total Fuel = 1.7331 gals

20 minute idle : Total Fuel Used = 0.2204 gals

Heating Value = 20,025.0 BTU/LB

Comments: None noted.

FUEL ECONOMY SUMMARY SHEET

BUS MANUFACTURER :**Diamond Coach** BUS NUMBER :**1005**
BUS MODEL :**VIP 2200** TEST DATE :06/30/10

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	.864	5.73	6.633	6.80
ART	.552	3.82	6.917	7.09
COM	.343	3.82	11.137	11.42
TOTAL	1.759	13.37	7.600	7.79
Run # :2, CW				
CBD	.851	5.73	6.730	6.90
ART	.548	3.82	6.977	7.16
COM	.345	3.82	11.060	11.34
TOTAL	1.744	13.37	7.665	7.86
Run # :3, CCW				
CBD	.851	5.73	6.736	6.91
ART	.554	3.82	6.895	7.07
COM	.340	3.82	11.222	11.51
TOTAL	1.745	13.37	7.661	7.86
Run # :4, CW				
CBD	.846	5.73	6.774	6.95
ART	.543	3.82	7.038	7.22
COM	.344	3.82	11.092	11.37
TOTAL	1.733	13.37	7.714	7.91

IDLE CONSUMPTION (MEASURED)

First 20 Minutes Data : .22GAL Last 20 Minutes Data : .22GAL
Average Idle Consumption : .66GAL/Hr

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

Run 1 : -.8 Run 2 : .1 Run 3 : .0 Run 4 : .7

SUMMARY (CORRECTED VALUES)

Average Idle Consumption : .65 G/Hr
Average CBD Phase Consumption : 6.89 MPG
Average Arterial Phase Consumption : 7.13 MPG
Average Commuter Phase Consumption : 11.41 MPG
Overall Average Fuel Consumption : 7.86 MPG
Overall Average Fuel Consumption : 63.59 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 47.6 dB(A); ranging from 46.6 dB(A) at the driver's seat to 48.3 dB(A) in line with the middle 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 70.3 dB(A) at the rear passenger seats to 76.0 dB(A) at the driver's seat. The overall average was 72.9 dB(A). The interior ambient noise level for this test was 36.9 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: 1005	Date: 4/8/10
Personnel: S.C.	
Temperature (°F): 62	Humidity (%): 54
Wind Speed (mph): Calm	Wind Direction: Calm
Barometric Pressure (in.Hg): 29.70	
Initial Sound Level Meter Calibration: ■ checked by: S.C.	
Interior Ambient Noise Level dB(A): < 34.0	Exterior Ambient Noise Level dB(A): 48.4
Microphone Height During Testing (in): 48.0	

Measurement Location	Measured Sound Level dB(A)
Driver's Seat	46.6
Front Passenger Seats	47.4
In Line with Front Speaker	47.3
In Line with Middle Speaker	48.3
In Line with Rear Speaker	48.0
Rear Passenger Seats	48.1

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: 1005	Date: 6/24/10
Personnel: M.R., T.S. & S.C.	
Temperature (°F): 82	Humidity (%): 63
Wind Speed (mph): 12	Wind Direction: WSW
Barometric Pressure (in.Hg): 29.88	
Initial Sound Level Meter Calibration: ■ checked by: S.C.	
Interior Ambient Noise Level dB(A): 36.9	Exterior Ambient Noise Level dB(A): 50.3
Microphone Height During Testing (in): 48.0	

Measurement Location	Measured Sound Level dB(A)
Driver's Seat	76.0
Front Passenger Seats	73.5
Middle Passenger Seats	71.6
Rear Passenger Seats	70.3

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: 1005	Date: 6/24/10
Personnel: M.R., T.S. & S.C.	
Temperature (°F): 82	Humidity (%): 63
Wind Speed (mph): 12	Wind Direction: WSW
Barometric Pressure (in.Hg): 29.88	

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 47.6 dB(A), the average test result obtained while accelerating from a constant speed was 69.9 dB(A) on the right side and 69.6 dB(A) on the left side.

When accelerating from a standstill with an exterior ambient noise level of 51.2 dB(A), the average of the results obtained were 69.9 dB(A) on the right side and 69.9 dB(A) on the left side.

