STURAA TEST

7 YEAR

200,000 MILE BUS

from

GLAVAL BUS, INC.

MODEL UNIVERSAL

JANUARY 2002

PTI-BT-R0122-P

The Pennsylvania Transportation Institute

PENNSTATE

1855

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

Bus Testing and Research Center

6th Avenue and 45th Street (814) 949-7944
Altoona, PA 16602

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EXECUTIVE SUMMARY

Glaval Bus, Inc., submitted a model Universal, diesel-fueled, 17 seat/26-foot bus, for a Partial STURRA test in the 7 yr/200,000 mile test category. The Federal Transit Administration determined that the following tests would be performed: 2. Reliability and 5.7 Structural Durability. Testing started on October 24, 2001 and was completed on December 7, 2001. The check-In section of the report provides a description of the bus and specifies its major components.

The primary part of the test was the Structural Durability Test, which also provides the information for the Maintainability and Reliability results. The Structural Durability Test was started on October 25, 2001 and was completed on December 3, 2001.

The interior of the bus is configured with seating for 17 passengers including the driver and 2 wheelchair positions. Free floor space will accommodate 11 standing passengers resulting in a potential capacity of 28 + 2 wheelchair positions. At 150 lbs per person, this load results in a measured gross vehicle weight of 15,240 lbs. In order to avoid exceeding the GAWR (9,450 lbs) of the rear axle. Ballast for all 11 standing passengers was eliminated. This reduction from full capacity resulted in an adjusted measured gross vehicle weight of 13,650 lbs and was used for dynamic testing. The first segment (GVW) and the middle segment (SLW) were performed at the same 13,650 lbs. The final segment was performed at a curb weight of 10,000 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.

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 or Class 2 failures. Of the four reported failures, one was a Class 3 and three Class 4.

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 Glaval Bus, Inc., model Universal. The test bus front door is located behind the front axle and a rear handicap entrance behind the rear axle. Note: the test bus is not equipped with a handicap device. Power is provided by a diesel-fueled, Ford 7.3 L Power Stroke engine coupled to a Ford 4R100 transmission.

The measured curb weight is 4,040 lbs for the front axle and 5,960 lbs for the rear axle. These combined weights provide a total measured curb weight of 10,000 lbs. There are 17 seats including the driver plus 2 wheelchair positions, and room for 11 standing passengers bringing the total passenger capacity to 28 plus 2 wheelchair positions. Gross load is 150 lb x 28 = 4,200 lbs. + 1,200 lbs (2 wheelchair positions)= 5,400 lbs. At full capacity, the measured gross vehicle weight is 15,420 lbs. In order to avoid exceeding the GAWR (9,450 lbs) of the rear axle, ballast for all 11 standing passengers was eliminated. This reduction from full capacity resulted in an adjusted measured gross vehicle weight of 13,650 lbs and was used for dynamic testing.

VEHICLE DATA FORM

Bus Number: 0122	Arrival Date: 10-24-01
Bus Manufacturer: Glaval	Vehicle Identification Number (VIN):1FDWE40F6HA66275
Model Number: Universal	Date: 10-24-01
Personnel: S.C.	

WEIGHT:*Values in parentheses indicate the adjusted weights necessary to avoid exceeding the GAWR. There Values were used for all dynamic testing.

Individual Wheel Reactions:

Weights (lb)	Front Axle		Middle Axle		Rear Axle	
	Right	Left	Right	Left	Right	Left
CW	2,000	2,040	N/A	N/A	3,090	2,870
SLW	2,050	2,230	N/A	N/A	4,710	4,660
GVW	2,250 (2,050)	2,450 (2,230)	N/A	N/A	3,090 (4,710)	2,870 (4,660)

Total Weight Details:

Weight (lb)	CW	SLW	GVW	GAWR
Front Axle	4,040	4,280	4,700 (4,280)	4,600
Middle Axle	N/A	N/A	N/A	N/A
Rear Axle	5,960	9,370	10,540 (9,370)	9,450
Total	10,000	13,650	15,240 (13,650))	GVWR: 14,000

Dimensions:

Length (ft/in)	26/6
Width (in)	99.0
Height (in)	112.5
Front Overhang (in)	30.0
Rear Overhang (in)	101.5
Wheel Base (in)	186.5
Wheel Track (in)	Front: 68.5
	Rear: 78.0

Bus Number: 0122	Date: 10-24-01

CLEARANCES:

Lowest Point Outside Front Axle	Location: Steering stabilizer Clearance(in): 10.9
Lowest Point Outside Rear Axle	Location: Tailpipe Clearance(in): 11.9
Lowest Point between Axles	Location: Step well Clearance(in): 9.1
Ground Clearance at the center (in)	9.9
Front Approach Angle (deg)	23.3
Rear Approach Angle (deg)	6.7
Ramp Clearance Angle (deg)	6.1
Aisle Width (in)	16.5
Inside Standing Height at Center Aisle (in)	78.7

BODY DETAILS:

Body Structural Type	Integral		
Frame Material	Steel		
Body Material	Plastic composite, fiberglass & steel		
Floor Material	Plywood		
Roof Material	Plastic composite & fiberglass		
Windows Type	☐ Fixed	☒ Movable	
Window Mfg./Model No.	KYG / AS3 M3 DOT620		
Number of Doors	_1_ Front	_1_ Rear	
Mfr. / Model No.	Glaval / NA		
Dimension of Each Door (in)	Front- 30.7 X 83.7	Rear- 46.0 X 69.0	
Passenger Seat Type	☐ Cantilever	☒ Pedestal	☐ Other (explain)
Mfr. / Model No.	Freedman / FW Highback		
Driver Seat Type	☐ Air	☐ Spring	☒ Other (explain)
Mfr. / Model No.	Freedman / Ford		
Number of Seats (including Driver)	17 + 2 wheelchair positions		

Bus Number: 0122	Date: 10-24-01

BODY DETAILS (Contd..)

Free Floor Space (ft^2)	16.5			
Height of Each Step at Normal Position (in)	Front	1. 11.2	2. 7.8	3. 7.8 4. N/A
	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 / 7.3 L Power Stroke		
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 / 7.3 L Power Stroke		
Carburetor Mfr. / Model No.	N/A		
Fuel Pump Mfr. / Model No.	Ford / 7.3 L Power Stroke		
Alternator (Generator) Mfr. / Model No.	Penntex / P520T		
Maximum Rated Output (Volts / Amps)	12 volts / 170/200 amps		
Air Compressor Mfr. / Model No.	N/A		
Maximum Capacity (ft^3 / min)	N/A		
Starter Type	⊠ Electrical	□ Pneumatic	□ Other (explain)
Starter Mfr. / Model No.	Visteon / N/A		

Bus Number: 0122	Date: 10-24-01

TRANSMISSION

Transmission Type	☐ Manual	☒ Automatic	
Mfr. / Model No.	Ford / 4R100		
Control Type	☒ Mechanical	☐ Electrical	☐ Other
Torque Convertor Mfr. / Model No.	Ford / 4R100		
Integral Retarder Mfr. / Model No.	N/A		

SUSPENSION

Number of Axles	2		
Front Axle Type	☒ Independent	☐ Beam Axle	
Mfr. / Model No.	Ford / Twin I-Beam		
Axle Ratio (if driven)	N/A		
Suspension Type	☐ Air	☒ Spring	☐ Other (explain)
No. of Shock Absorbers	2		
Mfr. / Model No.	Motorcraft / F5UA-18045-C		
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 / N/A		
Axle Ratio (if driven)	4:10		
Suspension Type	☐ Air	☒ Spring	☐ Other (explain)
No. of Shock Absorbers	2		
Mfr. / Model No.	Motorcraft / F5UA-18030-MA		

Bus Number: 0122	Date: 10-24-01

WHEELS & TIRES

Front	Wheel Mfr./ Model No.	Accuride / N/A
	Tire Mfr./ Model No.	Firestone R4S / LT 225/75R16
Rear	Wheel Mfr./ Model No.	Accuride / N/A
	Tire Mfr./ Model No.	Firestone R4S / LT 225/75R16

BRAKES

Front Axle Brakes Type	☐ Cam	☒ Disc	☐ Other (explain)
Mfr. / Model No.	TRW N/A		
Middle Axle Brakes Type	☐ Cam	☐ Disc	☐ Other (explain)
Mfr. / Model No.	N/A		
Rear Axle Brakes Type	☐ Cam	☒ Disc	☐ Other (explain)
Mfr. / Model No.	Dana / N/A		
Retarder Type	N/A		
Mfr. / Model No.	N/A		