With the vehicle stationary and the engine, accessories, and air conditioning on, the measurements averaged 59.3 dB(A) at low idle and 67.8 dB(A) at wide open throttle. With the accessories and air conditioning off, the readings averaged 7.5 dB(A) lower at low idle and 6.8 dB(A) lower at wide open throttle. The exterior ambient noise level measured during this test was 48.9 dB(A). Note; the test bus was not equipped with a high idle mode.

EXTERIOR NOISE TEST DATA FORM
Accelerating from Constant Speed

Bus Number: 1005	Date: 6/24/10
Personnel: M.R., T.S. & S.C.	
Temperature (°F): 82	Humidity (%): 63
Wind Speed (mph): 12	Wind Direction: WSW
Barometric Pressure (in.Hg): 29.88	
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): 47.6	

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	69.1	1	69.5
2	67.6	2	68.2
3	67.2	3	67.6
4	69.9	4	69.6
5	69.8	5	68.5
Average of two highest actual noise levels = 69.9 dB(A)		Average of two highest actual noise levels = 69.6 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: 1005	Date: 6/24/10
Personnel: M.R., T.S. & S.C.	
Temperature (°F): 82	Humidity (%): 63
Wind Speed (mph): 12	Wind Direction: WSW
Barometric Pressure (in.Hg): 29.88	
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): 51.2	

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	67.2	1	69.7
2	68.0	2	69.0
3	69.1	3	70.1
4	70.1	4	69.2
5	69.7	5	68.7
Average of two highest actual noise levels = 69.9 dB(A)		Average of two highest actual noise levels = 69.9 dB(A)	

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

Comments: None noted.

EXTERIOR NOISE TEST DATA FORM
Stationary

Bus Number: 1005	Date: 6/23/10
Personnel: M.R., T.S. & S.C.	
Temperature (°F): 82	Humidity (%): 63
Wind Speed (mph): 12	Wind Direction: WSW
Barometric Pressure (in.Hg): 29.88	

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): 48.9

Accessories and Air Conditioning ON

Throttle Position	Engine RPM	Curb (Right) Side dB(A)	Street (Left) Side db(A)
		Measured	Measured
Low Idle	675	58.5	60.0
High Idle	N/A	N/A	N/A
Wide Open Throttle	3,515	67.6	67.9

Accessories and Air Conditioning OFF

Throttle Position	Engine RPM	Curb (Right) Side dB(A)	Street (Left) Side db(A)
		Measured	Measured
Low Idle	701	52.1	51.5
High Idle	N/A	N/A	N/A
Wide Open Throttle	3,510	56.0	65.9

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

Comments: Test bus is not equipped with a high idle mode.

7.2 EXTERIOR NOISE TESTS

TEST BUS UNDERGOING EXTERIOR NOISE TESTING

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

8-I. TEST OBJECTIVE

The objective of this test is to provide comparable emissions data on transit buses produced by different manufacturers. This chassis-based emissions test bears no relation to engine certification testing performed for compliance with the Environmental Protection Agency (EPA) regulation. EPA's certification tests are performed using an engine dynamometer operating under the Federal Test Protocol. This emissions test is a measurement of the gaseous engine emissions CO, CO2, NOx, HC and particulates (diesel vehicles) produced by a vehicle operating on a large-roll chassis dynamometer. The test is performed for three differed driving cycles intended to simulate a range of transit operating environments. The cycles consist of Manhattan Cycle, the Orange County Bus driving cycle, and the Urban Dynamometer Driving Cycle (UDDS) and. The test is performed under laboratory conditions in compliance with EPA 1065 and SAE J2711. The results of this test may not represent actual in-service vehicle emissions but will provide data that can be used by recipients to compare buses tested under different operating conditions.

8-II. TEST DESCRIPTION

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

The emissions test will be performed as soon as permissible after the completion of the GVW portion of the structural durability test. The driving cycles are the Manhattan cycle, a low average speed, highly transient urban cycle (Figure 1), the Orange County Bus Cycle which consists of urban and highway driving segments (Figure 2), and the EPA UDDS Cycle (Figure 3). An emissions test will comprise of two runs for the three different driving cycles, and the

average value will be reported. Test results reported will include the average grams per mile value for each of the gaseous emissions for gasoline buses, for all the three driving cycles. In addition, the particulate matter emissions are included for diesel buses, and non-methane hydrocarbon emissions (NMHC) are included for CNG buses. Testing is performed in accordance with EPA CFR49, Part 1065 and SAE J2711 as practically determined by the FTA Emissions Testing Protocol developed by West Virginia University and Penn State University.