HVAC

Heating System Type	☐ Air	☒ Water	☐ Other
Capacity (Btu/hr)	65,000		
Mfr. / Model No.	Ford / NA		
Air Conditioner	☒ Yes	☐ No	
Location	Dash & ceiling mount		
Capacity (Btu/hr)	67,000		
A/C Compressor Mfr. / Model No.	A/C Industries / C-057746		

STEERING

Steering Gear Box Type	Hydraulic gear
Mfr. / Model No.	Visteon / N/A
Steering Wheel Diameter	15.4
Number of turns (lock to lock)	4.0

Bus Number: 0122	Date: 10-24-01

OTHERS

Wheel Chair Ramps	Location: N/A	Type: N/A
Wheel Chair Lifts	Location: N/A	Type: N/A
Mfr. / Model No.	N/A	
Emergency Exit	Location: Windows Doors	Number: 2 3

CAPACITIES

Fuel Tank Capacity (units)	55.0 gals
Engine Crankcase Capacity (gallons)	3.75
Transmission Capacity (gallons)	4.0
Differential Capacity (gallons)	1.0
Cooling System Capacity (quarts)	8.25
Power Steering Fluid Capacity (gallons)	N/A

VEHICLE DATA FORM

Bus Number: 0122	Date: 10-24-01

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

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

COMPONENT/SUBSYSTEM INSPECTION FORM

Bus Number: 0122	Date: 10-24-01

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	✓	N/A
Interior Fasteners	✓	
Batteries	✓	

CHECK - IN

GLAVAL BUS, INC.
MODEL UNIVERSAL

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 enroute interruption of revenue service. Service is discontinued until the bus is replaced or repaired at the point of failure.

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

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

2-III. DISCUSSION

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

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

The classification of repairs according to subsystem is intended to emphasize those systems which had persistent minor or more serious problems. There were no Class 1 or 2 failures. The one Class 3 failure was the result of a flat tire. These, and the remaining three Class 4 failures are available for review in the Unscheduled Maintenance List, located in Section 5.7 Structural Durability.

RELIABILITY DATA FORMS

Bus Number: 0122	Date:11-28-01
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
Exterior	4,630				1.00	1.00
	6,347				0.50	0.50
Tires	6,347				0.50	0.50
		6,347			0.50	0.50

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 October 25, 2001 and was conducted until December 3, 2001. The first 3,000 miles were performed at a GVW of 13,650 lbs and completed on November 14, 2001. The number of standing passengers was reduced from 11 to 0. This reduction in passenger weight was necessary to avoid exceeding the GAWR (9,450 lbs) of the rear axle. The next 1,500 mile SLW segment was performed at the same 13,650 lbs and completed on November 20, 2001, and the final 3,000 mile segment was performed at a CW of 10,000 and completed on December 3, 2001.

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 PTI Test Track Facility and Durability Test Track are attached for reference. Also, a durability element profile detail shows all the measurement of the different conditions. Finally, photographs illustrating some of the failures that were encountered during the Structural Durability Test are included.

GLAVAL - TEST BUS #0122
MILEAGE DRIVEN/RECORDED FROM DRIVERS' LOGS

DATE	TOTAL DURABILITY TRACK	TOTAL OTHER MILES	TOTAL
10/22/01 TO 10/28/01	136.00	56.00	192.00
10/29/01 TO 11/04/01	273.00	115.00	388.00
11/05/01 TO 11/11/01	1027.00	147.00	1174.00
11/12/01 TO 11/18/01	1204.00	755.00	1959.00
11/19/01 TO 11/25/01	1283.00	652.00	1935.00
11/26/01 TO 12/02/01	1077.00	725.00	1802.00
12/03/01 TO 12/09/01	0.00	51.00	51.00
TOTAL	5000.00	7501.00	7501.00

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

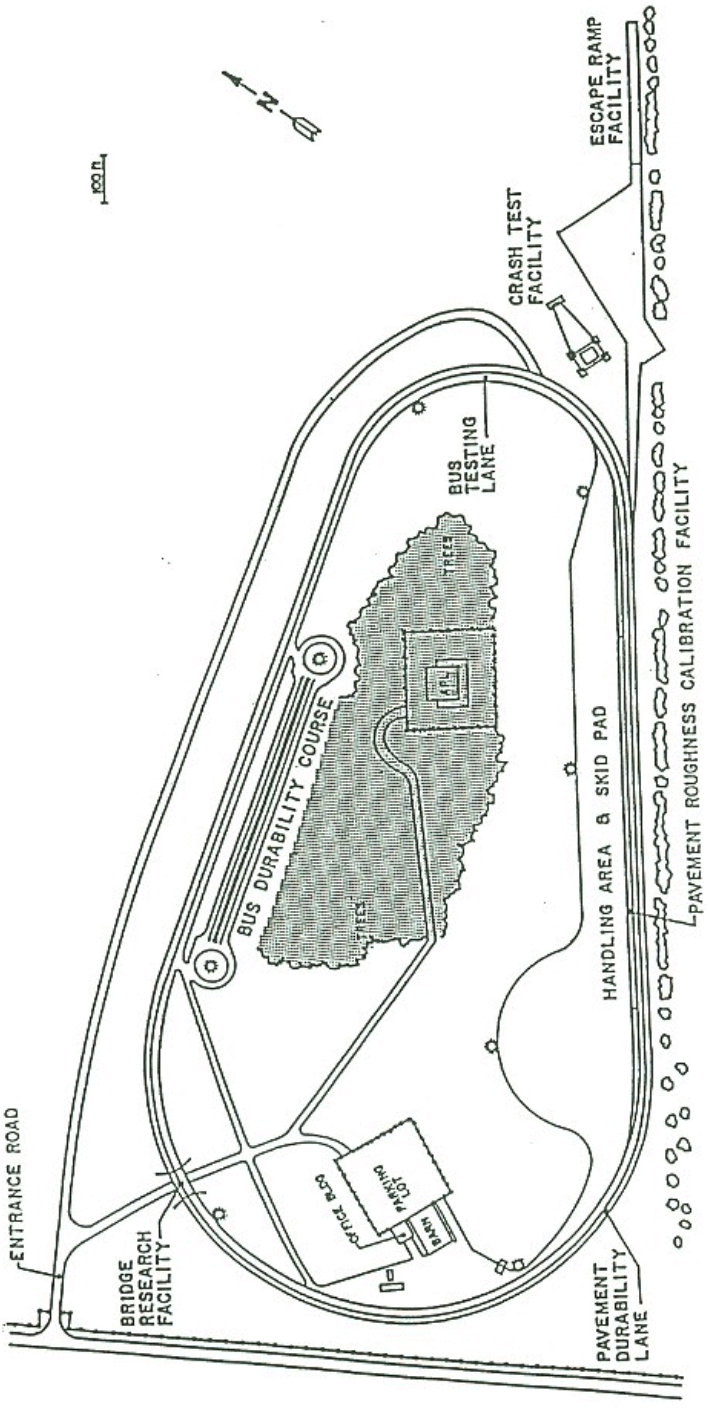
STANDARD OPERATING SCHEDULE

Monday through Friday

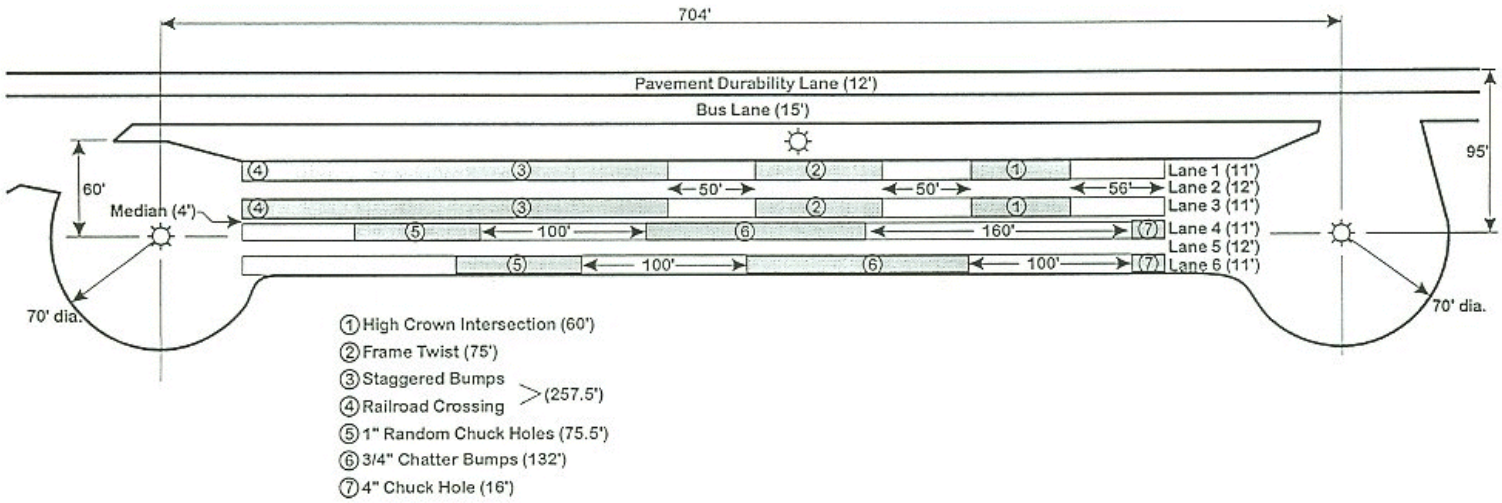
	HOUR	ACTION
Shift 1	midnight	D
	1:40 am	C
	1:50 am	B
	2:00 am	D
	3:35 am	C
	3:45 am	B
	4:05 am	D
	5:40 am	C
	5:50 am	B
	6:00 am	D
	7:40 am	C
	7:50 am	F
Shift 2	8:00 am	D
	9:40 am	C
	9:50 am	B
	10:00 am	D
	11:35 am	C
	11:45 am	B
	12:05 pm	D
	1:40 pm	C
	1:50 pm	B
	2:00 pm	D
	3:40 pm	C
	3:50 pm	F
Shift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