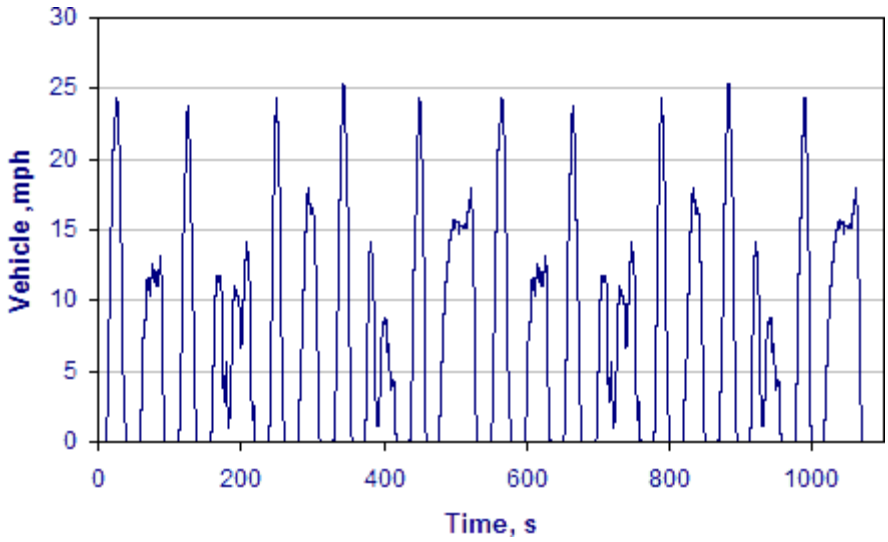


***Figure 1**. Manhattan Driving Cycle (duration 1089 sec, Maximum speed 25.4mph, average speed 6.8mph)*

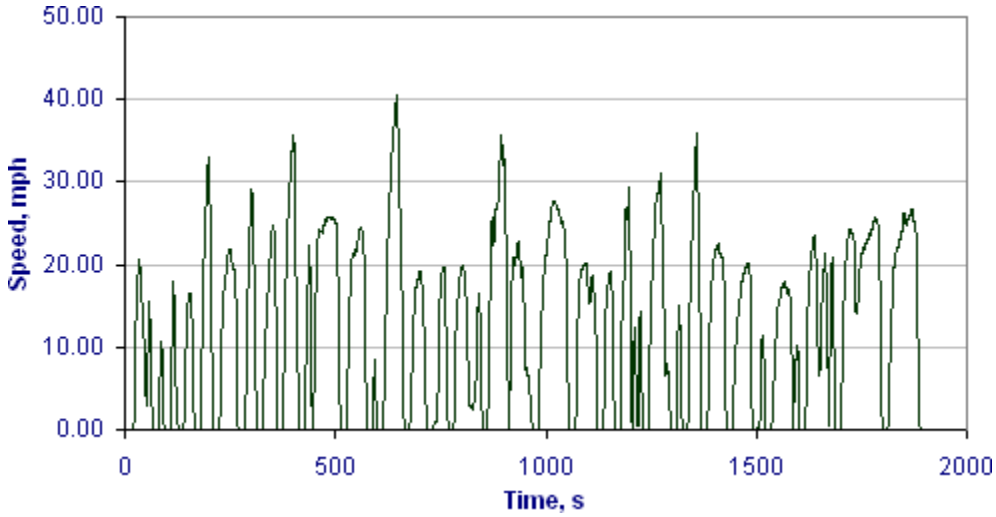


***Figure 2**. Orange County Bus Cycle (Duration 1909 Sec, Maximum Speed 41mph, Average Speed 12mph)*

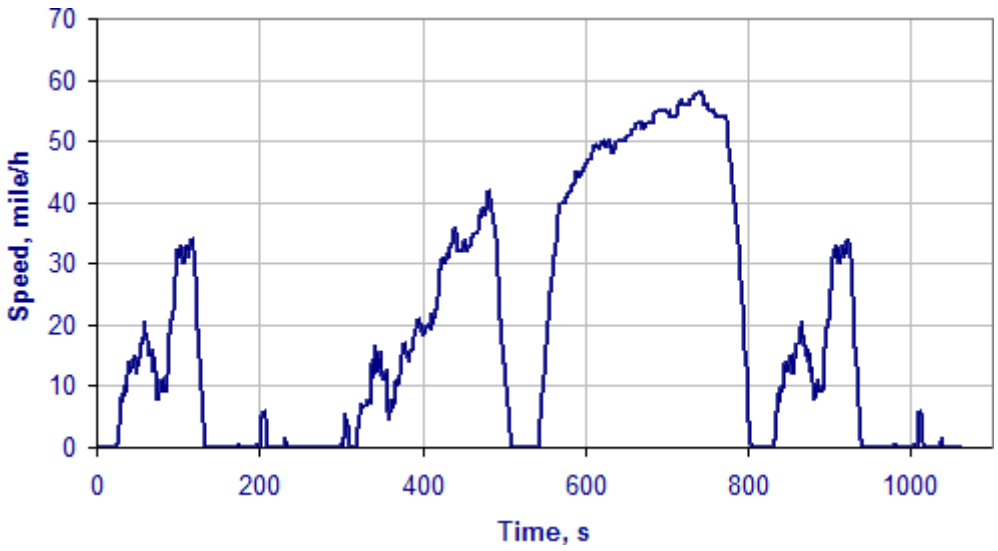


***Figure 3**. HD-UDDS Cycle (duration 1060seconds, Maximum Speed 58mph, Average Speed 18.86mph)*

8-III. TEST ARTICLE

The test article is a Diamond Coach Corp. VIP 2200 model transit bus equipped with a gasoline fueled Ford Motor Co. 6.8L engine. The bus was tested on July 15, 2010.

8-IV. TEST EQUIPMENT

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

Vehicle exhaust is collected by a Horiba CVS, full-flow dilution tunnel. The system has separate tunnels for diesel and gasoline/natural gas fueled vehicles. In the case of diesel vehicles, particulate emissions are measured gravimetrically using 47mm Teflon filters. These filters are housed in a Horiba HF47 particulate sampler, per EPA 1065 test procedures.. Heated gaseous emissions of hydrocarbons and NOx are sampled by Horiba heated oven analyzers. Gaseous

emissions for CO, CO2 and cold NOx are measured using a Horiba Mexa 7400 series gas analyzer. System operation, including the operation of the chassis dynamometer, and all calculations are controlled by a Dell workstation running Horiba CDCTS test control software. Particulate Filters are weighed in a glove box using a Sartorius microbalance accurate to 1 microgram.

8-V. TEST PREPARATION AND PROCEDURES

All vehicles are prepared for emissions testing in accordance with the Fuel Economy Pre-Test Maintenance Form. (In the event that fuel economy test was performed immediately prior to emissions testing this step does not have to be repeated) This is done to ensure that the bus is tested in optimum operating condition. The manufacturer-specified preventive maintenance shall be performed before this test. The ABS system and when applicable, the regenerative braking system are disabled for operation on the chassis dynamometer. Any manufacturer-recommended changes to the pre-test maintenance procedure must be noted on the revision sheet. The Fuel Economy Pre-Test Inspection Form will also be completed before performing. Both the Fuel Economy Pre-Test Maintenance Form and the Fuel Economy Pre-Test Inspection Form are found on the following pages.

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

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

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

1. Air conditioning off
2. Evaporator fan or ventilation fan on
3. One Half Seated load weight
4. Appropriate test fuel with energy content (BTU/LB) noted in CDTCS software
5. Exterior and interior lights on
6. Heater Pump Motor off
7. Defroster off
8. Windows and Doors closed

The test tanks or the bus fuel tank(s) will be filled prior to the fuel economy test with the appropriate grade of test fuel.

8-VI DISCUSSION

The following Table 1 provides the emissions testing results on a grams per mile basis for each of the exhaust constituents measured and for each driving cycle performed.

TABLE 1 Emissions Test Results

Driving Cycle	Manhattan	Orange County Bus	UDDS
CO_2, gm/mi	1525	1090	1102
CO, gm/mi	0.34	0.27	0.88
THC, gm/mi	0.15	0.04	0.13
NMHC, gm/mi	NA	NA	NA
NO_x, gm/mi	0.004	0.0	0.015
Particulates. gm/mi	NA	NA	NA
Fuel consumption mpg	5.65	7.91	7.81

FUEL ECONOMY/EMISSIONS PRE-TEST MAINTENANCE FORM

Bus Number: 1005	Date: 06-25-10	SLW (lbs): 12,530
Personnel: T.S., G.F., and J.P.		