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

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



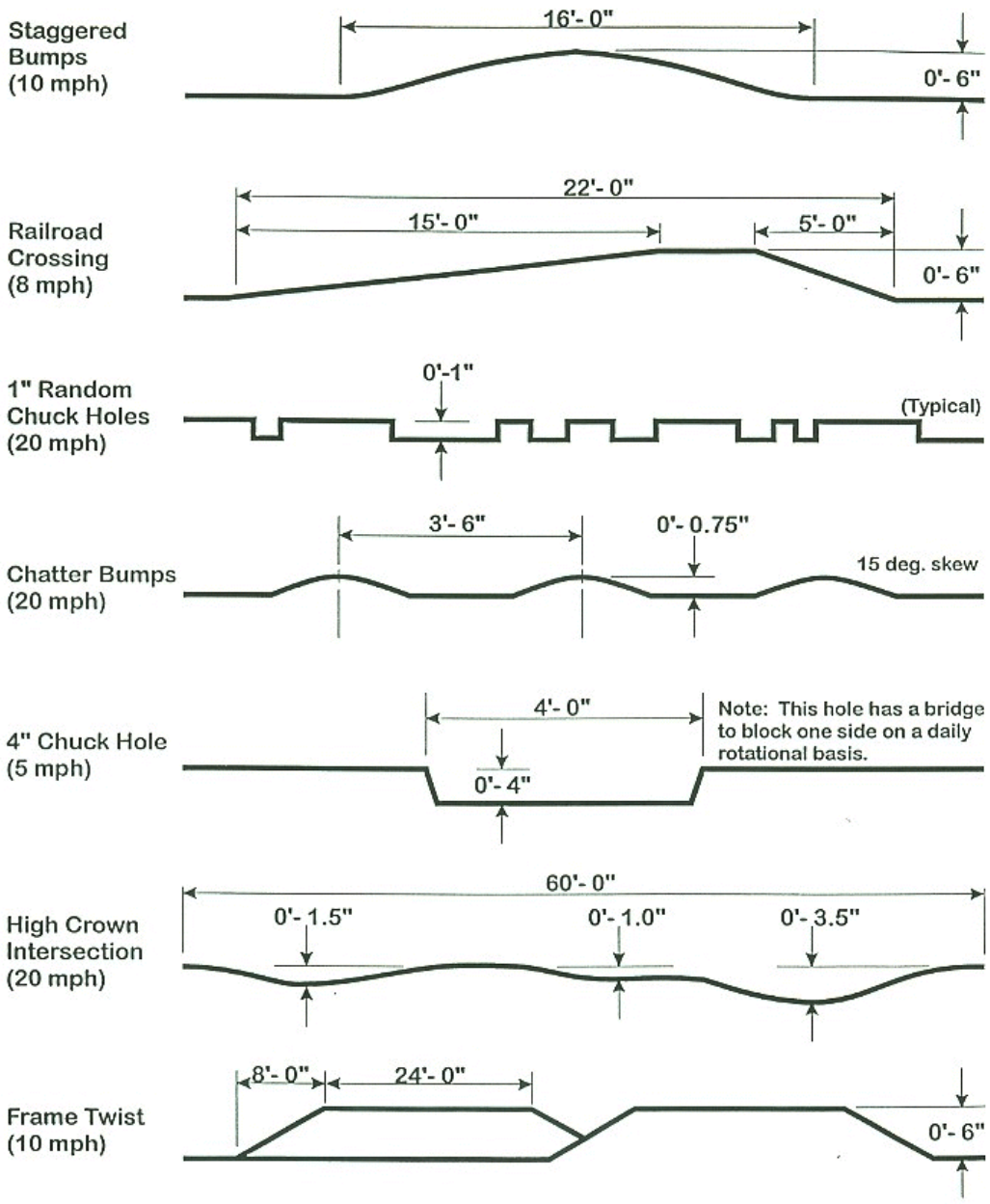
BUS TESTING AND RESEARCH TEST TRACK
UNIVERSITY PARK, PA



Plan View

Vehicle Durability Test Track

The Pennsylvania Transportation Institute
Penn State



Durability Element Profiles

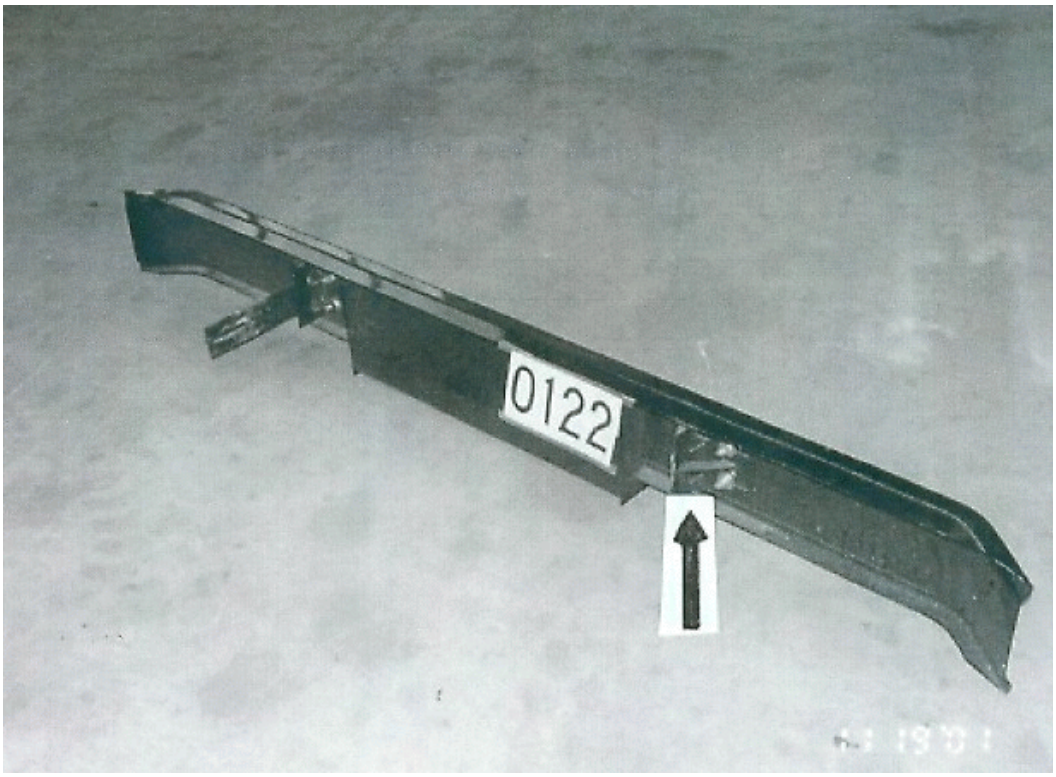
The Pennsylvania Transportation Institute
Penn State

UNSCHEDULED MAINTENANCE

Glaval 0122

DATE	TEST MILES	SERVICE	ACTIVITY	DOWN TIME	HOURS
11-21-01	4,630	The left rear bumper mounting bracket is broken and the right bracket is cracked.	Fabricated new left bracket and weld/repair right bracket.	1.00	1.00
11-28-01	6,347	Both front tires are wearing on the outer treads.	Front and rear outside tires rotated.	0.50	0.50
11-28-01	6.347	The left rear inside tire is flat	Tire plugged	0.50	0.50
11-28-01	6,347	The top hinge on the wheelchair lift door is loose.	Hinge rivets replaced.	0.50	0.50

UNSCHEDULED MAINTENANCE



BROKEN REAR BUMPER MOUNTING BRACKET (4,630 TEST MILES)