FUEL SYSTEM	OK	Date	Initials
Install fuel measurement system	✓	06/25/10	TS
Replace fuel filter	✓	06/25/10	TS
Check for fuel leaks	✓	06/25/10	TS
Specify fuel type (refer to fuel analysis)			
Remarks: None noted.			
BRAKES/TIRES	OK	Date	Initials
Inspect hoses	✓	06/25/10	TS
Inspect brakes	✓	06/25/10	TS
Relube wheel bearings	✓	06/25/10	GF
Check tire inflation pressures (mfg. specs.)	✓	06/25/10	TS
Remarks: None noted.			
COOLING SYSTEM	OK	Date	Initials
Check hoses and connections	✓	06/25/10	TS
Check system for coolant leaks	✓	06/25/10	TS
Remarks: None noted.			

FUEL ECONOMY/EMISSIONS PRE-TEST MAINTENANCE FORM (page 2)

Bus Number: 1005	Date: 06-25-10
Personnel: TS	

ELECTRICAL SYSTEMS	OK	Date	Initials
Check battery	✓	06/25/10	TS
Inspect wiring	✓	06/25/10	TS
Inspect terminals	✓	06/25/10	TS
Check lighting	✓	06/25/10	TS
Remarks: None noted.			
DRIVE SYSTEM	OK	Date	Initials
Drain transmission fluid	✓	06/25/10	JP
Replace filter/gasket	✓	06/25/10	JP
Check hoses and connections	✓	06/25/10	JP
Replace transmission fluid	✓	06/25/10	JP
Check for fluid leaks	✓	06/25/10	JP
Remarks: None noted.			
LUBRICATION	OK	Date	Initials
Drain crankcase oil	✓	06/25/10	GF
Replace filters	✓	06/25/10	GF
Replace crankcase oil	✓	06/25/10	GF
Check for oil leaks	✓	06/25/10	GF
Check oil level	✓	06/25/10	GF
Lube all chassis grease fittings	✓	06/25/10	GF
Lube universal joints	✓	06/25/10	GF
Replace differential lube including axles	✓	06/25/10	GF
Remarks: None noted.			

FUEL ECONOMY/EMISSIONS PRE-TEST MAINTENANCE FORM (page 3)

Bus Number: 1005	Date: 06/25/10
Personnel: TS	

EXHAUST/EMISSION SYSTEM	OK	Date	Initials
Check for exhaust leaks	✓	06/25/10	TS
Remarks: None noted.			

ENGINE	OK	Date	Initials
Replace air filter	✓	06/25/10	TS
Inspect air compressor and air system	✓	06/25/10	TS
Inspect vacuum system, if applicable	✓	06/25/10	TS
Check and adjust all drive belts	✓	06/25/10	TS
Check cold start assist, if applicable	✓	06/25/10	TS
Remarks: None noted.			

STEERING SYSTEM	OK	Date	Initials
Check power steering hoses and connectors	✓	06/25/10	TS
Service fluid level	✓	06/25/10	TS
Check power steering operation	✓	06/25/10	TS
Remarks: None noted.			

	OK	Date	Initials
Ballast bus to seated load weight	✓	06/25/10	TS

TEST DRIVE	OK	Date	Initials
Check brake operation	✓	06/25/10	TS
Check transmission operation	✓	06/25/10	TS
Remarks: None noted.			

FUEL ECONOMY/EMISSIONS PRE-TEST INSPECTION FORM

Bus Number: 1005	Date: 06/30/10
Personnel: SC	
PRE WARM-UP	If OK, Initial
Fuel Economy Pre-Test Maintenance Form is complete	SC
Cold tire pressure (psi): Front__80__ Middle_N/A___ Rear__80__	SC
Tire wear: less than 50%	SC
Engine oil level	SC
Engine coolant level	SC
Interior and exterior lights on, evaporator fan on	SC
Fuel economy instrumentation installed and working properly.	SC
Fuel line -- no leaks or kinks	SC
Speed measuring system installed on bus. Speed indicator installed in front of bus and accessible to TP and Driver.	SC
Bus is loaded to SLW	SC
WARM-UP	If OK, Initial
Bus driven for at least one hour warm-up	SC
No extensive or black smoke from exhaust	SC
POST WARM-UP	If OK, Initial
Warm tire pressure (psi): Front_80__ Middle_N/A_ Rear_80__	SC
Environmental conditions Average wind speed <12 mph and maximum gusts <15 mph Ambient temperature between 30E(-1E) and 90EF(32EC) Track surface is dry Track is free of extraneous material and clear of interfering traffic	SC

REVISIONS

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

Revision	Description	Date	Approval